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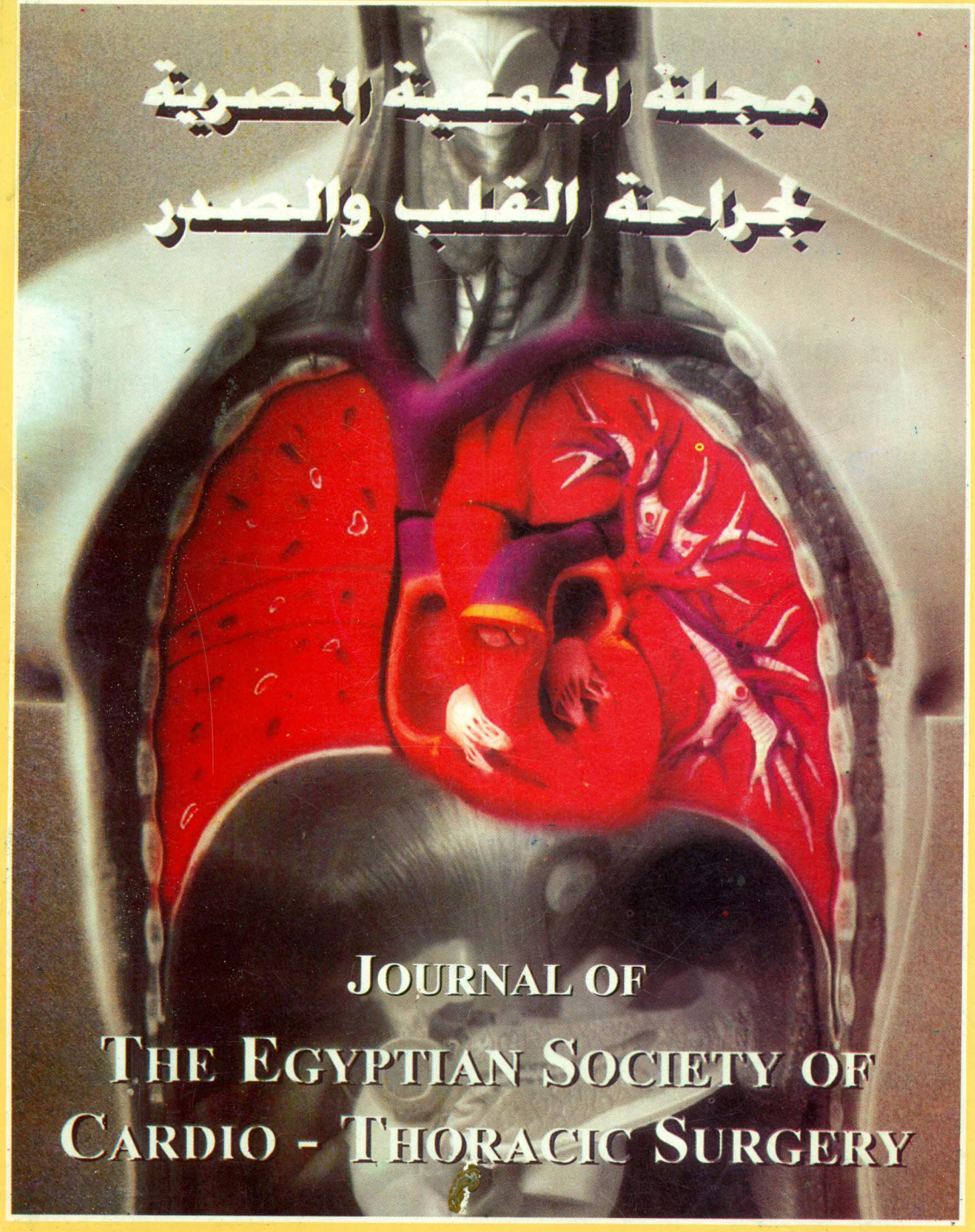

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Nasser H, Rasmy, Tarek M, Helmy, Yahia A, Balbaa, Ayman S, Gado, Mohamed Abdel Hady and Sherif H, El Mangoury

PREOPERATIVE ELECTIVE INTRAAORTIC BALLOON COUNTERPULSATION IN HIGH-RISK OFF-PUMP CORONARY ARTERY BYPASS GRAFT OPERATIONS

ABSTRACT

Background: For Off-pump Coronary Artery Bypass Grafting (OPCABG), considerable degrees of cardiac dislocation may be needed to revascularize the posterior and inferior coronary vessels. Despite the particular benefits & attraction that exists in it, the OPCABG technique may furtherly compromise the haemodynamic stability of a critical patient who is already compromised. Our work herewith is a report of our early experience / evaluation of the role /benefits of using elective IABCP for the purpose of safe and complete revascularization of the posterior / inferior coronary vessels using the OPCABG technique.

Patients and Methodology: Between March 1998, and October 2001, 40 patients having IHD with high risk conditions were submitted to OPCABG mainly to revascularize posterior & or inferior coronary vessels in Kasr El Ainy University Hospitals. Patients were classified into two groups. Data was prospectively-collected in grp I (20 cases) in whom IABCP was used, while retrospective data was collected for grp II (20 cases) in which IABCP was not used. Grp I was furtherly subdivided into: class A (10 cases) in which IABCP was electively preoperatively-inserted; and class B (10 cases) in which IABCP was intra or postoperative used. All patients shared being at high risk due to the presence of: left main coronary disease > 75% stenosis; intractable resting angina; postinfarction angina; LVEF < 35%; unstable angina; or documented cerebral vascular disease. Detecting this significant co-morbid pathology, made the avoidance of CPB desirable, if at all possible, in all patients.

Results: The average number of distal anastomoses done showed only a slight difference (as no statistical significance was calculated) between the study grps. However, the elective use of IABCPs appeared to facilitate more the performance and safety of the intraoperative management in our grp I patients. This was clearly-evidenced by the improved haemodynamic stability and virtual elimination (or decrease) of the inotropic / volume support needed with cardiac dislocations / manipulation during construction of distal anastomoses. A slight difference (with no statistical significance), existed between patients of both groups as regard: Ventilator support time & length of ICU and hospital stay. We had 5 deaths. One death (5%), occured in grp I class B; another 4 (20%), occurred in grp II. In grp I class B: 3 cases (15%), had morbidity complications related to IABCP insertion.

Conclusion: IABCP therapy facilitates posterior /inferior vessel OPCABG in high-risk patients. It improved the results of surgical intervention when compared to those in whom it was not applied. The risk-adjusted mortality was significantly-lower in these patients when IABCP was electively-used preoperatively. We encourage others to apply it preoperatively as its use was proved soundly-valuable in OPCABG patients showing high risk conditions.

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***IABCP: Intra aortic Balloon Counterpulsation. *CPB: cardiopulmonary bypass. *Grp: group. *LVEF: left ventricular ejection fraction *IHD: ischemic heart disease *Statistical significance: P value < 0.05.**

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INTRODUCTION

Compared to the pre-angioplasty era, and as a result of the enormous advancement in interventional cardiology with its advanced techniques, patients coming to surgery for ischemic heart disease (IHD), are often at the end stage of their disease, showing more ischemic myocardium with depleted energy sources Therefore, patients referred for cardiac surgery are now older, sicker, have poorer left ventricular function (LVEF), and more extensive disease, often after previous failed revascularization, than those of 10 years ago (1), (2).

Haemodynamic instability may result during the dislocations of the heart that are needed for exposure and construction of distal anastomoses in performing Off-Pump CABG (3), (4). This dislocation may impair cardiac function by decreasing stroke volume and cardiac output, lowering systemic blood pressure and further worsening regional myocardial ischemia (7), (8). These changes are expected to be more pronounced or serious in patients with high risk factors eg: left main coronary artery disease > 75% stenosis, resting angina refractory to medical therapy, post-infarction angina, LVEF < 35%, unstable angina, or reoperation (5). As a result, many authors have demonstrated that short-term circulatory support with the intraaortic balloon pump (IABP), during the perioperative period may hence be justified. There is growing evidence that the perioperative use of IABCP significantly improves cardiac performance and effectively controls myocardial ischemia in such patients (9), (10). Perioperative balloon therapy may permit safer induction of general anaesthesia and facilitate posterior vessel OPCABG in high-risk patients (11), (12).

Aim of work

The aim of our work was to assess the feasibility of performing posterior vessels OPCABG under IABCP support and evaluate its efficacy in different timing of insertion whether peri, intra, or postoperatively in high-risk IHD patients.

Patients and Methods

Fourty patients were chosen for this study that was carried out in our center: Kasr El Ainy University Hospitals during the period between March 1998, and October 2001. These patients were believed to be at an increased risk of both a likely occurance of haemodynamic instability and or a devastating complication thereof that could be encountered during the displacement of the heart required for OPCABG procedure to revascularize the posterior coronary vessels.

These patients were at increased risk due to various combinations eg: presence of severe ischemic heart disease basically due to marked posterior coronary vascular stenosis..etc (table II). The presence of other critical conditions also categorized the candidate as a "high-risk patient". The presence of this significant co-morbid pathology (disease), made the avoidance of CPB desirable, if at all possible, in all patients. In agreement with that opinion, we preferred and performed the OPCABG technique in all our surgical candidates.

We evaluated the clinical data and results obtained from 20 patients who, prospectively, underwent IABCP. In grp I: class A (10 patients), IABCP was electively preoperatively inserted; while in class B (10 patients), it was inserted intra or postoperatively. Grp II encompassed 20 patients who (retrospectively) had IHD with similar risk conditions, performed OPCABG without IABCP insertion.

Our criteria for inclusion (ie: for inserting IABCP) were:

1. Significant left main coronary artery disease > 75% stenosis.

2. Intractable (refractory) angina at rest despite giving the maximum medical treatment of nitroglycerins and heparin sodium via intravenous route.

3. Left ventricular dysfunction evidenced by low ejection fraction EF< 35%.

4. Recent acute myocardial infarction after 6 weeks from its onset.

5. Unstable angina at rest.

Surgical Technique:

In all patients, we used the Off-pump CABG technique by the same surgical team who employed the same surgical techniques. In all cases, the median sternotomy approach was used using heparin in an initial dose of 1 mg / kg to be periodically-supplemented to maintain the activated clotting time of more than 150 seconds. Temperature was maintained at normothermia using room temperature control, in addition to warm circulating water blankets and warm infusion solutions. After opening the pericardium, deep pericardial traction sutures were placed to facilitates pericardial retraction in order to help cardiac dislocation and achieve exposure.

The heart rate was kept reduced at a rate below 70-80 bpm to reduce myocardial oxygen consumption using either boluses or continuous infusion of B-Blockers eg: Esmolol. Ischemic preconditioning was not used in most of the cases.

Anaesthesia management, including volume loading and placing the patient in the Trendelenburg position, controlled haemodynamic derangement during displacement or manipulation of the heart. In order to reduce the amplitude of ventricular wall movement, a suction-type mechanical stabilizer (CTS: Cardio Thoracic Systems, Inc., Cupertino, CA, USA), in addition to the suction-type mechanical stabilizer (Octopus; Medtronics, Minneapolis, MN, USA) were used. After exposure of the coronary artery, vascular control was performed with elastic (rubber) vessel loops (Retract-O-Tape; Quest Medical Inc., Allen, Tx, USA) placed around the proximal artery and distal to the site of the anastomosis. These two sutures were carefully-retracted during the anastomosis to occlude the coronary artery. When a bloodless operative field was not adequately - maintained owing to

Table (I): Demographic data for the different groups.

Characteristic (IABCP)	Grp I (No IABCP)	Grp II	P-value
1. Mean age in years +-SD	72.1+-1.2	69.8+-2.9	NS
2. Males %	78 %	76 %	NS
3. Females %	22 %	24 %	NS

profuse collaterals, internal vascular control was achieved with a flow-occluding small vascular Bull-dog clamp. A blower using filtered oxygen gas or a microsucker system using a rubber-tip was sometimes used in order to obtain a bloodless field.

All proximal anastomoses on the ascending aorta were always constructed using 6-o polypropylene continuous sutures, using a side-occlusion clamp for partial clamping of the aorta, after distal anastomotic points were all fashioned. IABCP was placed on the standby during the proximal anastomosis on the ascending aorta, to avoid the possibility of causing aortic dissection. Distal anastomoses were constructed using 7-0 or 8-0 polypropylene sutures in a continuous fashion. Protamine sulphate was given at the end of the procedure in titration with the dose of heparin given before it.

IABCP insertion:

In all our grp I patients, we inserted IABP either preoperatively (class A); versus intra or postoperatively (class B). In class A subgroup, we inserted IABCP in the operating theater using local anaesthesia just before induction of general anaesthesia and then the correct placement of the balloon was routinely-confirmed via an image intensifier (without intravascular contrast material) as well as by manual palpation of its tip before proceeding to perform revascularization. In class B, we inserted it percutaneously (or sometimes by surgical cutdown via femoral artery cannulation) whenever it was needed due to haemodynamic instability (eg: Systolic BP < 80 mms Hg.; Pulmonary diastolic BP > 25 mms. Hg.; or intractable ventricular arrhythmias despite adequate anaesthesia) occurring intraoperatively. Usually, a 9.5 F Percor balloon (Stat-DL catheter, Datascope System; Datascope, Fairfield, NJ, USA) was used with a 10 French sheath through the common femoral artery. After insertion, all patients were given 1 mg./kg of heparin.

Results

According to our proper case matchability, and except for smoking, there was no marked difference in the demographic data like age, sex, or systemic diseases (Table number I).

Table number II, demonstrates the different preoperative general risk factors in the two study groups. It showed that smoking was the only preoperative risk factor that displayed a difference between both groups being 80% in grp I Versus 30% in grp II.

As regard the other factors ie: DM, Hypertension, obesity, hypercholesterolemia, previous stroke, previous myocardial infarction, cerebral stroke, previous renal

Table (II): Preoperative risk factors.

Characteristic	Grp I (IABCP)	Grp II (NO IABCP)	P Value
1. Smoking %	80 %	30 %	0.04
2. Diabetics %	23 %	28 %	NS
3. Hypertension %	38 %	42 %	NS
4. Excessive Overweight %	8 %	10 %	NS
5. Hypercholesterolemia %	28 %	33 %	NS
6. Previous cerebral strokes %	7 %	5 %	NS
7. Old myocardial infarction %	12 %	10 %	NS
8. Renal failure %	zero	zero	NS
9. Reoperation %	none	none	NS

NS: non significant result.

Table III: Cardiac high-risk factors in the study groups.

Cardiac High-risk factor	Group I class A (preop)	Group II class B (intra & post op)	P Value No IABCP
1. LMCA stenosis > 75 %	19 (95%)	15 (75%)	NS
2. Intractable resting pain	10 (50%)	8 (40%)	NS
3. LV dysfunction (EF< 35%)	5 (25%)	3 (15%)	NS
4. Recent MI (> 6 weeks)	2 (10%)	1 (5%)	NS
5. Unstable angina with ttt	19 (95%)	15 (75%)	NS
6. Ratio of Risk Factors / patient	2.2+-0.9	2.0+-1.3	NS

LMCA: left main coronary artery. LV: left ventricular EF: ejection fraction. MI: myocardial infarction ttt: treatment.

failure, and previous operation(s), no difference of a statistical significance was found between both groups.

In Table number III, the different cardiac high-risk factors are displayed and compared between both groups.

In Table number IV, the average (mean) number of distal anastomoses done was higher in grp I than in grp II (3.5 +- 0.9 versus 2.3 +- 0.2 respectively) with a relevant statistical significance. The number of individual vessels revascularized in both groups showed more achievement and ease in revascularizing the vessels of grp I patients in whom IABCP was used.

The different vessels were classified as follows:

1) Anterior: left anterior descending artery, diagonal, ramus intermedius, & proximal or middle right coronary artery.

2) Inferior: Posterior descending artery, postero-lateral branches, and distal right coronary artery.

Table (IV): The comparison of the distal anastomotic points accessed is displayed in both groups.

Site of distal vessel anastomosed	Grp I (IABCP)	Grp II (No IABCP)	P value
Number of distal anastomosis (mean +- SD)	3.5 +- 0.9	2.3 +- 0.2	0.05
1. Posterior vessels.	18	9	0.04
2. Inferior vessels.	20	11	0.05
3. Anterior vessels.	20	18	NS

*** Anterior: left anterior descending artery, diagonal, ramus intermedius, & proximal or middle right coronary artery.**
*** Inferior: Posterior descending artery, postero-lateral branches, and distal right coronary artery.**
*** Posterior: Obtuse marginal branches.**

3) Posterior: Obtuse marginal branches.

In table number V, the morbidity complications due to the insertion of IABCP are displayed. All (3 complications : 15%) occurred in grp I class B cases.

*One patient had transient limb ischemia that disappeared shortly after its removal.

*Another patient who had localized arterial injury needed corrective vascular surgery.

*In a third patient who preoperatively had calcified plaques in both femoral arteries, prolonged lower leg ischemia occurred and was treated successfully with popliteal thrombo-end-arterectomy.

Table number VI compares the postoperative mortality between both groups. The mortality was found higher in grp II compared to grp I patients (25% Vs. 5% respectively).

The IABP support was terminated once haemodynamic stability was restored in the last hours of the ICU stay. The mean time of using IABCP in group I was 8.7 +- 3.3 hours (Table number VII).

The postoperative events and morbidities between the two study groups are comparatively-displayed in table number VII. There was no significant differences in the time needed for mechanical ventilatory support or the total hospital stay time.

The duration of the postoperative pharmacologic inotropic support was longer, and the ICU time was found prolonged (with statistical significance) in patients who did not use IABCP.

There was no statistical significance found when other morbidity complications were compared (eg: AF; cerebral Stroke; renal insult; respiratory side events; reoperation for bleeding; or low CO syndrome).

To evaluate the incidence of perioperative myocardial infarction, we defined our results to be positive in comparison to the following: if peak serum CK-MB level was > 200 IU/L, when a new

Table (V): Shows the morbidity complications caused by the use of IABCP.

Complication (number & %)	Group I Class A	Group I Class B	Group II	P Value
Morbidity complication:	zero	3 (15%)	-	-
a) Transient limb ischemia	zero	1 (5%)	-	-
b) Localized arterial injury	zero	1 (5%)	-	-
c) Prolonged limb ischemia needing PTEA.	zero	1 (5%)	-	-

*** PTEA: Popliteal thromboendarterectomy.**

Q wave appears in the ECG, or when a newly-developed regional wall motion abnormality is noticed on the postoperative echocardiogram.

Discussion and comments:

The advantages of OPCABG have been clearly demonstrated, by many authors (8), (9), (10), (12), & (20) to offer a great help in avoiding the potentially-detrimental effects of CPB by eliminating the intraoperative global ischemia.

The advancement in the design and function of OPCABG stabilizing devices, intraoperative retraction techniques, anaesthesia support, and anticoagulation management have led to an increased application of OPCABG procedures to a wider range of patients (19), (20).

The benefits of OPCABG procedures are more valuable in the special category of patients who are believed to be at an increased risk due to the presence of pre or intraoperative critical situations. These situations are responsible of causing the haemodynamic instability that can occur during severe proximal or multivessel revascularization (20), (21).

This haemodynamic instability usually can be corrected in normal risk patients by temporarily supporting perfusion pressures with volume adjustments and inotropic drugs, hence avoiding progressive hypotension, myocardial ischemia, and the need for urgent conversion to CPB support (8), (22).

However, in some conditions, displacement of the heart during OPCABG may impair cardiac function by lowering systemic blood pressure, decreasing stroke volume and cardiac output, reducing the coronary blood flow, and further worsening regional myocardial ischemia and this may ,sometimes, cause incomplete revascularization (20), (23), (24), (25).

Further displacement of the heart to expose the posterior or the inferior vessels significantly decreases the coronary flow in the circumflex coronary artery compared with that in the left anterior descending or right coronary artery (10).

Workers like (9), and (11), have found the previous statement especially-true during grafting the circumflex and its higher branches and those branches that barely-emerge from the atrioventricular

Table (VI) : Comparison of postoperative Mortality.

Result	Grp I		Grp II	P value
	Class A	Class B		
* Operative mortality (No. & %)	zero	1 (5%)	5 (25%)	0.005

groove. Exposure of these branches and the left ventricular branch of the right coronary artery can often present extreme difficulty as it requires great cardiac displacement to the right, hence impairing adequate bi-ventricular function and eventually-leading to dangerous falls in the cardiac perfusion pressure.

In this context, OPCABG is sometimes contraindicated, by some authors, for haemodynamically unstable patients or patients with left main coronary artery disease (26), (27), although other workers argued that left main coronary artery disease does not contraindicate OPCABG as long as the anterior and right coronary territories are revascularized first before going to the circumflex area (28).

IABCP has long been appreciated as a valuable method of temporary mechanical support for assisting the ventricular contractile functions of the failing heart (13), (14), (15), (16). Using the IABCP provides significant afterload reduction and thus results in a more favorable enhancement of the diastolic pressures (16). Its effect also leads to redistribution of the coronary blood flow toward ischemic areas of the myocardium (17).

The benefits of using IABCP are of particular value for hearts that are more vulnerable because of severe proximal and or multi-vessel coronary artery disease, ventricular hypertrophy, and systolic dysfunction (10).

Several studies have stated that use of preoperative IABCP can reduce perioperative myocardial ischemia and hence improve the surgical outcome in IHD patients with high-risk conditions undergoing coronary artery bypass operations (3), (11), (18). Preoperative IABCP therapy could lead to preoperative reduction of myocardial ischemia, avoidance of progressive cardiac dysfunction, and minimization of the low-flow episodes (with subsequent end organ dysfunction).

Preoperative IABCP may, thereby, permit safer induction of general anaesthesia and improve surgical outcome in high-risk IHD patients in whom higher mortality and morbidity rates have been reported despite massive pharmacologic support in combination with postoperative IABCP support (29).

In this study, our goal was to seek and evaluate the protective effect of IABCP in reducing the susceptibility of acute perioperative stresses on the compromised heart that are caused by cardiac dislocations / displacement needed during OPCABG by supporting the haemodynamic stability and reducing myocardial oxygen demand.

Table (VII): Comparison of postoperative morbidity events.

Postoperative event	Grp I (IABCP)	Grp II (No IABCP)	P value
* Ventilator support (in hours)	12+- 2.3	16 +- 0.9	NS
* Need for inotropic support	4 +- 0.5	8 +- 1.1	0.05
* IABCP support (in hours)	8.7 +- 3.3	-	-
* Transient AF (no & %)	2 (10%)	3 (15%)	NS
* Myocardial infarction (no & %)	zero	1 (5%)	NS
* Postoperative stroke (no & %)	zero	zero	NS
* Acute renal insufficiency (no & %)	2 (10%)	1 (5%)	NS
* Low cardiac output syndrome (no & %)	zero	1 (5%)	NS
* Reoperation for bleeding control (no & %)	zero	zero	NS
* Posroperative Mediastinitis (no & %)	zero	zero	NS
* Respiratory complication (no & %)	zero	3 (15%)	NS
* Complication due to IABCP insertion	3 (15%)	none	NS
* ICU stay (in hours)	31 +- 4.1	50 +- 3.4	0.05
* Hospital stay (in days)	8 +- 1.1	11 +- 2.4	NS

We inserted preoperative IABCP before OPCABG in 10 patients (grp I, class A patients), and intraoperatively in another 10 patients (grp I, class B patients), when they met our criteria of being in the high-risk condition. Retrospectively, we gathered data of 20 patients who had the same risk factors, did the same OPCABG technique, but did not use IABCP.

The preoperative criteria of being at high-risk included:

1- Presence of significant left main coronary artery disease (> 75%).

2- Intractable resting angina or refractory angina despite maximum medical therapy.

In the form of Nitroglycerin or Heparin sodium.

3- Left ventricular dysfunction with LVEF < 35%.

4- Recent acute myocardial infarction six weeks after its onset.

5- unstable angina especially due to posterior or inferior coronary vessels.

According to our opinion as well as others (28), (30), (31), intraoperative high risk dangerous situations were anticipated if the following was noticed:

1-A significant decrease of systemic systolic arterial BP to less than 80 mms Hg.

2-When pulmonary diastolic pressure becomes elevated to more than 25 mms Hg.

3-When intractable ventricular arrhythmias happens despite Trendelenburg positioning of the patient, adequate anaesthesia management, or temporary pacing.

Whilst revising our earliest retrospective results of using the OPCABG

technique, we discovered that, due to circulatory collapse, we had a 25 % incidence of conversion to conventional CABG using CPB. However due to the built-up experience, our learning curve improved and we infrequently revert to using conventional CPB nowadays. Instead, we usually insert IABCP pre or intraoperatively if circulatory collapse was strongly-suspected or about to occur.

This study was performed prospectively and retrospectively to demonstrate the efficacy and safety of using IABCP (whether pre or intraoperatively) in comparison with not using it in OPCABG procedures to revascularize coronary arteries especially those posteriorly and or inferiorly-situated. The cases chosen in our two study groups were closely-matched as regards the degree of high risk to which each patient was exposed.

Our data showed that using IABCP obviously added much help as to achieve more safe and complete myocardial revascularization as a higher number of distal anastomotic points (per patient) was done in grp I (IABP) compared to group II (No IABP): mean of 3.5 ± 0.9 versus 2.3 ± 0.2 respectively.

This finding which confirms well the beneficial value of using IABCP during OPCABG procedures, was also reported by other researchers like Naunheim et al (14) who reported means of 3.8 Vs. 2.9 values; and Ascione et al (9) who reported 3.2 Vs. 2.6; and lastly Christensen et al (12) who declared 3.1 Vs. 2.8 respectively.

However, other groups like (6), (13), and (15) reported controversial results.

More postoperative morbidity complications were discovered in group II (the high risk group in which IABCP was not used). Despite no statistical significance (may be due to the small number of cases in our study), there were more incidence of OPCABG-related morbidity in grp II (using no IABCP) as regard: incidence of low cardiac output syndrome; incidence of postoperative myocardial infarction; incidence of transient AF; and the time needed for mechanical ventilatory support).

However there was a noticed difference , with statistical significance, in the average time spent under close observation in the ICU which was more in grp II patients not using IABP. Others like (8), (9), (10), (12), also reported similar findings of the more incidence of postoperative morbidity complications with OPCABG when IABCP was not used.

Three side complications occurred due to IABCP insertion in our group I (class B) patients (15%). In the first patient, transient limb ischemia occurred and disappeared shortly after removal of the balloon. In the second patient, localized arterial injury occurred and was surgically-repaired. In the third patient , prolonged lower limb ischemia occurred and required popliteal artery thrombo-end-arterectomy. We attributed this relatively-low rate of incidence to the haste during their insertion or at the end of surgery thus ending with these complications.

According to our findings, it is our belief (as well as others like (4), (8), (9)) that intraoperative or postoperative IABP insertion is usually associated with higher operative mortality and device-related complication rate compared with its preoperative use.

No major sequelae occurred as an IABCP-related complication, in our series.

This may be attributed to our experience gain, short IABCP insertion times, and proper preoperative evaluation of peripheral arterial status, and close surveillance of the peripheral circulation paying special attention at noting any early sign of acute ischemia. These precautions were also advised by other researchers as (3), (12), (15), (16), (30), (31).

In a recent controlled trial (3) of 52 high-risk patients performing OPCABG, the IABCP patients had a significantly lower postoperative mortality than patients who did not receive it (6% Vs. 25%). Furtherly, 55% of the latter group subsequently required IABCP intraoperatively.

In a larger retrospective study (4), of 163 patients having LVEF of less than 0.25 undergoing OPCABG, the patients who had preoperative IABCP progressed bitterly than those who did not have it with mortality of 2.7% Vs. 11.9% respectively.

A 27-year review of of IABCP use at Massachusetts General hospital (4) also demonstrated lower mortality of 13.6% (in 2.038 patients who did preoperative IABCP), in comparison with 35.7% mortality rate in 771 patients (who had intraoperative IABCP); and a 35.9% rate in 276 patients (who used it postoperatively)

In our study, we similarly had the total number of six mortalities (15%). One patient died (5%) in grp I class B in which IABCP was inserted intraoperatively.

Five patients died (25%) in group II in which IABCP was not used (high statistical significance).

Conclusion and recommendation:

In the work done herewith, we have found that the elective use of preoperative IABCP in OPCABG procedures, was of much help in inducing as well as keeping a favorable degree of haemodynamic stability during OPCABG surgeries.

IABCP also led to virtual elimination (or reduction) of the need for intraoperative inotropic support during OPCABG. It largely decreased OPCABG-linked postoperative morbidity complications. Furthermore, it aided the safe and complete construction of distal anastomoses in the coronary territories of difficult accessibility in the posterior and the inferior positions.

In conclusion, by virtue of its benefits, the application of preoperative IABCP with OPCABG, justified its use, and proved to effectively-overweigh its risks.

Its applicability is recommended to extend and include all patients who are believed to be at a specially-high risk of having haemodynamic deterioration during OPCABG surgeries.

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ROUTINE AUTOTRANSFUSION OF SHED MEDIASTINAL BLOOD AFTER OFF-PUMP CABG OPERATIONS: EFFECTS AND VALUE

ABSTRACT

Background: It is a well-known finding that cardiac surgical patients consume a significant fraction of the annual volume of homologous intra-hospital blood transfused. A combination of several techniques is necessary in order to minimize the amounts of blood that is needed for consumption in open heart operations. Autologous blood, scavenged via various techniques, may eventually serve as a valuable and cost-effective mean of conserving donated blood and simultaneously avoiding transfusion-related complications.

Patients and Methods: In a prospective randomized study, 50 IHD patients undergoing elective uncomplicated OPCABG were studied from March 2001 till October 2002 in Kasr El-Ainy French Educational Hospital. 35 patients were men while 15 were women. Mean age was 62.3±3 years. In all patients, heparin was given at the dose of 1.5 mg./ Kg Bwt. (to keep the ACT > 350 seconds) a short time after sternal splitting. Autologous blood is then withdrawn from grp I patients as 10 ml/kg BWT, stored in a blood reservoir to be reinfused after heparin neutralization at the end of surgery. Using the pump suckers, the intra-operatively-shed mediastinal blood was salvaged and collected in a 40 microm. Pores cardiotomy reservoir (Baxter Corp, CA USA). Postoperatively, the reservoir was used to autotransfuse the blood collected (during surgery and exclusively the first 6 hours postoperatively) as part of our routinely-used protocol. The indications for blood transfusion were standardized, and the physicians ordering blood products were blinded to the study. Patients were divided into two equal groups (each 25 in number) and studied during their ICU and hospital stay. The shed mediastinal blood was directly-reinfused in group I (n=25 patients), whereas in group II (n=25 patients), it was not. The variables comparatively-studied between the two groups included: the amount of blood lost and re-infused, homologous blood needed and actually-transfused (including complications of transfusion); complete blood count (including platelet count, and differential counts for WBCs); evaluation of the coagulation system was done by: CT, PT, ACT, PTT; coronary enzymes (CK, & CK-MB); renal functions; & total costs of surgery.

Results: Only Five (20%) of patients who had auto-transfusion (grp I), received perioperative homologous blood transfusion versus fifteen (60%) in grp II (P = 0.006). In grp I, 96% of the SMB was reinfused. Mildly-elevated postoperative serum levels of free Hgb, CK-MB and LDH were observed in grp I after autoinfusion. Compared with grp II, patients in the auto-transfusion grp.I, showed a 32% reduction of chest tube drainage at 10 and 14 hours postoperatively & a 44% reduction in the amount of homologous blood units transfused. Our results showed a 45% reduction in blood-linked transfusion risks. Total costs spent were reduced by an average of 18% in grp I Vs. grp II.

Conclusion: Autotransfusion of shed mediastinal blood in patients undergoing elective uncomplicated Off-pump coronary artery bypass graft surgery, markedly-reduces the

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amount (and consequently the related complications) of homologous blood given in the postoperative period. Autotransfusion proved also to be financially-rewarding as it obviously reduced the total costs of surgery for patients. Further studies are needed in this context to draw firmer conclusions.

***OPCABG: off-pump coronary artery bypass grafting.*IHD: ischemic heart disease*PO: post operative. *Kg/Bwt.: Per Kilogram of body weight. *ACT: activated clotting time. *SCK: serum creatine kinase. *CK-MB: its isoenzyme fraction. *LDH: Lactate dehydrogenase. * SMB: Shed mediastinal blood. *ACT: activated clotting time PT: prothrombin time PTT: partial thromboplastin time.**

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INTRODUCTION

The risks of homologous blood transfusion are well documented and include the transmission of serious infectious diseases (eg: hepatitis B,C, HIV etc...) as well as the risks and hazards of receiving incompatible blood (1), (2). A variety of blood conservation techniques have evolved to minimize the transfusion requirements for open heart operations (3), (4). The technique of "blood pooling" before the onset of cardiopulmonary bypass has been shown to be beneficial as a single technique in patients having elective operations and venous grafts (5), (6), (7).

Other methods of blood conservation include predonation of blood prior to operation (8), intraoperative withdrawal of blood before cardiopulmonary bypass (CPB) (9), and intraoperative plasma separation with a cell-saving device (10).

The first report on autotransfusion was by Blundell (11), in 1818. The first autotransfusion in a human was reported by Duncan (12), in 1886, and reinfusion of shed mediastinal blood was first described by Schaff and associates (13), in 1978.

A concern about the use of autologous blood transfusion after CABG is the sterility of the shed blood. For example, accidental bacterial contamination of the operative field during surgery might involve the shed mediastinal blood, implying a risk of bacterial growth in the shed blood and the reservoir containing it. Previous studies of autologous transfusion of shed mediastinal blood have found a varying degree of bacterial contamination of the blood (3), (16), (17), (19). However, no study has examined the contamination of shed mediastinal blood any later than 6 hours postoperatively. Today, autologous blood transfusion is given for a length of time varying from patient to patient, depending on the amount of postoperative bleeding and it does not seldom exceed 6 hours (23).

The Aim of our work

Was to investigate the safety and value of routinely-using autotransfusion of the mediastinal blood shed during Off-pump coronary artery bypass operations and

whether or not it could reduce the number of patients needing perioperative homologous blood transfusion and consequently reduce the total cost of surgery.

Material and Methods

In a prospective randomized study, 50 IHD patients undergoing elective uncomplicated OPCABG were studied from March 2001 till October 2002 in our center : Kasr El-Ainy French Educational Hospital. All patients were operated upon by the same group of surgeons employing uniform surgical techniques and postoperative care protocols. In all patients of both groups the Off-pump coronary artery bypass graft surgery was performed using the Octopus III cardiac stabilizing system (supplied by Medtronic corp. MN, USA) using the same type of conduits (radial/Internal mammary combination) for total arterial revascularization.

35 patients were men (70%); while 15 were women (30%). Their ages ranged between 38 and 68 years with the mean age of 62.3±3 years.

***Inclusion criteria were:**

Patients, who were carefully-chosen to be equally matching together, had primary isolated IHD (ischemic heart disease). All were scheduled for elective bypass surgery.

Off-pump coronary artery bypass graft surgery (OPCABG) was performed to all of them. Our study group was chosen from those in which surgery ended without serious complications.

***Criteria of exclusion were:**

1- Patients with postoperative bleeding requiring reoperation.

2- Presence of haemodynamic instability requiring more than 12 hours of inotropic support or the use of intraaortic balloon counterpulsation.

3- Patients who had a bleeding time of greater than 10 minutes (by the Ivy method).

4- Patients with significant carotid stenosis.

5- Patients having preoperative left ventricular ejection fraction < 30%.

6- Patients with uncontrolled systemic diseases eg: DM, lung or kidney diseases (eg. serum creatinine > 1.5...etc.)

7- Patients who demonstrated clear ECG changes of MI (Q wave etc..) in postoperative serial electrocardiographic examinations.

All patients of both groups were done by the same team of surgeons using the same operative technique. We used the OPCABG technique during which heparin sodium was given at the dose of 1.5 mg./ Kg Bwt. (to keep the ACT > 350 seconds) a short time after midline sternal splitting. Just before giving heparin, autologous blood was withdrawn from grp I patients as 10 ml/kg body weight and stored in a reservoir bag to be given once heparin had been neutralized with protamine at the end of surgery.

Using the pump suckers, the intra-operatively-shed mediastinal blood was salvaged and collected in a Baxter cardiotomy reservoir with 40 micro filter pores (Baxter Healthcare Corp, Irvine, CA, USA). Heparin neutralization was done by the end of surgery using the appropriately-titrated dose of Protamine sulfate.

At the end of the operation, patients of grp.I had their mediastinal (and if necessary pleural tubes) attached to the inlet port of the Baxter autotransfusion reservoir and then autotransfused exclusively over the first 6 hours as part of our routinely-used protocol

steps. The shed mediastinal blood from the reservoir was then retransfused PO if more than 100 ml. had accumulated in it.

Autologous transfusion was discontinued in the following conditions:

1- After the lapse of the first 8 hours of the first postoperative day.

2- If 3 hours have passed without bleeding (if blood collected was 20 ml or less provided the drainage tubes were confirmed patent.

3- If the blood coagulated in the autotransfusion reservoir.

4- If the patients developed massive haematuria.

The indications for blood transfusion were standardized (when Hgb conc was < 9 grams/dl)., and the physicians ordering blood products were blinded to the study. Postoperative volume therapy was basically performed using the collected blood aided by crystalloid solutions when Hgb values were > 9 grams/dl.

Patients were divided into two equal groups and studied during their ICU and hospital stay. The shed mediastinal blood which was collected either intraoperatively or exclusively during the first 6 hours postoperatively, was directly-reinfused in group I (n=25 patients), whereas in group II (n=25 patients), it was not.

The variables comparatively-studied between the two groups included : the mean amount of shed mediastinal (and pleural) blood lost and re-infused (including the homologous blood needed and transfused with attention at its hazards or complications); blood count (including differential counts for WBCs, and platelets); evaluation of the coagulation system (Clotting Time, Activated clotting time, Prothrombin Time, Partial Thromboplastin Time); coronary enzymes (creatinine kinase with its MB fraction); renal functions; & total costs of surgery.

Statistical Value:

A (P value) of less than 0.05 was considered significant.

Results

None of our patients was reexplored for excessive or uncontrolled bleeding, and all survived till discharge. According to our demographic data analysis and due to our good selection/matching of patients, there was no significant differences between patients of both groups as regards the perioperative parameters of the study (Table no. I).

In table number II., We comparatively-studied the total amount of the shed mediastinal blood (SMB) during the first 6 hours with its Hct level. We also studied the patient -related parameters (eg: Hgb, Hct%, WBCs and platelet counts..etc.), in addition to the amount of homologous blood needed and infused.

Demographics and Preoperative Data of our patients (mentioned in table number I) were equally comparable in the two patient groups as, due to our good patient selection, they showed no difference regarding their demographic characteristics. The age range, male to female ratio, body weight, height, surface area, preoperative Hgb and serum creatinine were matchable in both groups.

Preoperative Salicylates: Few more patients in grp I (12 cases : 48%), took regular preoperative salicylates (aspirin) than those of grp II (10 patients : 40%).

Table I. Demographic and Clinical Data of the Study Groups (mean +- SD).

Characteristic	Grp.I (25 cases)	Grp.II (25 cases)
* Age (range 38-68ys.)	64.3+-3.2	62.1+-2.1
* Body weight (average in Kgms.)	95.1+-2.5	94.8+-1.8
* Height (in cms.)	171.2+-8.4	175.1+-2.3
* Body Surface Area (in Meters 2)	1.95+-0.13	1.91+-0.71
* Male to female ratio	16:2	17:3
* Preoperative Haematocrit (%)	38.2+-2.2	34.8+-1.1
* Number of grafts/patient	2.7+-2	3.2+-1
* Number of IMA arterial grafts/patient	1.05+-0.5	0.98+-0.9
* Operative time (mins)	190+-30.2	180+-24
* patients using aspirin preoperatively	12 (48%)	10 (40%) *
Preoperative serum creatinine (mg/dl)	0.93+-0.04	0.89+-0.06
* Preoperative Haemoglobin (gms./dl)	11.2+-0.9	12.3+-0.1

Surgical technique: The average number and quality of the grafts done as well as the time spent in performing surgery were similar in both grps due to the fact that the same surgical team performed all operations using the same surgical technique. The average number of (LIMA) arterial grafts performed was slightly-more in grp.I None of our patients was reexplored for excessive bleeding, and all patients survived till they were discharged.

Collection & retransfusion of SMB: SMB was collected using pump suckers, its amount , Hct value were calculated, before it was reinfused again in grp I during the first 6 hours postoperatively. Grp I showed more total volume of SMB that collected over the first 6 hours postoperatively (R: 675-1975 with M: 1028 ± 50 ml SD) than Grp II (R: 550-1132 with 600 ± 40 ml SD) with statistical significance (P Value = 0.05). This difference in the hourly and the total calculations of the SMB, during the first 6 hours, indicates that there was a tendency for more mediastinal drainage continuing in group I than grp II for the first 6 hours postoperatively (Table number II).

Homologous blood: The average and the total amounts of homologous blood transfused, which was given according to standardized rules, was also comparatively-studied between the two grps. Only homologous Blood was transfused in both groups, and no patient received any other blood product.

There was more need for homologous blood transfusion in grp II (7 patients : 28%) Vs. grp I. (only 2 patients : 8%), (P value 0.005). The transfused blood units were averagely more in grp II (2.5 ± 0.9), than in grp I (0.9 ± 0.6) (P value 0.004) (Table number II).

The complications (side effects) of homologous blood transfusion were found more frequent in grp II (3 patients ie 12%) Vs. grp I (1 patient ie 4%) (P value 0.005).

Patient's Haematologic Variables: The range of values and mean value of the the patient's Hgb by the end of surgery were

Table (II): Balance of the Mediastinal Blood Shed, homologous blood given, and the related parameters.

Parameters	Value	Grp I. (25 cases)	GrpII. (25 cases)	P Value
*Amount of SMB in first 6 PO hrs:	(R in ml) (M in ml +- SD)	675 – 1975 1028 +- 50	550 – 1132 600 +- 40	0.05 0.05
* Hct of SMB in 1st. 6 hrs.:	(M in gms.% +- SD)	9.0 +- 0.8	8.9 +- 0.9	-
* Pt's Hgb at end of surgery:	(R in gms/dl) (M in gms/dl+- SD)	8.7 - 10.1 9.1 +- 0.8	9.7 - 11.9 10.8 +- 0.4	0.05 0.04
* Pt's Hgb in ICU after 6 hrs:	(R in gms /dl) (M in gms/dl +- SD)	10.5 – 11.6 10.9 +- 0.2	10.8 – 11.3 10.2 +- 0.9	NS NS
* Pt's Hct at end of surgery:	(R %) (M % +- SD)	18.2 - 23.8 22.2 +- 1.1	25.4 - 39.5 35.3 +- 2.3	0.05 0.04
* Pt's Hct in ICU after 6 hrs:	(R %) (M % +- SD)	30.3 - 35.5 33.3 +- 1.1	32.2 - 34.9 32.7 +- 1.5	NS NS
* No. of patients with homologous Bl. Tr.		2 (8%)	7 (28%)	0.005
* Average units of blood transfused		0.9 +- 0.6	2.5 +- 0.9	0.004
* Side effects of homologous blood transfusion		1(4%)	3 (12%)	0.003
* Febrile Episodes (temp > 38 °C) within 6 PO hrs.		2 (8%)	4 (16%)	0.05
* WBCs count during 6 hrs PO (M × 1000 +- SD)		9.5 +- 0.6	8.7 +- 0.9	NS
* PNLs Diff (Band / Segmtd ratio) after the first 6 hrs postoperatively	(% +- SD)	37% +- 1.6	21% +- 1.6	<0.005

SMB: shed mediastinal blood. PO: postoperative. Hct: haematocrit. Hgb: haemoglobin. M: mean. R: range. gms: grams /dl: per deciliter (100ml) SD: standard error /deviation. Pt's: patient's. Surg: surgery. No.: number. Bl.: blood. Tr.: transfusion. WBCs: white blood cells. NS: non-significant. PNLs: polymorphonuclear leucocytes. Diff: differential. Band: immature neutrophils. Segmtd: segmented mature neutrophils Temp: temperature. ° C: Celsius.

found higher in grp II (9.7- 11.9 & 10.8 ± 0.4); than in grp I (8.7-10.1 & 9.1 ± 0.8). Consequently, the patient's Hct values just at entering the ICU were lower in grp I (18.2-23.8 & 22.2 ± 1.1); than in grp II (25.4-39.5 & 35.3 ± 2.3). These relatively-lower Hgb and Hct values in grp I may be due to the blood withdrawal (10 ml/Kg) at the beginning of surgery and the continued removal of blood (by the pump suckers) being only replaced in both grps by crystalloid fluids hence leading to more haemodilution of grp I patients.

The range of values (as well as the mean value) of the patient's Hgb (and Hct) after the lapse of 6 hours postoperatively showed near values (after achieving proper replacement / dehydration of the patients' blood) in the two groups and hence no

Table (III): The Coagulation Variables were compared between both groups (in mean +-SD) for the first 6 postoperative hours.

Variable	grp I (mean +-SD)	grp II	P Value
• M Clotting time (mins.)	5.8 +-2.1	5.0 +-1.3	NS
• M Prothrombin time (s)	40.7 +- 4.5	30.4 +- 2.2	0.05
• M Partial thromboplastin time (s)	48.1+- 2.5	35.1 +- 2.3	0.05
• M Platelet count (× 10.000 = /HPF)	50	55	NS

M: mean value for the 1st. 6 hours postoperatively +- standard error or deviation. /HPF: per high power field.

Table (IV): Biochemical & Renal functions are demonstrated.

Variable		grp I	grp II	P Value
*** LDH (normal value 300 - 600 U/L)**				
- at end of surg	(Mean +- SD)	640 +- 10.3	632 +- 3.2	NS
- 6 hours later	(Mean +- SD)	750 +- 4.5	450 +- 2.2	0.05
- 1 week later	(Mean +- SD)	580 +- 3.3	450 +- 2.9	NS
*** CPK (normal value 33 – 194 U/L)**				
- at end of surg	(Mean +- SD)	350 +-15.6	290 +- 50.2	NS
- 6 hours later	(Mean +- SD)	550 +- 48.3	352 +- 24.1	0.04
- 1 week later	(Mean +- SD)	150 +- 6.9	135 +- 11.3	NS
*** CPK-MB (normal value < 2.5 U)**				
- at end of surg	(Mean +- SD)	18.2 +- 0.3	16.6 +- 0.5	NS
- 6 hours later	(Mean +- SD)	180 +- 6.7	93 +- 3.2	0.05
- 1 week later	(Mean +- SD)	8 +- 3.5	5 +- 2.2	NS
*** Plasma free haemoglobin (normally < 5 mg / dl)**				
- at end of surg	(Mean +- SD)	8.62 +- 1.7	6.58 +- 2 .2	NS
- 6 hours later	(Mean +- SD)	9.5 +- 2.1	6.0 +- 0.8	0.04
- 1 week later	(Mean +- SD)	4 +- 1.1	3.8 +- 0.6	NS
*** Serum creatinine (normal values 0.5 – 1.5 mg.)**				
- at end of surg	(Mean +- SD)	0.7 +- 0.2	0.5 +- 0.4	NS
- 6 hours later	(Mean +- SD)	1.0 +- 0.4	0.8 +- 0.5	NS
- 1 week later	(Mean +- SD)	0.9 +- 0.4	0.7 +- 0.3	NS

statistical significance could be obtained (Table number II).

Febrile episodes (defined as body temperature > 38 °C during the first 6 hrs postoperatively), consequently occurred more in grp II (4 patients : 10%) than in grp I (2 patients : 8%) (P value : 0.05). This finding indicate that although the infusion of un-washed SMB is associated with a moderately-elevated body temperature within 6 hours, yet the infusion of homologous blood (with its known side effects) is not immune against causing a similar and even an exaggerated effect (Table number II).

as well as postoperative autotransfusion of chest tube drainage for salvaging red blood cells (25), (26). However other components of haemostasis are lost. The technique of predonation of autologous platelet-rich plasma before cardiac operations has reduced chest tube blood loss postoperatively (27), (28).

However, this has not clearly-proven beneficial in reducing the homologous blood product requirements postoperatively.

The technique of intraoperative autotransfusion of whole blood is simple but has not been universally used by cardiac surgeons. Studies have not clearly-shown any incremental benefit of this technique when used in combination with other blood conservation techniques (5), (6). In our work , we used a combination of techniques as we employed concomitant withdrawal of blood as 10 ml/kg BW from grp I patients in order to salvage more platelet number and functions prior to surgery. Our criterion for homologous blood transfusion was serum Hgb < 9 grams /dl at any time during ICU or hospital stay.

The longevity of RBCs in the SMB: In 1996 Schmidt et al (33), stated that During CPB the red blood cells are damaged, with an increase of plasma free Hgb at its end. During salvage, SMB has been in contact with various tissue types and exposed to suction, which might damage the blood cells. Several trials (3), (17), (19), have shown that the concentration of free Hgb is elevated in SMB. Activation of the complement system, which occurs during autotransfusion, may also induce RBCs damage. However in an earlier study (35), Schmidt et al., demonstrated that the membrane stability of RBCs (Normal Osmotic Fragility) collected by a hardshell cardiotomy reservoir is comparable with that of circulating RBCs after CABG and better than that of stored RBCs. This indicates that RBCs saved from SMB may not be damaged furtherly during salvage.

The same group of workers stated in another series (35) that as regards the survival of RBCs of SMB, there was no significant difference between the 24-hour survival of SM RBCs and circulating RBCs. Their estimated mean cell life span was 20.5 days (range 11.6 to 29.0 days) for SMB RBCs and 22.7 days (range 14.4 to 36.2 days) for circulating RBCs.

Kent and associates (36), reached a similar conclusion. Finally these two groups of workers declared that the survival of RBCs from SMB after autotransfusion is comparable with the survival of RBCs in the patient's circulating blood.

We agree with their results as we noticed no marked decrease in our patients' haemoglobin ratios (which were being checked at regular intervals for the first month postoperatively). Moreover, we also noticed the return of the values for plasma free Hgb (were increased after 6 hours postoperatively) to their normal range within one week from surgery hence adding more confirmation to their results (tables II, and IV).

Concomitant anticoagulation therapy: Previous studies have excluded patients receiving aspirin therapy or heparin therapy, or patients requiring urgent operations (6), (7). In their studies, (25),(26), 62% and 55% (respectively), were receiving heparin therapy before operation, and 42% and 38% (respectively), were taking aspirin up to the time of operation. An elevated activated clotting time and partial thromboplastin time preoperatively confirm that many patients were partially-anticoagulated on arrival to the operating room.

We also had this experience in our patient groups as 12 patients (48% of grp I cases), Vs. 10 patients (40% of grp II cases) took aspirin on a regular basis preoperatively but owing to the evaluation of their clinical condition, we believed that they must, despite that, be submitted for surgery. This medical treatment with aspirin (with its known anti-platelet properties) did not markedly-affect the perioperative haemostasis as evidenced by the slightly-affected ranges of the platelet count and functions (clotting time and platelet counts in table number IV).

The need for homologous (banked) blood & criteria for transfusion: Randomized, prospective investigations of the benefit of autotransfusion of shed mediastinal blood have yielded conflicting results (14).

Three studies (14), (15), (16), showed a decreased requirement of banked blood transfusion and advocated that the method be used routinely in cardiac operations.

Only one of these randomized studies (16), reported a reduction in the number of patients receiving blood transfusions, ie, from 92% in the control grp. To 75% in the autotransfusion grp.

In one study (16), there was no fixed criteria for blood transfusion, and the average blood requirement in the autotransfusion grp. was 2.7 units.

In the other two randomized studies (14), (15), autotransfusion did not reduce the number of patients needing homologous blood transfusion.

On the other hand, five different randomized studies (17), (18), (19), (20), (21), argued and stated that autotransfusion did not decrease the need for homologous blood transfusion. In contrast to them, our study results (table II) agrees with the results reached by (14), (15), (16), (25), (23), (30), and (33) in that autotransfusion did not only decrease the number of patients needing homologous blood transfusion but also caused a marked decrease in the amount of the whole units of blood actually transfused. This was demonstrated by the increased need for Homologous blood and the average number of the units given (table number II).

In 1996, Schmidt et al, (33) performed their study which was among the first prospective randomized studies using clearly defined criteria for transfusion and volume replacement demonstrating the value of autotransfusing the SMB. They succeeded to reinfuse 95% of the SMB which resulted in a 50% reduction in the risk of exposure to homologous blood. In their previous work (35), they stated that by reinfusing the SMB after elective CABG operations, the number of patients needing homologous blood transfusion could be reduced from 54% to 28%.

In 1987, Schaff and associates (3), were able to transfuse only 50% of the SMB and their criterion for transfusion was a hematocrit of less than 35% (haemoglobin concentration less than 7.3 mmol/l).

Eng and co-workers (15), transfused only 40% of SMB and their used criterion for transfusion was a hemoglobin concentration < 5.0 mmol/l during ICU stay or < 5.5 mmol/l during hospital stay.

Our criterion for blood transfusion was Hgb < 9 grams /dl during ICU or hospital stay.

In our study, we succeeded to reinfuse 96% of the collected SMB. According to

our results we detected a 32% decrease in the amount of chest tube drainage at 10 and 14 hours postoperatively; a 44% decrease in the average amount of homologous blood given; and a 45% decrease in the risks (complications) in the autotransfusion group (I). This matches with the previously-mentioned results reported by (3), (14), (15), (16), (23), (25), (30), (33) & (35).

Only one randomized study by Lepore et al in 1989, involving 130 patients (16), has previously shown a reduction in the number of patients receiving homologous blood transfusion (from 95% in the control group to 75% in the autotransfusion group). No fixed criteria for transfusion and no information about haemoglobin or haematocrit values before, during, or after autotransfusion were reported. The period of transfusion was (like ours) 6 hours after which autotransfusion was halted. The average homologous blood requirement per patient was (close to our results) 2.7 units being more (3.3 units) in the control group. Three main reasons could explain the difference between our results and those reached by Lepore et al (16) as regards the number of patients needing autotransfusion : the smaller number of our patient groups, their higher or no fixed criteria for transfusion, and our transfusion of even smaller proportions of the SMB.

We believe that due to the strict respect to our transfusion protocol, our patients were at distinctly less risk for homologous blood transfusion.

Complications of homologous blood transfusion: We detected that the complications (side effects) of homologous blood transfusion were more frequent in grp II (3 patients ie 12%) Vs. grp I (1 patient ie 4%) (P value 0.005) Our results agrees with the results reached by (3), (15), (16), (19), (30), (33), & (35). Due to the lesser amounts of homologous blood needed and used, a considerable decrease in the complications of blood transfusion was noticed in grp I. These complications were found to be milder and easier to be dealt with than in grp II.

The potential for Bacterial Contamination Of SMB: The differential count (band / segmented ratio) was obviously-higher with clear statistical significance in grp I compared with grp II during the first 6 postoperative hours (37% ± 1.6 Vs. 21% ± 1.6). This reflects a significant shift towards the production of more immature neutrophil forms (bands) and away from the production of mature (segmented) forms in grp I but not in grp II as a result of the infused SMB (Table number II). There was no other remarkable differences in the haematologic variables found between the two experimental groups at the final sampling time done during our patient follow up one week later.

We considered these findings to be of academic interest only as they exerted no harmeful clinical impact on our patients.

In their 70-case series, Andreasen et al (23), performed a bacteriological work to study (using serial multiple bacterial cultures of different spectra) the concept of utilizing SMB continuously later than 6 hours in the postoperative period. They found no significant difference in the infection variables between patients with or without bacterial growth in the multiply-taken cultures and none of their patients suffered from early postoperative infectious complications. They, among others, (3), (16), (33), came to the clear conclusion that there is no fear of further contamination of the shed blood during the period between initiating the autologous transfusion and the following morning.

Febrile episodes (defined as body temperature > 38 °C during first 6 hrs postoperatively): Consequently occurred more in grp II (4 patients : 10%) than in grp I (2 patients : 8%) (P value : 0.05). This finding indicate that although the infusion of un-washed SMB is known to be associated (as an inflammatory response) with a moderate degree of elevated body temperature within the early 6 postoperative hours, yet the infusion of homologous blood (with its known side effects) is not immune against causing a similar or occasionally an exaggerated effect (Table number II).

Autotransfusion of SMB and blood coagulation variables:

In 1996, Vertrees et al, (32), stated that after several years of routinely infusing unwashed SMB in their clinical practice, they gradually gained the impression that patients who seemed to have good haemostasis early after operation sometimes began bleeding and acquired a coagulopathy after the first 2-3 hours of infusion of the SMB. They added that a number of other recent studies,

Other authors (23), (30), (32), (34), state that this increased coagulation time is a consequence of returning the SMB to the patient causing an elevation in the amount of FSP (fibrinogen split products) and circulating D-dimmers.

Earlier studies did not find evidence of any coagulopathy caused by the reinfusion of unaltered SMB (35), (37). This increased coagulation time was formerly thought to be due to the high levels of SMB infused but not consistent with increased fibrinolytic activity, caused by triggering the intrinsic complement system.

In their study (32), Vertrees et al, using Thromboelastogram (which is considered one of the most sensitive methods for detecting functionally-important derangements in the coagulation mechanism), showed clear evidence of a delayed onset of clot formation and decreased clot strength in the grp reinfused with SMB. However, due to the inadequacy of the time spent in following up the ongoing clot characteristics (which is at least 60 minutes), the resultant fibrinolysis could not be reliably detected or understood. Eventually, most of the investigators agreed to consider that multifactorial issues may participate altogether to account for these coagulation changes. Different factors (other than FSPs and D-dimers), are those due to the haemodilutional effect after CPB, and the persistent heparin effect.

In the work that we report herewith we (among others) are convinced to attribute the mild degree of coagulopathy (the prolongation in the coagulation time) seen in our SMB-reinfused cases to the theory of multiple aetiologies. We hence are convinced, reasonably, of the true worth of all the efforts that should be paid in order to alleviate or prevent them. Our routinely-followed protocol entails the use of the Off-pump CABG which causes less derangement of the coagulation system. Moreover, it does not lead to any considerable activation of the intrinsic body complement system that is responsible of releasing the FSP and D-dimers and hence we believe that their release is sluggish or even not present. The harmful effect of using heparin is, moreover, ameliorated as we use half the regular dose needed in conventional CABG with the CPB circuit. The final overall result or the net force is , in

our opinion, in favor of the safety of using SMB.

Influence of Autotransfusing SMB on serum specific cardiac enzymes:

In our study, samples of blood taken after 6 hours from surgery demonstrated, with statistical significance, a clear elevation of specific enzymes (LDH, CK, CK-isoenzyme MB fraction, and the plasma free Hgb) after reinfusion of the SMB in grp I compared with grp II.

Local and systemic sources of CK, CK-MB, and LDH, include myocardium at the atrial cannulation site, myocardial dissection to locate intramural coronary arteries, and their release from other tissues such as stomach, small intestine, lung, colon and liver secondary to noncardiac-related tissue injury from inadequate tissue perfusion or systemic inflammatory response after CPB. Systemic subclinical haemolysis due to mechanical trauma to erythrocytes during CPB would further contribute to the elevation of LDH activity. In cases of ASD, mitral valve replacement, and CABG patients having transmural postoperative myocardial infarction (MI), the greatest elevation of these values is usually present. Using calculations from mass determination, the elevated CK and CK-MB activity noted in the post-CABG period therefore reflected truely the levels of enzymes released from tissues and not due to the effect of blood haemolysis (33), (34).

In 1996, Nguyen et al., (34) demonstrated in their work that infusion of shed mediastinal blood alone or in association with IMA dissection (in which case there is more effect) resulted (with high statistical significance) in the greatest elevation of serum free Hgb, LDH and CK (and its MB isoenzyme fraction) values between 12 and 24 hours after operation. These figures remained elevated at 48 hours postoperatively and gradually-tapered afterwards. They attributed this finding to the high degree of haemolysis (due to the roller pump, and the suction devices of the CPB) present in the SMB. However, no patient, in our study, had a level of the CK-MB > than 55 or clinical findings (including ECG) consistent with perioperative myocardial infarction.

These data indicate well that unwashed SMB contains elevated levels of serum enzymes and plasma free haemoglobin and that on infusion, this results in elevated circulating blood levels. Our use of the Off-pump technique markedly helped to assist in controlling the values of these enzymes. This was confirmed by the fact that they seldom reached higher than 55 units, and the gradual tapering they showed (till normal ranges) during hospital stay few weeks from surgery. (Table number IV).

Cost-effectiveness analysis: In 1996, Kochamba et al (26), stated that the goal of transfusion-free cardiac operations meets patients' expectations and is cost effective in times of healthcare cost containment. The direct cost for processing a unit of packed red blood cells at their institution is $ 97. In contrast, the cost of the tubing and blood bag used for intraoperative autotransfusion is less than $ 10 per patient.

In 1998, Kilgore and Pacifico reported that their 834 patients-study found a 54% reduction in transfusion risk or a mean reduction of a 1.41 allogenic units per case (95% confidence interval, 1.04 to 1.79 units). This process saved between $49 and $62 per case. They concluded that the use of autologous blood has the potential to significantly reduce the costs and risks associated with transfusing allogenic blood after cardiac operations. In line with their

results, we found a mean reduction of 18% in the expenses of the average surgical intervention done in the autotransfusion grp. Of our patients.

Conclusion

Our study demonstrated that intraoperative and early postoperative autotransfusion is an effective method when done with Off-pump technique for CABG in combination with a standardized blood conservation protocol.

When practiced rightly, this simple and cost-effective technique is safe and reduces the patient's exposure to possible complications of homologous blood transfusion.

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TRUSLER REPAIR IN PATIENTS WITH VSD & AORTIC REGURGITATION

ABSTRACT

Thirty patients with VSD & AI have been operated upon between January 1995 & December 2001 utilizing the technique of Trusler repair in the NATIONAL HEART INSTITUTE, the patients were classified into 3 groups according to the technique & the approach for the VSD closure & the aortic repair. Group 1 (10 patients): The repair has been accomplished through the RV& the AO. Group 2 (10 patients): The repair has been accomplished through the RA& the AO. Group 3 (10 patients): The repair has been accomplished through the AO only. The 3 groups were compared as regard the incidence of aortic regurgitation, of a residual VSD & of heart block. In group 1 only 2 patients had mild AI, one patient had insignificant residual shunt & 2 patients had partial heart block. In group 2, 4 patients had mild AI, 1 patient had moderate AI & 1 patient had severe AI. Three patients had insignificant residual VSD & 2 patients had significant residual VSD. Two patients had partial heart block. In group 3, 2 patients had mild AI, 3 patient had moderate AI & 1 patient had severe AI. Three patients had insignificant residual VSD & 3 patients had significant residual VSD. Three patients had partial heart block & 3 patients had complete heart block. Trusler repair through the AO & the RV seems to be ideal as regard the incidence of heart block, of a residual VSD & of AI.

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INTRODUCTION

VSD with AI syndrome include hearts in which the AI is of congenital origin due to cusp prolapse or a bicuspid aortic valve.

Initial description of this syndrome is attributed to Laubry & Pezzi's publication in 1921(1).

Conoventricular VSDs are the most prevalent among patients with VSD & AI (2 & 3) Juxtaaortic & Juxtaarterial are less common (3).

The right cusp has prolapsed in most of the cases, the non-coronary in 10% of cases (4). The mechanism of cusp prolapse may result from lack of support of the aortic sinus of Valsalva & annulus by the infundibular septum (5 & 6).

Clinically the signs of VSD dominate when the AI is mild, but as the AI the shunt Such patients has a to & fro murmer simulating PDA.

Technique of operation:

When the AI is severe or moderate the aortic valve is repaired (7), the aortic valve must usually be replaced in adults.

Assistant Professor of cardiac surgery in the National Heart Institute.

In this study repair has been accomplished by Trusler's method of placation (8).

The patients were classified into 3 groups according to the technique & the approach for the VSD closure & the aortic repair.

Group I (10 patients): The repair has been accomplished through the RV & the AO Group 2 (10 patients): The repair has been accomplished through the RA & the AO Group 3 (10 patients): The repair has been accomplished through the AO only.

The aorta is opened by a transverse incision & a Frater stitch of 5-0 polypropylene is placed through the midpoint of each cusp, thus dividing each cusp into two halves. Traction on this stitch allows identification of redundant or elongated free edges of half of a cusp

If one half of the right cusp is the one prolapsed, the redundant portion of this half is folded upon the aortic wall so that the remaining portion of this half becomes stretched & of similar length as the other half of the same cusp & other cusps.

In group 1 patients, the RV is opened by a longitudinal incision below the AO (not below the PA as in F_4)

Usually the VSD is shown with the prolapsed cusp seen through it, we prefer to hold the cusp with a non-toothed forceps pushing it through the aorta to identify it through the aortotomy,thus we can judge with certainty which cusp is prolapsing.

We finish the Trusler repair first, then we close the aortotomy & through the ventriculotomy we can evaluate the aortic repair by injecting of cardioplegic solution into the aortic root & we visualize the cusps of the aortic valve through the VSD, this is the main advantage of the RV approach.

The VSD is repaired with a Dacron patch & the ventriculotomy incision is closed directly.

In group 2 patients, the aorta is opened & Trusler repair is completed, the right atrium is opened & the VSD is repaired but identification of the prolapsed cusp or evaluation of the AV after repair is not feasible, avoiding of the bundle is optimum when we work from the RA.

In group 3 patients, only the aorta is opened, both the aortic repair & the closure of the VSD is accomplished through the aorta, identification of the prolapsed cusp or evaluation of the AV after repair is not feasible, avoiding of the bundle is not safe when we work from the aorta, usually we put the sutures of the aortic border of the VSD in the base of the right aortic cusp (right sinus of Valsalva), but the sutures for the crest of the VSD is unfortunately made on the left ventricular side of the ventricular septum.

Material & Methods

Thirty patients with VSD & AI have been operated upon between January 1995 & December 2001 utilizing the technique of Trusler repair in the NATIONAL HEART INSTITUTE, the patients were classified into 3 groups according to the technique & the approach for the VSD closure & the aortic repair.

Table 1

Age(years)	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
1-2	2	3	2
3-4	3	3	4
5-7	4	3	2
8-10	1	1	2
Mean 5			

Table 2

Weight (kg)	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
10-13	3	2	3
14-16	2	3	3
17-20	3	2	2
> 20	2	3	2
Mean 16.5			

Table 3

Sex	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
Male	4	5	6
Female	6	5	4

Table 4

Degree of AI(pre-operative)	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
Mild	-	-	-
Moderate	2	3	3
Moderate to severe	5	3	4
Severe	3	4	3

Group 1 (10 patients): The repair has been accomplished through the RV& the AO.

Group 2 (10 patients): The repair has been accomplished through the RA& the AO.

Group 3 (10 patients): The repair has been accomplished through the AO only.

The 3 groups were compared as regard the incidence of aortic regurgitation, of a residual VSD & of heart block.

Tables 1, 2 & 3 show the age, the weight & the sex distribution & tables 4 & 5 show the degree of AI & the type of the VSDS.

The degree of AI is evaluated by echo-cardiography.

Mild AI (color jet is limited to LVOT), Moderate AI (color jet extends to tip of ant. Mitral leaflet) & severe AI (color jet extends to apex of LV apex)

Results

Mortality:

No single mortality.

Morbidity:

Table 6, 7 & 8 show a comparison of the 3 groups as regard the incidence & the degree of AI, residual VSD & Heart block.

Table (5):

Type of VSD	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
Cono-ventricul.	5	4	4
Cono-ventricul.sub-arterial.	2	3	4
Sub-arterial.	3	3	2

Table (6):

Post-operative AI	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
No AI	8	4	4
Mild AI	2	4	2
Moderate AI	-	1	3
Severe AI	-	1	1

Table (7):

Residual VSD	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
No residual VSD	9	5	4
Insignificant residual VSD PG>90 mmHg	1	3	3
Significant residual VSD PG<70 mmHg		2	3

Table (8):

Heart block	N° of patients (group 1)	N° of patients (group 2)	N° of patients (group 3)
No heart block	8	8	4
Partial heart block	2	2	3
Complete heart block			3

Mild AI (color jet is limited to LVOT), Moderate AI (color jet extends to tip of ant. Mitral leaflet) & severe AI (color jet extends to apex of LV apex)

Re-operation for aortic valve replacement is needed for the 2 patients with severe AI in group 2 & 3.

Discussion

Thirty patients with VSD & AI have been operated upon between January 1995 & December 2001 utilizing the technique of Trusler repair, the patients were classified into 3 groups according to the technique & the approach for the VSD closure & the aortic repair. Group I (10 patients): The

repair has been accomplished through the RV& the AO Group 2 (10 patients): The repair has been accomplished through the RA& the AO Group 3 (10 patients): The repair has been accomplished through the AO only.

From table 1, 2 & 3 we can see that there is no significant difference between the three groups as regard the age, the sex & the weight distribution.

Also there is no significant difference between the three groups as regard the degree of AI pre-operatively.

Also the position of the VSD is more or less the same in the three groups.

We can see that in group 1 only 2 patients have mild AI, one patient has insignificant residual shunt & 2 patients have partial heart block.

In group 2, 4 patients have mild AI, 1 patient has moderate AI & 1 patient has severe AI.

Three patients have insignificant residual VSD & 2 patients have significant residual VSD.

Two patients have partial heart block.

In group 3, 2 patients have mild AI, 3 patient have moderate AI & 1 patient has severe AI. Three patients have insignificant residual VSD & 3 patients have significant residual VSD. Three patients have partial heart block & 3 patients have complete heart block.

So in group I (RV & aortic approach) avoidance of AI is ideal, because we repair the aortic valve first, then we inject cardioplegic solution into the aortic root then we look to the aortic valve through the RV incision.

Also, avoidance of heart block is optimum from the RV approach & closure of the VSD from the RV is very accessible

In group 2 patients (RA & aortic approach) avoidance of AI is less optimum than in group 1, so 4 patients have mild AI, 1 patient has moderate AI & 1 patient has severe AI. Also closure of the VSD is sometime more difficult than the RV approach, as in the syndrome of VSD & AI the VSD usually has a sub-aortic or even a sub- arterial extension which is easily attacked from the RV. So 3 patients have insignificant residual VSD & 2 patients have significant residual VSD.

Avoidance of heart block is ideal from the RA (only 2 patients have partial heart block).

In group 3 patients (Aortic approach only) avoidance of AI is less optimum, so 2 patients have mild AI, 3 patient have moderate AI & 1 patient has severe AI.

Also closure of the VSD is sometime more difficult than the RV approach as in many cases the VSD has a peri-membranous extension which is easily attacked from the RA or the RV. So 3 patients have insignificant residual VSD & 3 patients have significant residual VSD. Avoidance of heart block is difficult with the Aortic approach as the sutures of the VSD are usually made on the left ventricular side of the septum. So 3 patients have partial heart block & 3 patients have complete heart block.

Conclusion

Trusler repair through the AO & the RV seems to be ideal as regard avoidance of heart block, of a residual VSD & of AI.

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OFF-PUMP REDO CORONARY ARTERY BYPASS GRAFTING: INITIAL EXPERIENCE AND EARLY RESULTS IN TWENTY PATIENTS

ABSTRACT

Background: Recent work reviews report that conventional redo coronary artery bypass grafting is closely associated with a significant degree of morbidity. The danger of redo surgery lies mainly in the process of sternal bone re-opening; in cardiac manipulation with the intact old grafts. An ideal technique must include a patient-specific approach in every case selected for surgery.

Patients and Methods: 20 patients were studied from March 2001 till October 2002 in Kasr El-Ainy French Educational Hospital. 18 patients were men while 2 only were women. Mean age was 62.3+-3 years. Mean preoperative LVEF was 38+-4.4%. All of them were submitted for redo surgery for coronary artery bypass grafting via routine median sternotomy, left anterior mini-thoracotomy (MIDCAB), or a left posterolateral thoracotomy. In all of them ,except one, the technique of open heart surgery (with cardiopulmonary bypass) was not used.

Isolated LIMA (left internal mammary artery) to LAD (left anterior descending coronary artery) was performed in six cases; in 9 cases two grafts were performed; in another three cases triple grafting was done; and finally in two cases, 4 grafts were reconstructed. In fourteen cases (of the two-grafts and the three-grafts sub-group), the LIMA-to-LAD graft (which was stenosed at its implantation site) was cut, furtherly-freed and then reimplanted again more distally. In two cases (within the same groups) a LIMA graft was removed and a new radial artery graft was reanasomosed to the LAD. In 2 cases (from the three-grafts group), as LAD was found non-graftable, the LIMA graft was implanted over the Ramus intermedius branch of the LCA. In all cases, a good distal run-off was present in the preop. Angiocath.

Results: We had one mortality (5%) from postoperative severe anaphylactic reaction due to unknown drug reaction. None of our patients sustained postoperative myocardial infarction. In two patients reexploration was needed (in the immediate postoperative day) to control troublesome bleeding and did quite well afterwards. In three patients the average of 3 units of fresh whole blood transfusion was surpassed and given during the first 24 hours postoperatively. In seven cases, only homologous blood (prepared and properly-refrigerated before surgery) was given postoperatively. In five cases (those who could be convinced to do so), a check cardiac angiocath.was performed and all were found to have patent and well-functioning redo grafts for an average of 6.3 ± 2.2 months postoperatively. Postoperative LVEF rose to a mean of 55.2 ± 2.2%. Ten other patients were investigated via Thallium screening and they also showed redo graft patency. ICU stay time was in average 20.4 ± 2 hours while hospital stay time was 6.2 ± 1.2 days. In all our survived patients (19), a marked improvement was reported in their cardiac capacity and the style of life with no remarks of new attacks of anginal pain.

Conclusion: In our group of well-selected cases, we could achieve redo coronary artery bypass graft surgery safely (with soundly-good postoperative graft patency) in the vast

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majority of patients without the need of cardiopulmonary bypass. As our perioperative mortality and morbidity results were found encouragingly-good, we urge others to employ this surgical modality to draw firmer conclusions.

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INTRODUCTION

With now over 20 years of experience available for study, it is clear that coronary bypass surgery provides relief from the symptoms of coronary artery disease and, for some subgroup of patients, prolongs their life expectancy (1) & (2).

Patients often survive for a long time after primary bypass grafting, and, therefore there are a large number of patients who have had CABG surgery that eventually present, for many reasons, with recurrent ischemic syndromes (or graft restenosis) that necessitate redo CABG operations (3) & (4).

The reoperation (redo surgery) procedures are usually accompanied with a considerable degree of technical difficulties that are both evident as well as different from the primary surgery done before. These alleged difficulties come from many incriminated factors eg: difficulties of exposure (reentry), danger of cardiac and or graft injury during dissection, the availability of new grafts (conduits), management of the intact or still-functioning conduits (especially vein grafts), proper intraoperative myocardial muscle protection , handling of blood loss and the associated use of blood and its products. (17)

With the noticed increase that occurred in in the overall experience of reoperation for CABG, alternative strategies have evolved in an attempt to lower the increased margin of operative dangers or risks that exceed those reported with the initial revascularization. (18)

These strategies include different techniques for reentry, strict avoidance of old grafts over-manipulation to minimize the risk of atherosclerosis/embolism, and modification in the techniques of intraoperative myocardial protection depending on the condition of the native coronary circulation and patency of vein or internal mammary artery (IMA) grafts. (19)

We used the Off-Pump technique in all (except one case) of our well-selected group of patients. In our opinion, this served as an alternative solution for myocardial protection to nullify (or obviate) the inherent risks of Cardiopulmonary Bypass (CPB). Herewith we review our initial experience of redo CABG using the Off-pump technique without CPB.

Patients and Methods

From March 2001 till October 2002, twenty patients were carefully-selected and operated upon in the French New Educational Hospital of Kasr El Ainy Faculty of Medicine. All patients underwent a "first" or "previous" CABG operation before our surgical intervention was done. Our inclusion criteria were: the presence of

unstable anginal pain (12 patient), or chronic anginal pain which is refractory to maximum regular medical therapy (8 cases). Cardiac angiocath was performed in all cases after the first surgery (before our redo surgery) in accordance with residual symptoms. As we discovered the neo-stenotic lesions, the decision for another surgery was dictated.

Our study group consisted of 18 men and only 2 women with the mean age of 62.3+-3 years. In 3 patients, old myocardial infarction was present before the first surgery while congestive heart failure was present in another 4 cases by the time of surgery. Their mean LVEF (left ventricular ejection fraction) as calculated by echocardiography was 38 ± 4.4%. table number (1).

The preoperative risk factors (before our surgery) are illustrated in table number (2).

The target vessels were: a single vessel (LAD) in 6 cases; two vessels in 9 cases; three vessels in 3 cases; and finally four vessels in 2 cases ..table number (3).

Description of technique:

In table number (4), we illustrated the general strategies and approaches that we used in our redo surgeries. We applied the classic (or traditional) median sternotomy route as well as others like left anterior mini thoracotomy (MIDCAB), and left posterolateral thoracotomy.

*** Redo via Median re-sternotomy:**

In patients re-operated upon through a median re-sternotomy, our standard technique(s) were used for sternal reentry eg: inguinal sterilization and separate draping (for emergency cannulation), oscillating sternal saw, sternal uplift during wire - cutting, step - by - step - sternal reopening..etc.

Proper conduit(s) were harvested and prepared (by our second surgical team) after careful dissection (lysis) of adhesions in cases where a LIMA graft was needed. Generally in our redo cases, we prefer using the radial artery in the LAD vessel if it was not consumed before. In cases in which LIMAs were decided for use, we used 1.5 mg/kg. Body weight of heparin for systemic heparinization just before finishing its recruitment.

During grafting the LAD vessel, folded gauze pads were put behind the heart to obtain proper exposure and to aid in its stabilization. Mild hypotension may occur in response to that and is usually corrected easily (using volume or vasopressor drugs such as Ephedrine or Noradrenaline) when its possibility for occurance is borne in mind. Segmental stabilization of the myocardium adjoining the target area was achieved in our cases using the Medtronic (type III) Octopus tissue stabilizer (Medtronics Inc., Mineapolis MN).

***MIDCAB via Anterolateral thoracotomy (6 cases, 30%):**

On the other hand, in patients who had patent graft or ungraftable distal targets in the circumflex or the PDA territory, the intact LIMA (not used in the previous primary surgery) was utilized to bypass LAD using the MIDCAB technique (minimally invasive direct coronary artery bypass surgery) if proper exposure was well-anticipated. An incision (through the 4-5th. intercostal space) was fashioned starting few centimeters just lateral sternal border on the left side. After that the pleural cavity was entered and the lung packed out of the field.

Neither the costal cartilages nor the ribs were resected.

A specially-chosen two small thoracic retractors and a cardiac muscle stabilizer (Cardiothoracic Systems, Inc., Cupertino, CA) were utilized, following which the pericardium was identified, incised (or dissected), and the LAD located.

In a redo MIDCAB, it is sometimes easier to identify the LAD due to the guidance of the previously-used vein graft. Following that, an adequate length of LIMA is dissected and carefully-recruited after systemic heparinization using 1.5 mg. Heparin/Kg body weight is given.

In one patients, LAD was found non-graftable and hence LIMA (after being dissected to an appropriate length) was anastomosed to the ramus intermedius branch.

In another 3 cases, the point of stenosis was found at the anastomotic point with the LAD vessel. LIMA was hence dissected free and then reanastomosed further distally after an appropriate distal run-off was clearly-confirmed.

***Posterolateral thoracotomy (6 cases, 30%):**

In six patients who showed lesion(s) in the coronary vessels of the lateral surface of the heart (eg: Diagonal or Circumflex branches), a left posterolateral thoracotomy was employed via the left 5th.intercostal space.

After careful reviewing of their anatomical course (in the angiocath film), Off-pump DCABG (using the local immobilization technique) was used with the inflow being derived via RA or SVGs.from the descending aorta.

Additionally, a double-lumen endobronchial tube is required before the patient is placed in the right lateral decubitus position with the pelvis cork-screwed to permit femoral-femoral CPB when dictated. The pericardium was opened posterior to the phrenic nerve. Following that any adhesions along the OM distribution were carefully-dissected and freed. Dissection of the posterior mediastinal adhesions was also performed in order to expose the descending aorta in the area of the inferior pulmonary ligament which should be thoroughly-mobilized in the beginning.

The tentacles of the Octopus tissue stabilizer were positioned as to straddle and lie in parallel to the desired OM vessels. A small rubber vascular snare was usually fitted proximal to the previous point of anastomosis before performing the coronary arteriotomy which was usually carried out beyond (distal to) the previous graft anastomosis. The saphenous vein (or betterly the Radial Artery) conduit was then grafted.

The proximal anastomosis was then carried out in the area of the descending thoracic aorta with the help of a partial-occlusion (side occlusion) clamp for vascular control. Our grafts lay, thus, forming a gentle curve (or loop) under the mobilized inferior pulmonary ligament.

Results

In our twenty-case series (18 men and 2 women), we reoperated through the sternum in 8 patients (40%); through left anterior mini thoracotomy in 6 patients (30%); and lastly through a left posterolateral thoracotomy in 6 patients (30%).

Six cases were operated upon for a single vessel (LAD) stenosis; 9 cases for

Table (1): Patient age and gender.

* Men	18
*Women	2
*Age range	57 -67years.
*Mean age	62.3+-3years.

Table (2): Preoperative risk factors profile.

# Age above 60 years	16 patients (80)
# Unstable angina	8 patients (42%)
# Congestive heart failure	3 patients (15%)
# Acute myocardial infarction + ventricular arrhythmias	2 patients (10%)
# Aortic atherosclerotic plaque (s)	2 patients (10%)
# Peripheral vascular disease	2 patients (10%)
# Multiple (triple vessel) disease	5 patients (25%)

Table (3): The Target vessels.

1) Stenosed (or occluded) LAD graft 20 cases (100%)
NB:One vessel was found non-graftable so the Ramus branch was grafted instesd.
2) Stenosed grafts to Obtuse Marginal branches 14 cases (70%)
3) Stenosed grafts to Diagonal Branch 4 cases (25%)
4) Stenosed grafts to PDA branch 3 cases (15%)
NB: Preoperative LVEF (mean value: 38+-4.4%).

Table (4): Surgical Strategies and Approaches used.

* Median sternotomy 8 cases (40%).
* Left anterior minithoracotomy 6 cases (30%).
* Posterolateral thoracotomy 6 cases (30%).

double-vessel stenosis; 3 cases for triple-vessel stenosis; and 2 cases for quadruple-vessel stenosis.

The coronary vessels targeted for grafting were: the left anterior descending (LAD) in 20 cases (100%); obtuse marginal branches (OMs.) in 14 cases (70%); Diagonal branch in 4 cases (25%); and the posterior descending branch (PDA) branch in 3 cases (15%).

In fourteen cases, an intact (and well-functioning) LIMA was usually-seen showing a stenosis at its anastomotic site with the LAD so it was removed and then reimplanted further distally.

In two cases, a non-functioning LIMA was explanted for a new graft, the radial artery.

In two cases, due to non-graftable LAD vessel, LIMA was grafted over the ramus intermedius branch of LCA instead.

In two patients, LIMA was recruited and then anastomosed over the hood of a previous SVG which was obstructed proximally from the aorta.

In our series, there was a single mortality (ie:5%) in the immediate postoperative day. Death occurred in this four-grafts patient due to a severe anaphylactic reaction in response to an unknown drug given. The

Table (5): Factors decreasing survival after reoperation (20)

Factor	P Value	Relative risk
LV dysfunction	0.0001	1.9
Age	0.0001	1.04
Current cigarette smoking	0.0001	1.6
Hypertension	0.0002	1.4
Left main > or = 50%	0.0001	2.0
Triple vessel disease	0.0001	1.6
NYHA III/IV symptoms	0.003	1.4
Peripheral vascular disease	0.001	1.5
Interval > 60 months	0.006	1.003
No ITA at first operation	0.03	1.5

condition was aggravated by the fact that this patient sustained post-operative myocardial infarction (after his previous CABG) and was under intra-aortic balloon counterpulsation support (due to congestive heart failure) during his emergent admission.

Another 2 patients presented preoperatively with CHF which markedly-improved in the postoperative period. Moreover, acute myocardial infarction was present in two other patients (10%) causing irregular runs of ventricular arrhythmias. This complaint gradually improved and then disappeared after surgery.

In the majority of our cases, blood transfusion was given in the average of 3 (or less) units of whole blood. In 7 cases, only homologous blood was given as sufficient amounts were collected and adequately-preserved using proper refrigeration perioperatively.

Three patients (15%) in the resternotomy group required more than the average amount (3 whole units) of blood transfusion. Re-exploration was done in another 2 patients (10%) of the resternotomy group to control troublesome bleeding due to dense extensive adhesions as well as collaterals from the surrounding mediastinal fat. Postoperatively, LVEF rose to 55.2+-2.2% for a mean period of 6.3+-2.2 months.

In our study, there were no cases of wound infection.

ICU stay time ranged around 20.4+-2 hours while hospital stay was 6.2 +- 1.2 days postoperatively.

Five patients (25%) agreed to perform postoperative check angiocath. After obtaining their written consent, this was performed and showed satisfactorily-patent and well-functioning redo-coronary grafts. Ten other patients (50%), were checked postoperatively using Thallium scanning which also revealed satisfactory graft patency.

Discussion

Nowadays, redo-operative coronary procedures are being met in an increasing part of most practices. Excellent results are

being reported by many investigators (21), (22), & (23).

The reoperation (redo surgery) procedures are usually accompanied with a considerable degree of technical difficulties that are both evident as well as different from the primary surgery done before. These alleged difficulties come from many incriminated factors that usually include: a) Difficulties of exposure (reentry). 2) Danger of cardiac and or graft injury during dissection. 3) The availability of new grafts (conduits). 4) Management of the intact or still-functioning conduits (especially vein grafts). 5) Proper intraoperative myocardial muscle protection.

6) Handling of blood loss and the associated use of blood and its products. (17)

With the noticed increase that occurred in in the overall experience of reoperation for CABG, alternative strategies have evolved in an attempt to lower the increased margin of operative dangers or risks that exceed those reported with the initial revascularization. (18)

These strategies include different techniques for reentry , strict avoidance of old grafts over-manipulation to minimize the risk of atherosclerosis/embolism, and modification in the techniques of intraoperative myocardial protection depending on the condition of the native coronary circulation and patency of vein or internal mammary artery (IMA) grafts. (19)

In a current study, approximately 10% of isolated revascularization operations in the united states are CABG reoperations (6).

In a study of 8000 patients who underwent primary coronary bypass surgery from 1971 through 1978, the cumulative incidence of reoperation was 2.7%, 11.4%, and 17.3% at 5,10, and 12 postoperative years respectively (7). The annual incidence of reoperation increased with increasing postoperative interval from 1.1% at 5 postoperative years to 3.9% at 10 years after primary surgery (8).

The study of specific factors that present at the time of primary surgery can give us further insight as to carefully-predict why the repeat procedures will be needed over time. These factors include: Young age ($P < 0.001$), normal left ventricular function ($P = 0.003$), single or double vessel disease ($P = 0.005$), class III or class IV preoperative symptoms ($P = 0.003$), incomplete revascularization ($P = 0.004$), and not having an internal thoracic artery (ITA) graft ($P = 0.0001$) (9).

In another study that was conducted between 1967and 1987, the factors decreasing late survival after reoperation were found as follows:...Table number (5).

Examination of the angiographic indications for repeat surgery in some of the studies done in the early years of the bypass surgery era (1967 to 1978), revealed that the mean interval between primary operation and a first reoperation was 45 months, and that the most common angiographic indication for reoperation was progression of atherosclerosis in the native coronary circulation in 55% of patients (5).

With time, the patterns of treatment for coronary heart disease (eg: PTCA...etc.) have changed and so have the characteristics of the patient population now undergoing reoperations. Today's candidate for reoperation usually had triple vessel disease at the time of the first operation, the interval between operations is often more than 10 postoperative years (mean interval of 116

months for patients undergoing repeat surgery from 1988 through 1991 at the Cleveland Clinic Foundation), and in 92% of cases bypass graft failure represents at least part of the indications for reoperation (9).

The fact that "atherosclerosis is a progressive disease"is quietly-well known and therefore, For patients with coronary artery disease, the likelihood of adverse events that occur after CABG surgery, is a function of time (ie: length of postoperative follow up), regardless of the type of treatments that are employed (5).

The pathologic changes that occur in the SVGs are different at different postoperative intervals. Autopsy studies revealed that SV grafts that are occluded within 2 months of surgery usually exhibit thrombosis and that non-occluded grafts may exhibit endothelial disruption with an associated mural thrombus (10).

Early SVG thrombosis is not solely related to endothelial pathology , however as haemodynamic factors also play a role. Vein grafts to small coronary arteries with limited outflow have a higher incidence of early thrombosis than do grafts to large coronary arteries. Within a few months after surgery, virtually all saphenous vein grafts develop some degree of proliferative intimal fibroplasias which is diffuse and may extend the entire length of the graft in a concentric fashion. Initially it is a cellular process , but within few months it grows and include more fibrous tissue. This intimal fibroplasia usually appear to provide the substrate for the subsequent development of vein graft atherosclerosis (11).

The difference in outcome for patients with early versus late SVG stenoses is based on the difference in the pathology of those lesions. Early vein graft stenoses are usually based on intimal fibroplasias whereas late vein graft stenoses are caused by vein graft atherosclerosis, an unstable lesion that appears to incite graft thrombosis and that may also cause spontaneous coronary embolization. Vein graft atherosclerosis is characterized by lipid infiltration. Characteristically, it is also diffuse and concentric although the stenotic lesions may be somewhat eccentric. Whereas native vessel coronary atherosclerosis tends to be segmental and eccentric, based on the media, and encapsulated, vein graft atherosclerosis is a superficial, intimal, lesion and is quite friable (12).

Vein graft atherosclerosis may be recognized in grafts explanted within 3-5 years of operation, and most vein grafts that are explanted exhibit some degree of vein graft atherosclerosis between 5-10 years after surgery. The distinct pathology of vein graft atherosclerosis is essentially important as its extreme friability is a major contributing cause of embolization during reoperation or during any percutaneous procedure performed (13).

The rate of graft attrition caused by vein graft atherosclerosis is difficult to study as late angiographic studies are usually unable to provide exact numbers regarding the likelihood of a vein graft becoming stenotic or occluded. However, the best data available indicates that by 10 years after bypass surgery, approximately 30% of SVGs are totally occluded, and of those that are still patent, approximately 30% exhibit some angiographic evidence of vein graft atherosclerosis (14). Examination of serial studies of vein grafts also provides a different kind of insight, and hence

reasonable data have shown that of vein grafts that were known to be patent within 5 years of operation, 26% were occluded, and 19% exhibited stenoses at repeat angiograpdy between 5-12 years after operation (10), (11), (12), (13),(14).

Although the mortality which occurs in association with the redo-operations has decreased, the rate of occurance of different morbidities remains significant since many patients with more complex conditions come to surgeons (23), (24). For strong economic reasons, the aim to decrease these morbidities have called for intensive efforts in all surgical fields to focus on less invasive techniques (26) , (28).

Unlike general thoracic and gynecologic operations, a reduction in redo coronary morbidity depends primarily on avoiding the detrimental physiologic and cerebral effects of CPB, rather than simply creating alternative smaller-access MIDCABG incisions (28).

Redo-CABG operations without CPB is less demanding in terms of operative time, postoperative hospital stay, which is translated finally to a reduced hospital cost.

Despite the number of cases we reoperated to control bleeding complications, however still a higher percentage of cases requires none (or less) blood transfusion and really, so to speak, some authors reported that no patient was reexplored for excessive mediastinal haemorrhage (28).

Although construction of distal anastomosis on the beating heart is technically more demanding and requires a short period of coronary occlusion, the observed incidence of postoperative myocardial infarction in general was low.eg: In 2000, according to Trehan et al, (28) it was 4%; while in 1993, it was 3% in Cosgrove's work (17); and in 1997 in Mishra et al (19), like us, it was zero%.

MIDCABG procedures, for redo cases, avoids manipulation of healthy patent grafts and dissection of adhesions due to previous operations. Satisfactory results of MIDCABG procedures in redo-CABG surgeries for revascularizing the LAD using LIMAs have been reported by many authors (19), (20), & (21).

We performed MIDCABG, via anterolateral thoracotomy, in 6 of our patients. In these cases, an adequate length of LIMA was dissected free with the help of the LIMA-lift retractor.

In our patients, LIMA was grafted to LAD distal to the previous (occluded SVGs.) anastomosis via either restenotomy (8 cases: 40%) or MIDCABG anterolateral thoracotomy, in 6 cases : 30%).

In two cases of MIDCABG (using anterolateral thoracotomy), the LAD vessel was found non-graftable due to its small size and its intra-myocardial course, so the ramus intermedius branch was grafted instead.

In another two cases, LIMA was recruited and then anastomosed over the hood of a previous SVG which was obstructed proximally from the aorta. In our opinion, this technique served us well as to provide a safe enlargement of the orifice through which coronary blood flows to the myocardium without putting the old coronary-anastomotic point in jeopardy.

In another two patients, a non-functioning LIMA was replaced for a new RA graft.

In fourteen patients, the "still-functioning" LIMA was disconnected from its previous anastomotic site to LAD (where

stenosis is usually-seen) and reimplanted again more distally. Careful dissection/manipulation was always performed using indirect (or minimal) touch during handling of old LIMAs.

In our patients, we used a combination of LIMA; RA; and saphenous vein grafts for redo-revascularization.

As for postoperative follow up , check angiograms were performed in five (those who could be convinced to do so) of our patients and they all had properly-working patent grafts. In another ten cases we used Thallium screening and it showed similar results.

Postoperative LVEF (as calculated by echocardiography) showed a remarkable improvement to a mean of 55.2 ± 2.2% for a mean period of 6.3 ± 2.2 months denoting successful revascularization. This was furtherly confirmed by our patients as they reported improvement in their quality of life with no new attacks of anginal pain.

In the work presented herewith, we did not use other techniques eg: TMLR or the HYBRID PROCEDURE (ie:combinig MIDCABG with PTCA) as the technique(s) we selected and used provided us with satisfactory results for the redo-revascularization procedure. Moreover, we think that the former should be reserved only for cases with no distal vascular targets (which was not the condition in our cases) suitable for CABG or PTCA especially in the Cx. or the PDA zones; while the latter is only justified for high-risk patients (not tolerating CPB or resternotomy) to combine LIMA/LAD anastomosis with a previous single-graft re-stenosis (eg: SVG / circumflex territory).

The technique of Off-Pump revascularization was combined successfully with the thoracotomy route for reoperative CABG surgery by Baumgartner and colleagues (27).

In our present series, we employed left 5th.posterolateral thoracotomy in six patients to bypass Diagonal and or Obtuse Marginal branches on the lateral wall of the heart using SVGs. And/or RA grafts without CPB.

Our proximal anastomosis was fashioned on the descending aorta when a patent LAD graft was confirmed patent. We found this method to be reliable, successful, and safe as was confirmed by postoperative follow up. The work presented herewith comes as the continuation of our previous efforts in the field of using Off-pump technique for CABG (29), (30).

Conclusion

We believe that modifications in all aspects of reoperation for CABG will continue to evolve and improve as surgeons are being more and more confronted in their daily experience by the ever-increasing number of patients requiring reoperative revascularization. One of the successful techniques that we used is Diagonal/OM grafting via posterolateral thoracotomy (especially in patients with patent IMA grafts); while another was the MIDCABG via small anterolateral thoracotomy. CABG without CPB is thus a modifiable technique that can be tailored to the needs dictated by special cases of individual patients. We , in accordance to our initial experience and results, urge colleagues to apply more research to it to draw firmer conclusions about its safety.

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LOW EJECTION FRACTION: IS IT SAFE FOR OFF-PUMP CORONARY ARTERY BYPASS SURGERY?

ABSTRACT

Background: For Off-pump Coronary Artery Bypass Grafting (OPCABG), a considerable degree of manipulation to the heart is usually needed. Despite the particular attraction that exists in OPCABG for this patient group, these procedures furtherly compromise the haemodynamic stability of a patient who is already presenting with depressed left ventricular function compared with the conventional Coronary Artery Bypass Garft approach (CCABG). Many questions exist regarding the noxious effect of this manipulation, and whether or not it induces (or at least contributes in causing) a more dramatic state of cardiac hypoperfusion that may increase the likelihood (or incidence) of related morbidity/complications and/or mortality. This work comes as a trial in an attempt towards finding an answer to these questions.

Patients and Methodology: Between February 1999, and November 2001, 30 patients with low ejection fraction (ranging from 18 to 30% with a mean of 25 ± 10%) underwent Classic (ie: through a full sternotomy) Coronary artery bypass graft surgery at Kasr El Ainy's French Educational Hospital. 27 were men (90%), while 3 were women (10%). Their ages ranged from 42 to 70 years (mean of 62 ± 4.1 years). Out of them, 15 patients underwent OPCABG procedures while the other 15 performed the classic CCABG procedure. Pre, intra, and postoperative variables and parameters (as identified by the Society of Thoracic Surgeons National Cardiac Surgery Database were comparatively studied and analyzed.

Results: Mean number of grafts were 2 ± 0.6 (ranging from 1-3). The IMA was used in all patients (100%), while the RA was used in 25 patients (83.3%). Despite the recognized haemodynamic derangement, blood loss, and cardiac enzyme leak during cardiac negotiations, the group of OPCABG patients appeared to tolerate the procedure well. Hospital survival rate was 93.4% as only one mortality occurred in the CCABG group due to cardiac muscle pump failure. Follow up (for a mean of 6.4 ± 1.3 months) was possible for all cases using Thallium scanning. Cardiopulmonary Bypass, as we expected, was the major predictor for all postoperative complications as a clear relation could be traced between them.

Conclusion: Multivessel coronary artery bypass grafting utilizing the OPCABG procedure in patients with depressed left ventricular ejection fraction of 30% or less is a critical condition that can be applied with certain precautions. Using comparative analysis of OPCABG and CCABG parameters, we found that these variables were statistically insignificant apart from operative and postoperative blood loss and peak cardiac enzyme leak that were slightly raised in the OPCABG grp. Careful attention to each and every intraoperative detail as well as proper and well-experienced haemodynamic management greatly-give credits in favor of a successful OPCABG procedure.

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INTRODUCTION

Inspite of the remarkable advances implemented in coronary artery bypass surgery (CABG), the treatment of patients with coronary artery disease having severe left ventricular dysfunction still poses a particularly-important challenge as perioperative mortality can range up to 37% with high morbidity in this patient subgroup (1).

Management of patients with greater ventricular function impairment is unclear. Some cardiologists and surgeons are reluctant to refer these patients for surgical intervention. A recent study suggested that in high-mortality patients (more than 10% preop.predicted risks), as defined according to the risk module of the Society of Thoracic Surgeons National Cardiac Surgery Database, operative mortality is significantly-lower when performed without cardiopulmonary bypass (CPB) (5).

Many earlier studies have concluded that risks of operations and operative mortality are considered prohibitive for CHD patients with low LVEF (1),(2),(3).

On the other hand , several other studies have demonstrated favorable results from surgical revascularization in this particular patient group (6),(7),(8).

Moreover, long-term follow up outcome from a prospective randomized study, comparing medical therapy with CABG, for patients with symptomatic coronary artery disease and efection fraction as low as 30%, have shown a long-term survival benefit for those receiving CABG (4), (9).

The aim of this study was to analyze our own experience in our CHD patients with severly-depressed left ventricular function (EF of 30% or less) who underwent Off-Pump multi-vessel CABG (OPCABG) by comparing them to those who underwent conventional CAB (CCABG) with a similar impairment of the LVEF. The final goal in our analytical work is to contribute in detecting variables that are responsible for causing a higher postoperative complications or death in either of these groups.

Patients and Methods

Between February 1999, and November 2001, 30 patients with low ejection fraction (ranging from 18 to 30% with a mean of 25 ± 10%) underwent Classic (ie: through a full sternotomy) Coronary artery bypass graft surgery at Kasr El Ainy's French Educational Hospital.

27 were men (90%), while 3 were women (10%). Their ages ranged from 42 to 70 years with an overall mean of 62 years ± 4.1 SD.

They were divided into two groups of equal number:

*Group I: included 15 patients underwent OPCABG procedures.

*Group II: while the other 15 patients performed the classic CCABG procedure.

In choosing patients of both groups, these data were equaled or cross matched as possible (as the variables of comparison), and were comparatively studied and analyzed.

Patients' demographic data are displayed in table number (1).

As concerns the patients with LVEF of equal or less than 30% in the first group (OPCABG), their NYHA staging revealed 2 patients (13.3%) in class I; 3 patients (20%)

in class II; 4 patients (26.6%) in class III; and 6 patients (40%) in class IV.

In the second group (CCABG), the NYHA staging was 1 patient (6.6%); 3 patients (20%); 6 patients (40%); and 5 patients (33.3%) respectively.

Preoperative angiography for group I (OPCABG) patients revealed a single vessel disease in 2 patients (13.3%); double-vessel disease in 4 cases (26.6%); three-vessel disease in 6 cases (40%); and four-vessels in 3 patients (20%). In group II, a single vessel was found in 3 patients (20%%); a two-vessel in 3 patients (20%); a three-vessel disease in 5 patients (33.3%); and a four-vessel disease in 4 patients (26.6%).

Comorbidity factors in both groups were comparatively-displayed in Table number II.

The predicted Risk Factor was 5.7 (with a SD of 8.7) in group II (CCABG); Vs. 6.4 (with a SD of 5.5) in group I (OPCABG).

*** Methodology Of The Study:**

Pre, intra, and postoperative variables and parameters were those identified by the Society of Thoracic Surgeons National Cardiac Surgery Database. They were prospectively-looked for, tabulated, comparatively-studied, and thoroughly-analyzed.

Post-operative Clinical follow-up was performed after hospital discharge aided by Thallium scanning done six months after surgery.

Surgical Techniques:

a) Group I: Off-Pump CABG (OPCABG):-

Procedures were all carried out through a full sternotomy incision together with take down of the left internal thoracic or mammary artery "LIMA" and the Left Radial Artery (RA) (in 15 patients ie:100% of cases); while additional Saphenous Vein grafts (SVGs) were used (to the diagonal , circumflex branches, and/or the right coronary system) in only 11 cases (73.3%). All procedures were performed using the OCTOPUS III cardiac stabilizing system (supplied by Medtronics Inc., Mineapolis, MN, USA). Heparin was administered in a dose of 2-3 mg/kg body weight. After opening of the pericardium, a left atrial catheter was introduced for LA pressure blood monitoring. Temporary pace-maker electrodes were attached to the right atrium and the right ventricle. Two, or preferably-three, deep pericardial traction stitches were placed on the left side of the pericardium, below the phrenic nerve, near the left upper and lower pulmonary veins and to the left of the inferior vena cava (IVC). One or two gauze sponges (and /or slings) were additionally-placed under the heart. These manoeveres described hereby provided us a good exposure and achieved a satisfactory vertical displacement of the apex of the heart. With perfectly-placed stitches and aggressive traction, the cardiac apex should be elevated to approximately 90 degrees. For further assistance in providing haemodynamic stability and achieving a good presentation of the target arteries on the lateral and inferior aspects of the heart , patients were placed in a gentle right decubitus (Trendelenburg position) by tilting the operating table. With the addition of the suction capability on the octopus device, presentation, and stabilization of the remote target arteries near the circumflex trunk were feasible. After placement of the octopus paddles, blood flow through the vessel was usually temporarily-interrupted by snaring with vessel loops or rubber-tourniquets. Grafting of the coronary vessels

Table (1): Patients' Demographic Data (age and sex).

Variables	Group II. Classic CABG using CPB (CCABG) N: 15 patients	Group I. Off-Pump CABG (OPCABG) N: 15 patients
Female sex (%)	2 (13.3%)	1 (6.6%)
Male sex	13 (86.6%)	14 (93.3%)
Age (years) mean (SD)	59 (3.4)	62(1.3)

was then performed in the usual manner. For assuring a bloodless anastomotic field, we used a filtered-O2 blower via a 14 FG venous cannula. Close and continuous monitoring was well-prepared and equipped anaesthetic personnel was always available throughout the surgery. Any haemodynamic instability is instantly-dealt with using proper fluid volume filling and or pharmacologic drug support.

b) Group II: Conventional On-Pump CABG (CCABG):

On-pump coronary artery bypass operation was carried out through a full sternotomy incision with takeout of the LIMA vessel, the RA, and or the SVGs. CPB was instituted by cannulating the ascending aorta and the right atrium and using a centrifugal pump with membrane oxygenators. Antegrade intermittent warm-blood cardioplegia (with intermittent venting) was delivered by the pump via the aortic root to achieve myocardial protection.

Results

Demographic data between the two groups are listed in table number I.

The OPCABG group was significant for increased mean age: 62 Vs. 59 years respectively (P = 0.022), as well as reduced mean LVEF: 24.5 Vs. 25.3 respectively (P = 0.06).

The preoperative risks and the co-morbidity factors for both groups were compared in table number II. The preoperative predicted risks for both groups were non-statistical (5.7 for CCAB and 6.4% for OPCAB, P= 0.5). However, by close analysis of both groups, it was revealed that the clinical presentation and pharmacologic management of the OPCABG group were greater for symptoms that occurred in association with decompensated (decompressed) cardiac function eg: CHF at time of operation (OPCABG 20% Vs. CCABG 13.3%, P= 0.05); New York Heart Association functional class IV was 40% Vs. 33.3% respectively (P= 0.8). The need (and use) of preoperative drugs and medications was also more for OPCABG: 66.6% Vs. 53.3% respectively (P0.02).

Additional benefit in favor of OPCABG in this high-risk group may be related to the haematologic disadvantages and the noxious effects of heparinization that occur in association with CPB.

*** Survival:**

We had one mortality case in the CCABG group (6.6%) due to the occurance

Table (2) : Patients' Comorbidity Factors.

Variables	Group II. Classic CABG using CPB (CCABG) N: 15 patients	Group I. Off-Pump CABG (OPCABG) N: 15 patients
*NYHA class IV%	5(33.3%)	6 (40%)
*3 vessel disease	5 (33.3%)	6 (40%)
*LVEF% mean (SD)	25.3 % (3.2)	24.5 % (2.6)
*CHF (%)	2 (13.3%)	3(20%)
*Unstable angina	4 (26.6%)	5 (33.3%)
*Previous MI	2(13.3%)	1 (6.6%)
*History of CVS	1 (6.6%)	3 (20%)
*Hypertension	7 (46.6%)	9 (60%)
*Diabetes	3 (20%)	4 (26.6%)
*COPD	1 (6.6%)	1 (6.6%)
*Smoking	13 (86.6%)	11 (73.3%)
*Morbid obesity	6 (40%)	9 (60%)
*PVD	2 (13.3%)	1 (6.6%)
*Max. medical ttt	8 (53.3%)	10 (66.6%)
*Predicted risk % & (SD)	5.7(8.7)	6.4 (5.5)

CHF: congestive heart failure. COPD: chronic obstructive pulmonary disease. EF: ejection fraction. NYHA: New YorK Heart Association. PVD: peripheral vascular disease. SD: standard deviation. CVS: Cerebro Vascular stroke. MI: myocardial infarction.

Table (II): Perioperative factors.

Variables	Grp.I. OPCABG	Grp. II. CCABG
*Average number of distal grafts/patient (SD)	2.7 (1.1)	3.3 (1.5)
*Skin to Skin time (hrs) mean (SD)	4 (0.5)	5 (0.5)
*Hours of postoperative intubation mean (SD)	12 (4.2)	15 (2.1)
*Mean ICU stay in hours (SD)	70 (6.6)	85 (4.5)
*Duration of hospital stay (average in days)	9	12

Table (III): Postoperative Complications.

Variables	Grp.I OPCABG	Grp.II CCABG
*Postoperative TIAs. number (%)	0 (0)	2 (13.3%)
*Postoperative MI (%)	0 (0)	0 (0)
*Reoperation for haemostasis	0 (0)	2 (13.3%)
*Reoperation for graft occlusion	0 (0)	0 (0)
*Deep sternal infection	0 (0)	0 (0)
*Superficial wound collection	0 (0)	3 (20%)
*Renal insufficiency	1 (6.6%)	3 (20%)
*Thoracentesis for residual effusion	1 (6.6%)	0 (0)
*Estimated blood loss (expressed as number of "whole blood"units given	3.50	5.25
*Perioperative need of IABCP.	1	3
*Enzymes in mg/ml mean (SD)		
Peak CPK	354 (233)	890 (790)
Peak CPK-MB	31 (35)	43 (58)
*Need for inotropic support during Ist. 24 hours : number (%)	3 (20%)	6 (40%)
*PO arrhythmias : number (%)	4 (26.6%)	3 (20%)
*ICU readmission	3 (20%)	5 (33.3%)
*Mortality (pneumonia & septic shock)	0 (0)	1 (6.6%)

of severe postoperative pneumonia that terminated in septic shock.

*** Intraoperative events:**

The significance of skin-to-skin times should be considered or evaluated in relationship to the mean number of distal anastomoses performed in each group (in OPCABG: 2.7 ± 1.1 grafts in 4 ± 0.5 hours Vs. 3.3 ± 1.5 grafts in CCABG in 5 ± 0.5 hours. Eliminating CPB (ie: cannulation, rewarming, weaning off-bypass..etc.), has considerably saved an average of one hour of expensive operating room utilization time in OPCABG cases.

As regard the "intraoperative and postoperative" blood loss, a considerable difference was noticed. Averagely, 3.5 whole units were needed in OPCABG Vs. 5.2 for CCABG ($P< 0.03$).

The mean number of distal grafts done was, however, less in OPCABG: 2.7 ± 1.1 Vs. 3.3 ± 1.5 for CCABG.

An Intraaortic balloon pump was inserted intraoperatively in one OPCABG patient and 3 CCABG patients. This utilization of IABCP was initiated to counteract the sudden compromise of the ventricular functions that occurred (during CPB or cardiac manipulation during OPCABG) causing low cardiac output. In our series, balloon support was needed and utilized not only less often but also nonsignificantly in the OPCABG group. Moreover, any impact from the physiologic

effects experienced during cardiac manipulation (in OPCABG grp.) was not evidenced in postoperarive occurrence of permanent stroke, trasient ischemia attack, preoperative myocardial infarction as all were of zero value.

We also noted the small, albeit significant, variation in CPK myocardial brand (CPK-MB) enzyme levels are also confidently-supported by the electrocardiographic findings of no peri or postoperative myocardial infarction in either study groups (Table no. III).

*** Clinical course:**

The majority of patients were extubated within the first 12 hours postoperatively. The average for OPCABG cases was 15 ± 4.2 hours, and for CCABG was 15 ± 2.1 hours.

ICU stay averaged 70 ± 6.6 hours for OPCABG; compared to 85 ± 4.5 hours for CCABG. Hospital stay was in average 9 days for OPCABG; and 12 days for CCABG.

*** Clinical follow-up:**

A clinical follow up was obtained for all patients (except one which was lost for follow up in the CCABG grp.) with the mean follow up period of 6.4 ± 1.3 months postoperatively. Follow up was carried out by Thallium screening which confirmed the patency of the grafts performed in both groups. An improvement in the NYHA clinical class as well as the tolerance to effort and the quality of life was positively-stated by almost all patients in both groups.

Discussion and comments:

The use of beating heart operation in patients with severe dysfunction of the LV seems to be particularly attractive due to the avoidance of of the deleterious or detrimental effects and complications of CPB eg: induction of a systemic inflammatory response, stroke, neurocognitive defects, renal or pulmonary insufficiency (10).

Although sophisticated protocols of myocardial protection in CPB have provided improved results in myocardial revascularization in patients with critical LV dysfunction, the use of CPB is hence still incriminated as it is still associated with a considerable degree of morbidity (11).

Improvements in myocardial preservation have made OPCABG for CHD patients much safer than before (12). These improvements have enabled surgeons to achieve good results in the number of CHD patients with severe LV dysfunction referred for operation (13). In these patients the slightest depression of the myocardial cardiac reserve can lead to a disastrous or a detrimental outcome (14).

In contrast to that, the On-pump fibrillating heart without cross-clamping may provide a better blood supply to the subendocardium and interventricular septum (14) & (15) leading to improved myocardial preservation and outcomes for the high-risk patient (8) & (15).

In order to be able to allow for complete revascularization in the OPCABG patient, the heart must be elevated.. The degree of displacement is variable according to the location of the target vessels. A more gentle displacement is usually all that is needed to achieve revascularization of the LAD and the Diagonal arteries. Revascularization of the branches of the Circumflex and the RCA system requires a more vertical displacement that is even more pronounced for the posterolateral system (16).

To accomplish this displacement, insertion of three deep pericardial traction stitches is, in our opinion, of paramount importance as with proper placement of these three stitches, the vertical displacement of the cardiac apex can be achieved even without using a sling or a cardiac supporting device (17).

It has been shown that a 90-degree displacement of the heart in animal models causes hemodynamic derangement which is characterized by a major drop in the cardiac performance i.e. stroke volume, cardiac output, and mean arterial blood pressure despite elevation of the right side volume overload (15).

In another study using flow probe and a microsphere perfusion study, Grundeman and co-workers (18), showed that coronary blood flow (CBF) was decreased in all coronary arteries with a more pronounced effect in the circumflex system.

The pathophysiology of CBF on displacement of the heart is complex. The decrease in CBF is likely to be reflected through autoregulation and a decrease in myocardial work and wall tension reduction when afterload is decreased.

The assumption that cardiac work has decreased during displacement resulting in a drop in arterial pressure is supported by the observation that left ventricular myocardial oxygen consumption is diminished (18). Extrapolation of these results to clinical practice must be carefully-considered. Off-pump revascularization of the posterior wall is feasible while the heart is displaced vertically and the patient placed in the Trendelenburg position (17) & (18).

In their study, Arom et al (5), noticed that vertical displacement of the heart causes a decline in the cardiac index, a decline in arterial blood pressure, together with fluctuation in the heart rate. The preload of both left and right sides fluctuated , although fluctuation was more pronounced on the right. In their clinical setting they found it very difficult to interpret whether these changes were related to the findings as shown in the animal model studies alone or in combination with aggressive intravenous treatment with Neosynephrine and a short-acting beta-blocker. They deduced that haemodynamic instability can be minimized when the three deep pericardial traction stitches were perfectly-placed and vertical displacement of the heart accomplished without the addition of a sling or sponge pad inside the cradle. They added that haemodynamic instability was minimized with the patient in the Trendelenburg position, which creates bilateral filling pressures to reach 20 mms. Hg or higher. Waiting approximately 2-3 minutes allows for normalization of the parameters so application of the stabilizing device and completion of the anastomosis can then be accomplished. Moreover they concluded that it is easier to reach the posterolateral aspect of a large dilated heart than the heart with a concentric hypertrophied left ventricle.

The limitation of our study is that it includes only a small number of patients (30). However, the selection of which surgical approach to apply in our patients was strictly a surgeon decision based on the patient's clinical presentation and not the existing co-morbidities. We herewith state that for the OPCABG approach, we always prefer to choose our surgical candidates with no calcified vessels, no intramuscular arteries, and the size of the target artery must not be smaller than 1.5 mms. Also we

prefer not to perform OPCABG surgery in patients with evident severe left ventricular hypertrophy.

Researchers may argue that the mean number of distal anastomoses between our patient groups was worth-considering and that it may point to the presence of an unmatched comparison, or may suspect an incomplete revascularization in the OPCABG group.

As an answer to this possible assumption , our comment lies in the fact that this discrepancy between the mean number of the distal anastomoses has nearly-reached uniformity. This event occurred in parallel with the build up of our learning curve which is showing clearly in our recently-performed surgeries.

According to this last statement , we can daringly declare that in fact OPCABG does allow for possible complete myocardial revascularization. We, among many others (7) , (8) & (19), believe that this technique offers an alternative concept to conventional CABG as its advantages refer to less mortality, and in particular to morbidity which was relatively-low in our patient group. We also noticed that the low LVEF in our patients had no influence on the total hospital stay and thus was only partially-related to a more cautious observation in these patients.

We believe that more experience will increase the number of cases in which a complete revascularization was achieved , specifically of posterior vessels , despite the challenges of "patient selection" and "choice of the surgical procedure".

We believe, with other workers (7), (8), (13), (17) & (19), that the essential factors to achieve optimal outcome include:

1-Perfect placement of the three deep pericardial traction stitches that allow easy vertical displacement of the heart.

2-Controlled raising of the filling pressure of both sides of the heart to equal to or greater than 20 mms.Hg before and during Trendelenburg positioning.

3-The watchful waiting for few minutes until near-normalization of the haemodynamic parameters occurs after application of the stabilizers and prior to beginning of the arteriotomy / anastomosis procedure.

Conclusion

Nowadays, with the continued rise in the patients' age and multiple body system impairment that occur secondary to acute or chronically-depressed Left Ventricular function, thorough evaluation of the various modalities in surgical intervention/treatment for this high-risk patient group is warranted. The ultimate goal for surgeons should be always to seek complete revascularization which is the crucial factor responsible for providing long-term survival and and a higher-quality of life. Our work resulted in further support of the feasibility of multi-vessel OPCABG in patients with LVEF of equal or less than 30%. The immediate (and short-term) results that we reached were satisfactory but long-term follow up is needed. We kept many questions in our minds, during our work, as to whether or not right or left heart support devices for partial cardiopulmonary bypass could be of possible service during OPCABG procedures in the near future. Our basic belief is that the perseverance and commitment of all personnel in the working crew together with the attention to every single detail and the assistance of all the highly-trained and experienced surgical and

anaesthesia team is the corner stone for any success in the OPCABG procedure.

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ON-PUMP BEATING HEART MYOCARDIAL REVASCULARIZATION IN "HIGH RISK PATIENTS"

ABSTRACT

Objectives: To evaluate the effects of on-pump/beating heart myocardial revascularization technique in patients with impaired left ventricular (LV) function in terms of early survival, morbidity and improvement of left ventricular function.

Methods: This study included seventeen patients admitted during a one-year period to King Fahad Cardiac Center. Inclusion criteria included patients with severe left ventricular dysfunction (ejection fraction ≤ 30%). Mean age was 59.5 years, left ventricular end disotolic demension (mm) was 65.5 and preoperative ejection fraction was 22.5%.

Results: No mortality and no perioperative myocardial infarction were observed in our series. Mean number of grafts were observed 3.4/patient. Intraaortic balloon pump was used in two patients preoperatively and in further four patients intraoperatively. Mean intensive care unit stay was 2.5 days and hospital stay 8.7 days. At mean follow-up of 7.3 months, there was significant improvement in LV function and functional status of the patients.

Conclusion: In patients with poor LV function and graftable coronary arteries who may not tolerate cardioplegic arrest, the on-pump, beating heart technique was associated with good early results supporting its use for such patients. This technique allows for total revascularization without global ischemia. It offers the heart a degree of support which is responsible for the good early results in this subset of patients.

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INTRODUCTION

One of the most challenging aspects of coronary artery bypass grafting (CABG) is the optimum management of patients with impaired left ventricular function in order to achieve acceptable morbidity and quality of life. It is known that medical treatment only for such patients has suboptimal results and surgical options other than CABG (e.g. heart transplantation or cardiomyoplasty) are still limited (1,2). Therefore, CABG is still considered to be the best solution for such patients provided that you choose the proper way to deal with them (3). Theoretically, the ideal solution for such patients is myocardial revascularization without extracorporeal circulation. (4) However, due to the presence of cardiomegaly which is frequently encountered in this subset of patients with left ventricular dysfunction rendering manipulation and rotation of the heart more difficult thus being an obstacle against complete revascularization, the choice of the best approach remains controversial. An optimum method in such patients especially to achieve total revascularization is to use cardiopulmonary

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bypass (CPB) but to eliminate the ischemic component by avoiding aortic cross clamping, thus keeping the heart beating throughout the procedure.

The aim of this study was to evaluate the role of the on-pump, beating heart total myocardial revascularization technique in patients with impaired left ventricular function in terms of early survival, morbidity and early improvement of left ventricular function and functional status. Intubation time, ICU and hospital stay were also reviewed.

Patients and Methods

This study included seventeen patients admitted to King Fahad Cardiac Center (King Khalid University Hospital) during a one-year period. Inclusion criteria included patients with severe left ventricular dysfunction (ejection fraction $\leq$ 30%) with either predominant anginal symptoms or reversible myocardial ischemia on Dobutamine echocardiography in patients with silent ischemia in addition to the presence of graftable vessels on coronary angiography. Patients presenting with acute myocardial infarction were excluded.

Pre-operative evaluation of the patients included history taking, full preoperative laboratory check list including complete blood picture, liver function test, renal function test and cardiac enzymes, coronary angiography including left ventricular angiography and echocardiography. Dobutamine (stress) echocardiography was done to patients presenting with silent ischemia mainly heart failure symptoms to detect the presence of hibernating myocardium. Anginal symptoms were evaluated on the basis of the Canadian Cardiovascular Classification (CCS) and heart failure symptoms were evaluated on the basis of New York Heart Association (NYHA) classification.

Coronary angiograms were properly evaluated for the severity of the lesions. Left ventricular function was estimated by LV angiography in fifteen (15) patients and by echocardiography in 2 patients. Patients presenting mainly with failure symptoms were stabilized medically before going to surgery. Two (2) patients had preoperative intra aortic balloon pump (Datascope system 98/XT, Datascope Corp., Montvale, NY) insertion in the CCU due to ongoing ischemia and persistent chest pain refractory to medical therapy and underwent surgery on the next day.

Anesthetic Technique:

Premedication consisted of Lorazepam tab 2 mg and Morphine (0.1 mg;kg I.M) 2 hours preoperatively. Monitoring inside the operating room included ECG, pulse oximetry, end carbon dioxide measurement and direct arterial blood pressure measurement in addition to measurement of cardiac output, cardiac index, systemic vascular resistance and pulmonary artery pressure using a Swan-Ganz catheter introduced through the right internal jugular vein. Anesthesia was induced with Midazolam 0.1 – 0.15 mg/kg, Sufentanyl 0.8 – 1.0 ug/kg and Vecurronium 0.1 mg/kg. Maintenance of anesthesia was carried out according to the body surface area (BSA) as follows: Midazolam 1.5 – 2 mg/m2//hr, Sufentanyl 20 ug/m2/hr and Vecurronium 3-4 mg/m2/hr. These dose were supplied by preparing 100 ml 0.9 % NaCl containing 100 ug Sufentanyl, 10 mg Midazolam and

20 mg Vecurronium. The maintenance dose (ml/hr) was calculated as follows: BSA x 205. Hypotension during induction was treated with boluses of Aramine (0.5 mg). Nitroglycerine infusion (0.5 – 5 ug/kg/min) was started if systemic vascular resistance > 1200 dyne.cm-5 sec, arterial blood pressure > 140 mmHg, or pulmonary artery pressure > 35 mmHg. Level of anesthesia was adjusted by small doses of Sevoflurane.

Surgical technique:

All patients were approached through a median sternotomy. One patient had the intraaortic balloon pump (IABP) inserted after induction of anesthesia due to a low cardiac output syndrome with a cardiac index < 2 l/min/m2 in the presence of low systemic arterial pressure and high pulmonary pressure. We routinely place a femoral artery line at the start of the procedure so that insertion of an IABP is an easy procedure whenever needed. Harvesting of the conduits was done in the usual manner, all patients received an internal mammary artery but two, one of them an 85 year old and the other had multiple stenting of the LAD and the artery had to be grafted distally. Cardiopulmonary bypass was instituted using ascending aorta cannulation and a two-stage venous cannulation in the right atrium. Heparin was given at a dose of 300 unit/kg to achieve a target activated clotting time of 400 sec. The core temperature was allowed to drift down to 34°C. Myocardial stabilization was achieved using Octopus 3 stabilizer (Medtronic Inc., Minneapolis, Minn.). The heart was allowed to beat during the procedure. Venting was done through the right superior pulmonary vein when needed. The target vessel was occluded proximally using 4/0 prolene. A blower-mister (Medtronic Inc.) was used for enhanced visualization during performing the anastomosis. Elevation and rotation of the heart was obtained by Starfish exposure system (Medtronic Inc.) Proximal anastomoses were done using a side-biting clamp. Intraoperative transesophageal echocardiography was done after induction of anesthesia and at the end of the procedure for evaluation of left ventricular function and evaluate the mitral valve in patients with significant mitral regurgitation. Flow in the grafts was checked at the end of the procedure using Transit-time flowmetry device (Medistim BF 2001, Medistim, Oslo, Norway). Serial laboratory investigations including cardiac enzymes in addition to ECG were done once the patient was admitted to the ICU and every 6 hours for 48 hours.

Surgical outcome: Initial results were assessed primarily on the clinical outcome of the patients which included hospital mortality, prerioperative myocardial infarction defined as appearance of new Q-waves or peak creatine phosphokinase(CPK) – MB fraction greater than 10% of the total CPK, requirement of inotropic agents or intraaortic balloon pump support, ICU and postoperative hospital stay. Intubation time was defined as the duration of mechanical ventilation from the time of admission to the intensive care unit till extubation.

Follow-up: Follow-up was complete for all patients, with a mean of 7.3 months (range 6-11 months). All patients underwent post-operative echocardiography before discharge and at least 3 months postoperatively.

Statistical Analysis: We used statPac Gold statistical analysis package for the analysis. Results were expressed as mean ± standard deviation. P-value was considered significant if < 0.05.

Table I: Preoperative data:

Age (years)	59.5 ± 11.5 years
Hypertension	11 (64.7%)
Diabetes	10 (58.8%)
NYHA class	2.8 ± 0.6
CCS class	2.9 ± 0.9 (mean)
Previous cardiac intervention (PTCA + stent)	1 (5.8%)
Left main stenosis > 75%	3 (17.6%)
LVEF (%)	22.5% ± 2.5 (range 20%-30%)
LVEDD (mm)	65.5 ± 4.4 (range 56-70)
Preoperative IABP	2 (11.7%)
Preoperative ischemia:	
Silent ischemia	5 (29.4%)
Unstable angina	3 (17.6%)
Stable angina	9 (52.0%)

NYHA: New York Heart Association **CCS: Canadian Cardiovascular Society**
LVEF:Left ventricular ejection fraction **IABP: Intraaortic balloon pump**
LVEDD:Left ventricular end diastolic dimension
PTCA: Percutaneous transluminal coronary angioplasty.

Table II: Operative data:

CPB time (min)	83.6 ± 11.1
Number of distal anastomoses	3.4 ± 0.4 graft/patient
LITA	15
Target vessel:	
LAD	17
Obtuse marginal	13
Ramus	4
Diagonal	12
PDA	11
RCA	3
Intraoperative IABP	4 (26.6%)

LITA – Left Internal Thoracic Artery
LAD – Left Anterior Descending
PDA – Posterior Descending Artery
RCA – Right Coronary Artery

Results

Patient Profile: (Table I)

Seventeen patients presenting with ischemic heart disease and severe left ventricular dysfunction (mean 22.5%, range 20-30%) during one year period were included in this study. All patients were males with a mean age of 59.5 years (range 46-85 years). One patient had previous cardiac intervention in the form of stenting to the right coronary artery and left anterior descending artery and presented with unstable angina due to instent restenosis. One patient presented with pulmonary edema and was intubated and ventilated and the condition was stabilized before taking the patient to the operating room. Another patient had ventricular fibrillation at the time of presentation to the emergency room.

Table III: Postoperative Outcome:

Perioperative myocardial infarction	-
CPK_MB%	1.79% ± 0.6
Mortality	-
Intubation time (hr)	7.6 ± 11.6
ICU stay (days)	2.5 ± 0.9
Postoperative hospital stay (days)	8.7 ± 1.8

Table IV: Effect of Surgery on Clinical Status and Left Ventricular Function.

Variable	Pre Operative	Post Operative	P - Value
LVEF	22.5 ± 2.63	27.6. ± 5.6	0.016
LVEDD	65.5 ± 4.68	60.5 ± 4.4	0.0013
NYHA Class	2.8 ± 0.63	1.3 ± 0.48	0.0001

Significant mitral regurgitation (grade 2-3) was present in three patients.

Operative Data: Table II:

Complete data concerning the revascularization procedure are summarized in table II.

The mean over all number of distal anastomoses was 3.4 ± 0.4 patient. Mean CPB time was 83.6 min. IABP was inserted in another four patients intraoperatively, one of them after induction of anaesthesia as mentioned before and three at the end of the revascularization procedure to help in weaning the patient from CPB with one inserted through the ascending aorta due to the presence of peripheral vascular disease. Intraoperative TEE revealed significant decrease in the grade of mitral regurgitation (MR) in those 3 patients with a preoperative grade 2-3 MR which is attributed to improvement in wall motion abnormality.

Surgical outcome: Table III.

Serial analysis of ECG and cardiac enzymes revealed no perioperative myocardial infarction in our series. There was also no hospital mortality. The mean intubation time (hrs) was 7.6 ± 11.6 with a range of 6-27 hrs. The mean intensive care unit stay was 2.5 days (range 1-4). Post operative IABP support ranged between one and 3 days in the six patients who were on balloon support. No complication was related to the use of IABP. Prolonged inotropic support >48 hrs in moderate doses was required in 4 patients. Postoperative hospital stay ranged between 5 and 11 days (mean 8.7).

Effect of surgery on clinical status and left ventricular function: Table IV

All patients were followed up for a mean of 7.3 months. All patients were alive at the time of follow-up. There was a significant improvement in the angina class and NYHA classification ($P < 0.05$). All patients were in class I angina post operatively compared to a mean of 2.9 ± 0.9 preoperatively. The grade of dyspnea improved in most of the patients who became in NYHA class I/II. Echocardiography was done to all patients at the time of follow up. Significant improvement in the ejection fraction was noticed with a mean of 27.6%. Three

patients showed an improvement of more than 10%, nine patients had an improvement between 5 and 10% while five remained within their preoperative range. LVEDD also showed a significant decrease at time of follow up with a mean of 60.5 ± 4.1 mm compared to the preoperative data.

Discussion

In the current practice with advanced angioplasty techniques, it is likely that the number of patients with complex coronary artery disease and bad LV function will continue to increase and surgical revascularization may be the only chance for such patients for better long-term survival and quality of life. Thus, surgeons should be ready to deal with such cases in a proper way to ensure a good early and late outcome.

As low left ventricular ejection fraction (LVEF) is one of the most important factors associated with increased morbidity and mortality after CABG (6), the point of consideration is which approach is best for such patients and how to select the patient who is most likely to benefit from surgical revascularization. Despite the new myocardial protection techniques, there are some hearts which do not tolerate aortic cross clamping. Even continuous warm blood cardioplegia which keeps the heart in an aerobic environment does not completely prevent post operative stunning possibly because of the myocardial edema intrinsic to the diastolic state of the arrested heart (7). It has also been postulated that keeping the heart beating, even with reduced contractility, is associated with less myocardial edema and better function (8).

Though the ideal solution in such patients is myocardial revascularization without extracorporeal circulation, this technique is not applicable to all patients with a dilated heart especially those who need revascularization of the posterior vessels where the heart may not tolerate such manipulation for proper exposure. Thus, the on-pump, beating-heart myocardial revascularization technique may be considered as an alternative approach for such patients as also suggested by the results of Sweeney and Frazier (9) who used biventricular assist devices during surgical procedures in patients with ischemic cardiomyopathy. Perrault et al (10) demonstrated a lower release of Troponin Ic, a highly cardiac specific marker of tissue damage using the on-pump, beating –heart technique compared to conventional CABG. They also had a 3-fold increase in the post operative myocardial content of mRNA coding for heart shock protein (HSP) 70 reflecting the preserved ability of the beating heart to display an appropriate adaptive response to surgical stress, whereas the arrested heart seems to have lost this capacity. This is consistent with the observation of McGrath et al (11) who failed to document any change in myocardial levels of HSP 72 in patients protected with cardioplegia when undergoing various open heart operations. The present report demonstrates that the use of the on-pump, beating-heart technique is associated with a good surgical outcome and improvement in the life style of such patients. We as many others do believe that to obtain good early and long-term outcome, we need to achieve total myocardial revascularization. Trachiotis et al (12) mentioned that supplying one graft to each of the three major myocardial territories in patients with left ventricular dysfunction is of greatest prognostic significance. This confirms

earlier data by Jones and Weintraub (13) that show that the type of the conduit is less important on survival than on the ability to completely revascularize the myocardium.

In patients presenting with limiting or frequently occurring angina we didn't use myocardial viability testing as presence of chest pain by itself denotes viability despite the presence of a low ejection fraction. However, in those with minimal or no chest pain myocardial viability is of utmost importance to predict improvement in LV function following coronary revascularization (14). Myocardial viability testing can be done using Thallium scintigraphy (15), position emission tomography scan (16) or Dobutamine echocardiography (17) In this study, we relied on Dobutamine echocardiography to detect hibernating myocardium. Different studies(18) proved the reliability of this technique in addition to its low cost and wide availability. Rahimtoola (19) postulated that LV dysfunction at rest could be due to infracted, fibrotic, ischemic, stunned, hibernating myocardium or a combination of the above. Hibernating myocardium is a state of persistently impaired myocardial function at rest due to reduced coronary blood flow that can be partially or completely restored to normal if the myocardial oxygen supply/demand relationship is improved. Stunned myocardium is an abnormality in regional left ventricular wall motion that persists for hours or days following reperfusion. Therefore, the improvements in outcome is probably related to the amount of stunned and hibernating myocardium and the ability to completely revascularize the heart. Dreyfus (20) reported significant improvement in LVEF in selected patients who demonstrated viable myocardium on pre operative studies.

We used the LITA as an arterial conduit except in two patients. We believe, as proven by others, that the use of this conduit and its early patency proven by transit time flowmetry has contributed a lot to the event free survival during follow-up. The IABP was used in six of our patients (35.2%). It should be used whenever you feel that there is a need for it as timing is very important whether preoperatively or perioperatively allowing the myocardium to recover from the low output state. The IABP augments myocardial performance without increasing workload on the heart and myocardial oxygen requirements. Craver (21) reported the use of IABP electively to enable and facilitate a selected group of high-risk patients to undergo off-pump coronary artery bypass (OPCAB) with good results thus avoiding dangerous hemodynamic instability that may occur. We recommend insertion of a femoral artery line before starting surgery as this makes insertion of an IABP much easier when needed. Elefteriades (22) used the IABP freely for perioperative support especially in patients with extreme impairment of left ventricular function and left main disease. The mean intubation time was 7.6 ± 11.6 hrs compared to a group of high-risk patients operated by Lee et al (23) using conventional cardiopulmonary bypass with a mean intubation time of 9.5 ± 41 hrs. We observed significant improvement in the quality of life of our patients as a result of control of their anginal symptoms and amelioration of their failure symptoms during the early follow-up period. The available evidence suggests that patients with moderated to severe LV dysfunction and concomitant angina have improved survival with CABG and also improved functional status. (12,22) Trachiotis et al (12) postulated that despite poor functional status, patients with compromised left ventricular function have

good in hospital outcomes and a 5-year survival more than 60%. Hausmann et al (24) operating on a group of patients with ejection fraction between 10 – 30% had an operative mortality of 7.1% but at 6 months follow-up 90% were in NYHA class I/II compared to a preoperative value of 91% with functional class III/IV. Improvement in ejection fraction is not a universal finding after revascularization as it depends on the presence and extent of stunned and hibernating myocardium and the ability to completely revascularize the hibernating tissue. Elefteriades and Edwards (22) suggested that there are two modes of benefit from CABG in such patients. First, recruitment of hibernating muscle and second, protection of the heart from future infarction by the constructed bypass grafts. In their opinion, there is no ejection fraction that is too low and no ventricle that is too big to undergo CABG surgery.

However, changes in LVEF may not reflect the postoperative improvement in coronary flow reserve in areas of viable myocardium with no resting ischemia. Therefore, a patient with no significant improvement in LVEF can still have improved heart failure symptoms due to resolution of ischemic LV dysfunction induced by exercise (6).

Limitations of the study:

No randomization against conventional CABG or OPCAB because there is still controversy about the ideal surgical method for management of such patients with poor left ventricular function. OPCAB does not allow for total revascularization which is important for event-free survival and improving the lifestyle in those patients. Also such poor hearts may not tolerate cardioplegic arrest and global myocardial ischemia during conventional CABG despite the myocardial protection technique.

In Conclusion

There is a significant number of patients with ischemic left ventricular dysfunction in whom surgical revascularization may be the only chance for symptomatic improvement and survival. The criteria to operate on such patients with low ejection fraction is the presence of ischemic myocardium whether detected from the symptomatic status or by myocardial viability studies in addition to graftable coronary arteries. The on-pump, beating-heart technique was associated with good early outcome with no hospital mortality and no perioperative myocardial infarction supporting that it is an excellent approach in such high-risk patients who may not tolerate cardioplegic arrest and at the same time also don't tolerate to be operated on totally without the extracorporeal circulation.

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PULSATILE VERSUS NON-PULSATILE CARDIOPULMONARY BYPASS

ABSTRACT

Fifty patients with rheumatic valvular heart disease subjected for open heart surgery were randomly studied in the Cardiothoracic Surgery Department in Mansoura University between November 1998 and December 1999. This study included 29 males and 21 females. The same anesthetic technique and standard cardiopulmonary bypass were used in all patients with aortic and bicaval cannulation, bubble oxygenator and moderate systemic hypothermia (rectal temperature at 29°C). The patients were divided into two groups: group A, where pulsatile flow was used and group B, where non-pulsatile flow was used. Data were presented as mean ± SD.

There was no significnat difference in the demographic data of both groups regarding age, weight, height and body surface area (BSA). There was no significant difference between both groups regarding hemodynamic data including mean blood pressure, perfusion flow rate, aortic clamp time and perfusion time. Also, there was no significant difference between both groups regarding arterial oxygen saturation, arterial oxygen content and rectal temperature.

On the other hand, there were highly significant differences between both groups A and B respectively regarding venous oxygen saturation (89±10 vs 80±11%, P<0.006), venous oxygen content (19±2.2 vs 17±2.5 gm%, P<0.006), arterio-venous oxygen content difference (3±2 vs 5±2.2 gm%, P<0.004) and whole body oxygen consumption (68±43 vs 103±49 ml/min/m2, P<0.01). There were significant differences between both groups A and B respectively regarding the brain recovery time (31±34 vs 208±146 min, P<0.000), extubation time (330±120 vs 560±294 min, P<0.0007), mortality rate (4 vs 8%) and postoperative hospital stay (15±9 vs 28±26 days, P<0.03).

We can conclude that pulsatile perfusion is more physiologic with less operative stress, and lower whole body oxygen consumption. Also, rapid brain recovery, early extubation and lower postoperative hospital stay accompany it. So we recommend the use of pulsatile perfusion during cardiopulmonary bypass.

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INTRODUCTION

Although the debate still continues over the effectiveness of pulsatile versus nonpulsatile perfusion, it has been clearly proven that there are several significant physiological benefits of pulsatile perfusion during cardiopulmonary bypass (CPB) compared to non pulsatile perfusion [1].

Neurological injury continues to be a significant source of preoperative morbidity and mortality in cardiac surgical procedures. To reduce the incidence and/or severity of

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Although much has been learned about cerebral physiology during CPB in the past decade, the role of alterations in cerebral blood flow (CBF) and cerebral metabolic rate of oxygen (CMRO2) during CPB and the unfortunately common occurrence of neurophysiologic injury still is understood incompletely. It is apparent that during CPB temperature, depth of anaesthesia, CMRO2 and PaCO2 are the major factors that affect CBF [3].

Despite numerous advances in cardiac surgical technique, there have been few changes in perfusion methods since the early days of open heart surgery in particular, the use of nonpulsatile flow during extracorporeal circulation (ECC) has continued. Much of the uncertainty regarding the possible dangers of nonpulsatile flow and the theoretical benefits of the more physiological pulsatile flow may be attributed to two principal factors: (1) The lack of clear objective data on organ metabolism during non pulsatile ECC and (2) The fear of increased hemolysis from pulsatile flow as suggested in the earlier studies [4].

The pulsatile flow was used as early as 1978 by Taylar et al., when they evaluated a new commercially available pump system able to deliver pulsatile flow. They found that this pump was reliable, simple to operate, and able to produce satisfactory arterial pulsatile flow at conventional flow rates. They also found that this flow does not produce any increased incidence of hemolysis, platelet or blood cell depletion when compared with nonpulsatile perfusion [5].

The fears that pulsatile perfusion would be associated with increased haemolysis are widespread although not supported by objective data and it dates back to the earliest days of open heart surgery [5].

The use of pulsatile perfusion during cardiopulmonary bypass is still controversial in the literature [6].

Aim of the work

The aim of this work is to compare between pulsatile and non pulsatile cardiopulmonary bypass regarding venous oxygen saturation, venous oxygen content, arteriovenous oxygen content difference, whole body oxygen consumption, brain recovery time, extubation time, overall mortality and postoperative hospital stay. This will allow us to use the best type of perfusion during cardiopulmonary bypass.

Patients and Methods

This randomized prospective study was done in the Cardiothoracic Surgery Department, Mansoura University between November 1998 and December 1999. It included 50 patients with rheumatic valvular heart disease subjected to open cardiac surgery. Our study included 29 males (58%) and 21 females (42%) (Table 1). The patients were divided into two groups:

Group A: In which pulsatile cardiopulmonary bypass was used. It included 25 patients, 16 males and 9 females, 12 patients with aortic valve disease (AVD), 6 patients with mitral valve disease (MVD), 5 patients with aortic and mitral valve disease, one patient with endocarditis of the mitral valve and one patient with endocarditis of the aortic valve.

Group B: In which non-pulsatile cardiopulmonary bypass was used. It included 25 patients, 13 males and 12 females, 9 patients with aortic valve disease, 14 patients with mitral valve disease

and 2 patients with aortic and mitral valve disease (Table 2).

In group A, aortic valve replacement (AVR) was done in 13 patients, mitral valve replacement (MVR) was done in 7 patients and double valve replacement (DVR) was done in 5 patients.

In group B, AVR was done in 9 patients, MVR was done in 14 patients and DVR was done in 2 patients (Table 3).

The anesthetic technique used in both groups was the same. All patients were premeditated with 0.05mg/Kg midazolam and 1□g/Kg fentanyl I.V. 10 minutes preoperatively. Prior to anesthesia induction, a left radial artery (20G) and a right subclavian central venous catheters were inserted under lidocaine local anesthesia (1%) to monitor the arterial blood pressure, blood gases and central venous pressure. Anesthesia was induced by slow I.V. administration of fentanyl 30□g/Kg and 0.07 mg/Kg pipecuronium to provide neuromuscular blockade and facilitate tracheal intubation. With loss of consciousness, positive pressure ventilation was begun via face mask at a rate of 12-15 breaths per minute. Patients were mechanically ventilated with 100% O2 and the end-tidal CO2 was monitored and maintained between 35-40 mmHg. Anaesthesia was maintained with incremental doses of fentanyl, mediazolam, isoflurane 0.2-0.8% and pipecuronium to maintain muscle relaxation. During all procedures, HR, rhythm and computerized ST segment analysis were monitored on ECG monitor, pulse oximetry for O2 saturation measurements. A urinary catheter was placed to monitor urine output and rectal and nasopharyngeal temperatures were continuously monitored.

Sarns roller pump model 7000 was used in both groups. In group A, (pulsatile group) the arterial line was short to make the pulsatile wave maximal. The trigger mode of pulsatile flow was chosen as it is simple and does not need extra connections to the patient as in the synchronized mode. The heart rate was adjusted to be the same as the prebypass heart rate and the pulsatile waveform was adjusted to be similar in height and width to the prebypass pressure wave in order to minimise hemodynamic changes and to give a pump output equal to the calculated cardiac output depending on the body surface area. This technique was successful as it avoids asynchrony between the pump ejection and the heart ejection.

The following regimen was used in the pulsatile group:

1) At the onset of ECC nonpulsatile flow was used until left ventricular ejection ceased or putting the aortic clamp.

2) Pulsatile flow was used during the whole period of aortic cross clamp.

3) Nonpulsatile flow was used from the begining of left ventricular ejection till the end of bypass.

In the first few minutes of bypass, continuous flow was given and this was augmented on the cardiac flow to give a final pulsatile flow and this was also used in the few minutes from the start of successful defibrillation to the end of bypass and this also gave a final pulsutile flow.

In group B (nonpulsatile group), continuous flow was used and the pump output was calculated from the formula:

Pump output = BSA x CI (2.4) L/min., where; BSM = Body surface area and CI = cardiac index.

The BSA was calculated from special charts using body weight and height. The heart is also ejecting in this group in the first few minutes of bypass and also after successful defibriliation till the end of bypass with a final pulsatile flow. So the actual comparison between both groups in this study will be in the periord of ischaemic arrest which is the longest period of bypass compared to the begining and end of bypass.

Included in this study were all patients with rheumatic valvular aortic or mitral valve disease or combined aortic and mitral valve disease subjected to open heart surgery. Excluded from this study were all patients who died on table or in the immediate postoperative period or patients who did not show brain recovery after 12 hours.

Both groups were compared regarding venous oxygen saturation, venous oxygen content, arteriovenous oxygen content difference. These data were obtained by immediate blood gas analysis using AVL 995 blood gas analyser. They were also compared regarding whole body oxygen consumption (VO2) while was calculated from the standard Fick's principle:

VO2 = (Ca O2 - CvO2) X Perfusion Flow rate / Body surface area.

where:

VO2 = whole body oxygen consumption.

CaO2 = Arterial oxygen content.

CvO2 = Venous oxygen content.

After skin closure, all patients were transfered to the surgical intensive care unit (ICU) and it took about 15 minutes from the skin closure to stabilize the patient in the ICU. All patients were mechanically ventilated using Bard Ventilators. The scoring of the level of consciousness as an indicator for brain recovery was assessed using the Birmingham's level of consciousness in which the patient gots 15/15 if becomes fully conscious (Table 4).

Both groups were compared regarding the time of full brain recovery. When all criteria of weaning from mechanical ventilation were fulfilled, the patients were extubated. Both groups were also compared regarding extubation time, mortality rate and postoperative hospital stay.

Results

Demographic data are persented in table (5). There was no significant difference between both groups A (pulsatile) and B (nonpulsatile) respectively regarding hemodynamic data including mean blood pressure, perfusion flow rate, aortic clamp time and perfusion time (Table 6). Table (7) shows arterial and mixed venous blood gas parameters, rectal temperature in both groups, and whole body oxygen consumption.

There was non-significant difference between both groups A and B respectively regarding arterial oxygen saturation, arterial oxygen content and rectal temperature. On the other hand, there were significantly higher venous oxygen saturation and venous oxygen content values during pulsatile CPB than non-pulsatile CPB ($P<0.006$), while, arterio-venous oxygen content difference and whole body oxygen consumption showed significant lower values during pulsatile CPB when compared with non-pulsatile CPB ($P<0.01$) (Table 7).

Table (8) shows postoperative data including brain recovery time, extubation time, and postoperative hospital stay.

Table (1): Sex distribution.

Sex	Group A (pulsatile)	Group B (nonpulsatile)	Total
Male	16 (64%)	13 (52%)	29 (58%)
Female	9 (36%)	12 (48%)	21 (42%)
Total	25 (100%)	25 (100%)	50 (100%)

Table (2): Diagnosis.

Diagnosis	Group A (pulsatile)	Group B (nonpulsatile)
AVD	12	9
MVD	6	14
AVD & MVD	5	2
Endocarditis of MV	1	-
Endocarditis of AV	1	-
Total	25	25

Table (3): Procedure.

Procedure	Group A (pulsatile)	Group B (nonpulsatile)
AVR	13	9
MVR	7	14
AVR & MVR	5	2
Total	25	25

Table (4): Birmingham scoring of level of consciousness.

Eye opening		Best verbal response		Best motor response	
Spontaneous	4	Oriented	5	Obeys commends	6
Opening to speech	3	Confused	4	Localizing pain	5
Opening to pain	2	Inappropriate words		Withdrawal to pain	4
Non	1	Incomperhensive	3	Flexion to pain	3
		Sounds	2	Extension to pain	2
		Non	1	Non	1

Table (5): Demographic data of both groups (data are expressed as Mean ± SD).

	Pulsatile group	Non-pulsatile group
Age (years)	24 ± 13	25 ± 11
Weight (Kg.)	58 ± 22	59 ± 21
Height (cm.)	156 ± 25	164 ± 22
BSA (m2.)	1.6 ± 0.37	1.6 ± 0.4

Table (6): Hemodynamic data of both groups (data are expressed as Mean ± SD).

	Pulsatile group	Non-pulsatile group
Mean blood pressure (mmHg.)	45 ± 14	46 ± 12
Perfusion flow rate (L/min/m2.)	3.5 ± 1	3 ± 1
Aortic clamp time (min.)	65 ± 32	68 ± 21
Perfusion time (min.)	112 ± 42	118 ± 36

Table (7): Arterial and mixed venous blood gas and other parameters of both groups (data are expressed as Mean ± SD).

	Pulsatile group	Non-pulsatile group	P value
Arterial oxygen saturation (%)	99 ± 0.4	99 ± 0.3	
Venous oxygen saturation (%)	89 ± 10	80 ± 11 *	<0.006
Arterial oxygen content (gm.%)	22 ± 0.4	22 ± 0.6	
Venous oxygen content (gm.%)	19 ± 2.2	17 ± 2.5 *	<0.006
Arterio-venous oxygen content difference (gm.)	3 ± 2	5 ± 2.2 *	<0.004
Oxygen consumption (ml./min./m2.)	68 ± 43	103 ± 498 *	<0.01
Rectal temperature (oC)	28.9 ± 0.18	29.1 ± 0.2	

*** P < 0.05 Significant when compared with pulsatile group.**

Table (8): Postoperative data of both groups (Data are expressed as Mean ± SD).

	Pulsatile group	Non-pulsatile group	P value
Brain recovery time (min.)	31 ± 34	208 ± 146*	<0.000
Extubation time (min.)	330 ± 120	560 ± 249 *	0.0007
Postoperative hospital stay (days)	15 ± 9	28 ± 26 *	<0.03

*** P < 0.05 Significant when compared with pulsatile group.**

Significant rapid brain recovery (P<0.000), faster extubation (P<0.0007), and shorter hospital stay (P<0.03) accompanied pulsatile CPB when compared with non-pulsatile perfusion.

Discussion

Although the debate still continues over the effectiveness of pulsatile versus nonpulsatile perfusion, it has been clearly proven that there are several significant physiological benefits of pulsatile perfusion compared to nonpulsatile perfusion [1]. The nonpulsatile perfusion was first used in 1954 by Gibbon and the pulsatile perfusion was first used in 1978 by Taylor et al, (1978). However, the majority of perfusions used today are nonpulsatile for fear of hemolysis. This issue was studied by Taylor et al. in twenty patients and they found no evidence of increased hemolysis with pulsatile flow. They found also no increased depletion of red blood cells or platelets in pulsatile flow when they used pulse pressure of 25 to 30 mmHg at mean flow rates of 3 to 4 L/min. [5]. Also, Minami et al., (1990) found no significant difference between pulsatile and non pulsatile perfusions in hemoglobin or plasma-free hemoglobin contents postoperatively [6]. In our study, hemolysis was found in one out of 25 patients with pulsatile perfusion (4%) and this was corrected during bypass by decreasing occlusion of the arterial limb and it is our policy to decrease the occlusion of the arterial limb in pulsatile perfusion to avoid hemolysis.

The majority of articles comparing pulsatile and nonpulsatile perfusions are experimental and few are clinical. Trinkle et al., (1969) in their experimental work found that pulsatile perfusion is associated with reduced lactic acid production [7]. Matsumoto et al., (1971) in their experimental work on dogs found that in pulsatile flow there is increased lymph flow and improved capillary blood flow in the brain microcirculation which has a protective effect on brain tissues and nerve cells [8]. Hindman et al., in (1994) in their experimental research on white rabbits found that in the uninjuried rabbit brain, nonpulsatile perfusion perse does not appear disadventageous in terms of brain blood flow or oxygen metabolism at 27oC. They suggested additional studies of brian histology and or neurologic outcome before neurologic benefits of pulsatile CPB can be confirmed or refuted [2]. Cooke et al., (1997) in their experimental work on dogs found that pulsatility has no effect on cerebral or renal perfusion over a broad range of cardiopulmonary hypothermic and flow conditions. Cerebral blood flow and metabolism were functions of temperature rather than pulsatility or flow rate. Renal blood flow was affected by both temperature and flow rate but not by pulsatility [9].

Jacobs et al., (1969) in their experimental work found that pulsatile flow showed improved renal excretory function in terms of total urine flow and sodium excretion with lower vascular resistance[10]. Lodge et al., (1997) in their study on piglets found improved regional blood flow to the myocardium and kidneys in pulsatile CPB compared to nonpulsatile CPB [11]. Under et al., (1997) in their experimental study on piglets found improved cerebellar, basal ganglia, brain stem as well as global cerebral blood flow during pulsatile CPB using the radionuclide labeled microsphere technique [12].

Champsaur et al., (1997) in their experimental work on preterm fetal lamb found significantly lower systemic vascular resistance in pulsatile versus nonpulsatile flow (550 $\pm$ 160 vs 821 $\pm$ 212 dynes/sec./cm-5.) and this was due to the

release of endothelium derived relaxing factor through oscillating shear stress [13]. Vedrinne et al., (1998) in their experimental study on fetal lamb found significantly lower maternal systemic vascular resistance under pulsatile versus nonpulsatile flow (9.1 $\pm$ 0.6 IU vs 12.7 $\pm$ 1.1 IU) due to nitric acid release form the fetoplacental unit under pulsatile fetal flow [14]. Hutcheson and Griffith, (1991) in their experimental work found that the greater peak shear stress of pulsatile flow inhibits erythrocyte aggregation and flow stagnation and promotes release of endothelial derived vasodilators such as prostacyclin and nitric oxide [15].

The components of the extracorporeal circuit have not been fully investigated regarding the quality of the pulsatility [1]. In their experimental work on piglets, Under et al., (1998) found that the criteria for pulsatility evaluation were based upon pulse pressure (between 30 and 40 mmHg), aortic dp/dt (greater than 1000 mmHg/s.), and ejection time (less than 250 ms). They found that in addition to a pulsatile pump, the aortic cannula and the type of membrane oxygenatos must be chosen carefully to achieve the best physiologic pulsatile flow during pulsatile CPB. They found the best membrane oxygenator to be Capiox 308 hollow fiber membrane oxygenator and the best aortic cannula to be that with a very short Fr. tip [1].

In our study, the best physiologic pulsatile wave was adjusted by giving the same prebypass heart rate, adjusting the height and width of the pulsatile wave to be the same as the prebypass arterial wave of the patient, by keeping the pulse pressure between 30 and 40 mmHg, by using a nonrestrictive and carefully estimated aortic cannula, by avoidance of long-tip aortic cannula, and by making the arterial limb of the circuit to be as short as possible.

Inzoli et al., (1997) in their experimental analysis recommended the reduction of the length of the arterial pipe lines in order to optimize the pulsatile power along the circuit [16]. In our study the length of the arterial lines was made as short as possible in the pulsatile group to optimize the pulsatile power along the circuit. This was also done in the nonpulsatile group to avoid exposure of the blood to an unnecessary artificial tubing surface.

Although clinical studies on pulsatile perfusion started on 1976, yet, the number of studies was not sufficient to solve the problem and so the majority of perfusions now are still nonpulsatile. Taylor et al., (1978) compared the levels of cortisol during pulsatile and nonpulsatile perfusions. They found that there was a significant reduction in plasma cortisol levels during nonpulsatile perfusion as a result of adrenocortical hypofunction and this reduction was prevented in the pulsatile perfusion [17]. There was no significant difference in both groups in cortisol level two and twenty four hours after the end of ECC [17]. Taylor et al., (1978), studied the influence of the type of perfusion on the response of anterior pituitary gland to the thyrotropin releasing hormone and plasma levels of adrenocorticotropic hormones (ACTH). They found subnormal pituitary function and lower levels of ACTH in the nonpulsatile flow and this was prevented by the use of pulsatile flow. The pituitary gland did not respond to the tropic stimulus of thyrotropine-releasing hormone during nonpulsatile perfusion [18]. This pituitary hypofunction was present in all patients in

the nonpulsatile group and was reversed 30 and 60 minutes after ECC. On the other hand, the response of anterior pituitary gland to thyrotropin-releasing hormone (TRH) was normal in the pulsatile group [18].

There was no significant differences between both groups in postoperative hemodynamic parameters [6]. Minami et al, (1990), on their study of 30 patients submitted for CABG found that there was significantly higher levels of mean arterial blood pressure, positive fluid balance and total peripheral vascular resistance with nonpulsatile perfusion compared with pulsatile perfusion [6]. Badner and Doyle, (1997) measured the radial artery pressure gradient in 80 patients subjected to CABG during and after CPB. They found significantly higher mean pulse pressure measured at the aortic root in pulsatile versus nonpulsatile group during CPB ($P<0.0001$). However, there was no significant difference in both groups after CPB [19].

Pulsatile perfusion decreases vascular resistance, increases the uniformity of tissue perfusion and improves tissue perfusion [20]. The clinical experience in patients with nonpulsatile perfusion suggest that blood volume redistribution resulting from increased vascular resistance may lead to serious complications such as fluid accumulation in the lungs and brain and myocardial strain caused by fluid overload [21]. Minami et al., (1990) in their study on 30 patients submitted for CABG found higher peripheral vascular resistance and mean arterial pressure during nonpulsatile perfusion than during pulsatile perfusion. They explained this effect by the constricting effect of catecholamines (alpha adrenergic stimulation) in the precapillary circulation. They also found significantly higher venous compliance in patients with nonpulsatile perfusion and they explained it by higher catecholamines that lead to venoconstriction. This leads to increased resistance in the venous bed, increased mean capillary pressure, increased capillary pressure, increased filtration in the capillary region and tendency to swelling in patients with nonpulsatile perfusion [6].

They also found that the net fluid balance during CPB was 40% higher in patients with nonpulsatile perfusion [6]. Minami et al., (1990) compared pulsatile with nonpulsatile perfusion 5 minutes after institution of CPB. They found lower levels of elevation of (168 ± 40 to 444 ± 100 pg/ml. vs 176 ± 56 to 611 ± 108 pg/ml.) and lower levels of elevation of norepinephrine (162 ± 44 to 267 vs 231 ± 48 to 518 ± 100 pg/ml.) in pulsatile perfusion. Also higher levels were found with nonpulsatile perfusion at the end of CPB with highly significant levels as 5 minutes from the start of CPB. In both types of perfusion the plasma catecholamine levels increased 5 minutes after the start of CPB and persisted 4 hours after the end of CPB. The maximal level of catecholamine was nearly two times higher in the nonpulsatile group and the higher catecholamine release in non-pulsatile perfusion is due to absence of pulsation during CPB [6].

Chow et al., (1997) in their clinical study found no significant difference between the arterial and venous lactate, glucose, and beta-hydroxybutyrate ($P > 0.05$) during pulsatile and nonpulsatile CPB [22].

Shepard and Kirklin, (1969) found increased whole body oxygen consumption (VO2) in pulsatile perfusion [20]. This does not cope with our study where we found higher levels of whole body oxygen consumption (VO2) with nonpulsatile

perfusion (103 ± 49 ml./min./m2.) compared to pulsatile perfusion (68 ± 43 ml./min./m2.) with a highly significant difference (P<0.01).

All except one factor in our study that could affect whole body oxygen consumption (VO2) showed no significant difference between pulsatile and nonpulsatile perfusion such as age (24 ± 13 vs 25 ± 11 years), body surface area (1.6 ± 0.37 vs 1.6 ± 0.4 m2.), mean blood pressure (45 ± 14 vs 46 ± 12 mmHg.), perfusion flow rate (3.5±1 vs 3±1 L./min./m2.), arterial oxygen saturation (99 ± 0.4 vs 99 ± 0.3%), arterial oxygen content (22 ± 0.4 vs 22 ± 0.6 gm.%) and rectal temperature (28.9 ± 0.18 vs 29.1 ± 0.20C.) (P>0.05) respectively. The only factor that was left to affect (VO2) was the type of perfusion, and our explaination for higher values of VO2 in nonpulsatile perfusion was higher levels of catecholamines and exagerrated stress response to CPB in nonpulsatile versus pulsatile perfusion.

Taylor et al., (1978), found that the normal stress response patterns become highly significantly disordered during nonpulsatile perfusion with restoration of normal response patterns in the early post ECC phase [5]. The pulsatile perfusion is more physiologic with highly significant metabolic superiority in the pituitary adrenal axis and as a whole it maintains normal stress response pattern during this type of perfusion in contrast to the disordered response associated with nonpulsatile perfusion [18]. Minami et al., 1990 found that pulsatile perfusion can attenuate the catecholamine stress response to CPB [6]. Tripp et al., (1999) used pulsatile perfusion clinically with high perfusion pressure and high flow rate to preserve placental hemodynamic function and maintain fetal viability [23]. There is evidence that during CPB, pulsatile pump flow improves cerebral metabolism [22].

Also, we found significant differences between pulsatile and nonpulsatile perfusions respectively regarding brain recovery time (31 ± 34 vs 208 ± 146 min., P<0.000). Minami et al., 1990 found that the average postoperative tracheal extubation time was about two times longer in patients with nonpulsatile perfusion (276 ± 72 hours vs 162 ± 48 min., P<0.001)[6]. This was also true in our study where the postoperative tracheal extubation time was about two times in the nonpulsatile compared with the pulsatile group (560 ± 294 vs 330 ± 120 min, P<0.0007). In our study, the postoperative hospital stay was about two times longer in patients with nonpulsatile versus pulsatile perfusion (28 ± 26 vs 15 ± 9 days, P<0.03). Murkin et al, 1995 in their clinical study found that eight of their nine deaths were in the nonpulsatile group (5.1% vs 0.6%, P = 0.018). They found the incidence of myocardial infarction was 5.7% in the nonpulsatile group and 0.6% in the pulsatile group (P = 0.010) and the use of intraaortic balloon was more common in the nonpulsatile group (7% vs 1.9%, p = 0.029). The overall percentage of patients having major complications was also significantly higher in the nonpulsatile group (15.2% vs 5.7%, P = 0.006). They found that the duration of CPB, age, and use of nonpulsatile perfusion all correlated significantly with adverse outcome. They concluded that the use of pulsatile perfusion was associated with decreased incidence of myocardial infarction, death, and major complications [24].

Conclusion

We can conclude from our study that pulsatile cardiopulmonary bypass is more physiologic than non pulsatile bypass with less operative stress, and lower whole body oxygen consumption. Also, rapid brain recovery, early tracheal extubation and lower postoperative hospital stay accompany it. So we recommend the use of pulsatile perfusion during cardiopulmonary bypass.

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LONG TERM (FIVE YEARS) RESULTS OF MITRAL VALVE REPAIR VERSUS REPLACEMENT

ABSTRACT

The correction of the mitral valve disease by repair versus replacement depends in multifactors specially the state of the mitral valve mobility which is frequently affected in cases of rheumatic valve disease. The follow of the mitral repair and replacement is very important for assessment; but the long term is poorly to the difficulty of connection with the patients.

In this study many patients underwent, but the patients whose remain in connection for five years follow up are 60 patients with repair and 60 patients with prosthetic replacements.

The repair group were 15 males and 45 females while in replacement group; the males were 40 and females 20 patients. As regards NYHA classes; there is obvious improvement in both groups. According to mortality and morbidity there are five deaths after five years in replacement group and one death in repair group. There is no any thromboembolic complications in the repair group while there are 7 cases affected by thromboembolic complications in the replacement group. The hospital stay in the repair group was 8 while it was 15 dayes in replacement group.

As regard operative techniques; in repair group Carpentier ring was used in all cases beside other maneuvers of repair while in replacement group prosthetic valves were used in all cases. Reoperation was needed in 7 (11%) cases of the repair group due to residual lesion but in 2 (2%) cases of the replacement group due to endocarditis and valve thrombosis.

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INTRODUCTION

Mitral valve repair to correct mitral valve disease has shown an advantage in comparison with replacement because it offers a reduced incidence of thromboembolism and the necessity of anticoagulation related the mechanical prosthesis. In addition, maintenance of the mitral valve apparatus is of particular importance in supporting postoperative ventricular function.

Long term follow up after five years (of the mitral valve repair and replacement) proves the effacy of the repair versus the replacement as regards the preservation of the intrinsic support role of the valve apparatus beside the anticoagulation, thromboembolism LV function.

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Long term follow up after five years (of the mitral valve repair and replacement) proves the effacy of the repair versus the replacement as regards the preservation of the intrinsic support role of the valve apparatus beside the anticoagulation, thromboembolism LV function.

Patients and Methods

This study includes 60 patients who underwent mitral valve repair with prosthetic ring for correction of mitral valve disease. While the other group includes 60 patients who underwent mitral valve replacement with prosthetic valves and they were done during the same period of the repair. The causes of the mitral valve disease in the repair group were as follows; rheumatic 65%, degenerative 20%, and endocarditis 15%. While the pattern of the replacement was as follows; rheumatic 80%, endocarditis 20%.

Standard cardiopulmonary bypass techniques for intracardiac valve operations were used in all patients. Myocardial protection was achieved with systemic hypothermia, ischemic arrest with cold potasium cardioplegia and topical hypothermia in all cases except one case; in which cardiac fibrillator was used without aortic clamping and cardioplegia.

Prosthetic mitral valve rings (Carpantier ring) were used in all cases of repair while prosthetic valves were used in all cases of replacement (St.Jude in 40 cases, Carbomedics in 20 cases).

Mitral repair includes beside the prosthetic ring a series of techniques; including commssurotomy, sliding and cylindrical chordoplasty and suture annuloplasty.

Intraoperative evaluation of the adequacy of valve repair was made by direct visual inspection of the leaflet coaptation, by filling of the left ventricle and observation of regurgitation and by intraoperative transesophageal echocardiography.

Long term follow up (five years) postoperative for all patients is the matter of our study in the form of study of comparisson of the data of both groups including age, sex, ejection fraction, mortality and morbidity after five years.

Results

The demographic data of the patients as shown in table one there was a tendency towards the repair in the early age and the female sex, but no difference as regards the NYHA classes postoperatively.

As regards the Functional improvements; both groups of the patients showed reasonable improvements in NYHA II and III functional classification at follow up in all patients. Patients who underwent valve repair were in the better NYHA class at the time of follow up than parients who underwent valve replacement.

However, the mortality after five years was as following: five patients of the replacement group, one patient of the repair group. The direct cause of death in the replacement group was coagulation anticeagulation problems three of them died fom cerebral hemorrage due to overanticoagulation and one from valve thrombosis and end-stage multiorgan failure

Table (1):

	Repair group	Replacement group
Number of patients	60	60
Sex		
Male	15	40
Female	45	20
Age (mean)	20 10	35 10

Table (2): NYHA classification.

NYHA Class	Repair group	Replacement group
II	40	35
III	16	20
IV	4	5

Table (3): Causes of mitral valve disease.

The cause	Repair group	Replacement group
Rheumatic	20	51
Degenerative	35	0
Endocarditis	5	9

Table (4): Aortic cross clamping time.

	Repair group	Replacement group
Aortic cross clamping time	58 30 minutes	42 20 minutes
Total bypass time	140 50 minutes	100 20 minutes

Table (5): Early post 2 perative complications.

Complications	Repair group	Replacement group	P value
Infarction	0	2	NS
Bleeding & reexploration	2	4	0.04
Neurologic events	1	2	NS
Arrhythmia	12	20	0.01
Wound infection	3	5	NS

Table (6): Hospital stay.

Repair group	Replacement group	P value
8 3 days	15 5 days	NS

NS= not significant

Table (7): Echocardiographic data preoperative data.

Parameter	Repair group	Replacement group
LAD	58 10	64 13
LVEDD	59 12	73 8
LVESD	40 11	50 8
FS	33 10	35 7
EF	45 10	60 8
MVG	10 5	14 4

Table (8): Two years postoperative.

Data	Repair group	Replacement group
LAD(mm)	45 10	60 12
LVEDD(mm)	55 10	65 10
LVESD(mm)	38 11	52 8
FS(%)	32 7	32 7
EF(%)	47 8	46 10
MVG (mmHg)	3 3	5 2

Table (9): Five years postoperative.

Data	Repair group	Replacement group
LAD(mm)	40 11	50 10
LVEDD(mm)	51 10	65 7
LVESD(mm)	35 11	52 8
FS(%)	35 8	33 10
EF(%)	55 10	47 8
MVG (mmHg)	3 3	5 2

Table (10): Two years and preop, rative comparison of the repair.

Data	Preoperative	2 years postop	P value
LAD(mm)	58 10	45 10	<0.001
LVEDD(mm)	59 12	55 10	<0.004
LVESD(mm)	40 11	38 11	<0.001
FS(%)	33 10	32 7	<0.001
EF(%)	45 10	47 8	<0.001
MVG (mmHg)	10 5	3 3	<0.02

Table (11): Five years and preoperative comparison of the repair.

Data	preoperative	5 years postop	P value
LAD(mm)	58 10	40 11	<0.001
LVEDD(mm)	59 12	51 10	<0.001
LVESD(mm)	40 11	35 11	<0.001
FS(%)	33 10	35 8	<0.001
EF(%)	45 10	55 10	<0.001
MVG (mmHg)	10 5	3 3	<0.001

Table (12): Two years and five years comparison of the repair (equatorial assessment

Data	Two years	Five years	P value
LAD(mm)	45 10	40 11	<0.004
LVEDD(mm)	55 10	51 10	<0.001
LVESD(mm)	38 11	35 11	<0.001
FS(%)	32 7	35 8	<0.004
EF(%)	47 8	55 10	<0.001
MVG (mmHg)	3 3	3 3	NS

Table (13): Five years comparison between repair w id replacement

Data	Repair	replacement	P value
LAD(mm)	40 11	50 10	<0.001
LVEDD(mm)	51 10	65 7	<0.001
LVESD(mm)	35 11	52 8	<0.001
FS(%)	35 8	33 10	<0.001
EF(%)	55 10	47 8	<0.001
MVG (mmHg)	3 3	5 2	<0.004

due to ignorance of anticoagulant dose. The fivth one was due to prosthetic valve dehescene and acute heart failure. While the patient who died of repair group, was due to arrythemia of unknown cause.

As regards the thromboembolic and the anticoagulant related complications: the five year freedom from thromboembolic was one hundred percent after mitral valve repair and seventy five % after mitral valve replacement.

Reoperation:

The patients that need reoperation through 5 years are 7 patients from the repair group (11.6%) and 2 patients from the replacement group (3.3%). The causes of reoperation in the repair group are recurrent rheumatic activity in 5 cases and residual regurgitation in 2 cases. The operative procedures in all cases were prosthetic valve replacement; no trials of redo repair was done. While the causes of reoperation in cases of replacement group were prosthetic endocarditis in one case and valve thrombosis in the other one.

Discussion

In our study we compared the late results (five years postoperative) of mitral repair and replacement with assessment of the mitral repair procedures after 2 and 5 years. The present study of most patients undergoing mitral valve procedures at our department revealed significant differences in some preoperative criteria of the two groups studied. There was difference between both groups as regards total bypas time and clamping time, as the repair procedures is more complicated and time consuming; but there is no effects on the outcome during the late follow up. Long term valve related problems in our study in patients who underwent valve repair were few in comparison with mitral valve replacement. Depite a high incidence of reoperation for failed repair the good outcome at long term follow up and low valve related morbidity and mortality led us to recommend the repair as a surgical correction of the mitral valve disease instead of replacement as can as possible.

Several series have compared the results of mitral repair with mitral replacement for mitral valve lesions in early postoperative period and midterm, but few series have compared the results at long term period. Duran and colleagues reviewed their experience in Spain, with operative mortality of 2.5% in the repair group. The report of Perrier and colleagues emphasized the durability and freedom from late complications with mitral repair in comparison with valve replacement.

The big difference between our series and Cohn and co-workers is the pathology of the diseased valve that directly affects the results of the repair, most of our patients were rheumatic while in the other series were degenerative.

With this results demonstrating favorable comparison of valve repair with valve replacement in a matched population, and with data now being reported of the late (five years) morbidity and mortality of mechanical valves and mitral repair. The improved long term results of the mitral valve repair let us to recommend the reepair as a solution for the mitral disease to avoid the morbidity and mortality of the prosthesis if the repair was feasible.

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PERI-OPERATIVE RESULTS OF BILATERAL INTERNAL THORACIC ARTERY IN CORONARY ARTERY BYPASS SURGERY

ABSTRACT

This retrospective study was conducted to find out the indications of using bilateral internal thoracic artery grafts (BITAG), the common coronary artery sites which were selected for bypass and the postoperative complications. Patients and methods: Between August 1995 and February 2000, 77 patients underwent CABG using BITAG. There were 3 females 3.9% and 74 males 96.1%. The age ranged from 31 to 75 years mean was 56.3 ± 9.3. Poor left ventricular function was present in 5 (6.5%), moderate in 30 (39%) and good in 42 patients (54.5%). There were 41 smokers (53.2)%, 26 diabetics (33.8%), 23 hypertensives (29.9%), 31 hyperlipidemic (40.3%), 36 patients used to drink alcohol (46.8 %) and 19 patients (24.7%) had family history of coronary artery diseases. Thirty-three patients (42.9%) had myocardial infarction before the procedures. The procedures were done on emergency bases in one patient (1.3%), urgent in 6 (7.8%) and elective in 70 patients (90.9%).

Results: The total number of grafts was 259 and the mean number of grafts per patient was 3.35 ± 0.7 with no hospital mortality. The LITA was grafted to 91% of LAD and RITA to 51% of RCA. There were 7.8% developed AF and 5.2% had sinus tachycardia. Three 3.8% had sinus bradycardia and 1.3% went to nodal rhythm. Two patients 2.6% required exploration for surgical bleeding and 2.6% bled but did not require exploration. One patient 1.3% developed deep wound infection, 6.5% had superficial lower end sternal wound infection, 2.6% had superficial lower end leg wound infection and mediastinal dehiscence in 2.6%. Three patients 3.8% had non-cardiac pain. Statistically LV function had a significant effect on wound infection P=0.01. However, there was no any significant effects of the other risk factors on wound infection, dysrthymia, postoperative pain or bleeding. Conclusion: Bilateral internal thoracic artery grafting would be preferred in elective situation for selected patient, in whom arterial revascularization would last optimum and difficult to be repeated (young age, family history, hyperlipidemia and diffuse disease). Grafting LITA to left coronary and RITA to right coronary system without crossing the heart is recommended. Still wound infection in BITA grafts is a risk factor.

Key words: internal thoracic artery in coronary surgery.

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INTRODUCTION

Although the results of coronary artery bypass grafts (CABG) are excellent (1,2), there are continued efforts to improve complete revascularization, short and long-term benefits, which are influenced by crucial factors. Sites and techniques used in

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bypass grafting are dependant factors in determining the early results (3). Patency of the bypass conduits has been considered as an important factor in long-term results (4,5,6,7) Inspite of knowing that coronary artery diseases in the majority of cases are progressive systemic diseases could affect the grafts as well as the coronary arteries.

In recent years, various publications have demonstrated the supremacy of the internal thoracic artery (ITA) over the saphenous vein in patency (6,8) when used as a single (9), bilateral (10,11), sequential or even as a free graft. However, using bilateral internal thoracic artery grafts (BITAG) as a routine procedure creates some debates. Early post operative wound infection and subsequent sternal dehiscence in diabetics (12) and obese patients (13) have raised concern. Others reported increased incidence of surgical bleeding and respiratory dysfunction (14,15) in bilateral than in single use of internal thoracic arteries. Heart failure, emergency operations and elderly group of patients are another challenges.

This retrospective study was conducted to find out the indications of using BITAG, the common coronary artery sites which were selected for bypass and the postoperative reported complications in this series.

Patients and Methods

Between August 1995 and February 2000, 77 out of 647 consecutive patients underwent CABG using BITAG at Bupa Hospital Leicester UK. The information for these patients was obtained from the patients' clinical records including pre-operative assessment, operative reports and postoperative follow up data.

There were 3 females 3.9% and 74 males 96.1%. The age ranged from 31 to 75 years mean 56.3 ± 9.3 years. Eight patients (10.4%) were of age 44 years or less, 57 (74%) between 44-64, and 12 (15.6%) of 65 or above. Poor left ventricular (LV) function was present in 5 (6.5%), moderate in 30 (39%) and good in 42 patients (54.5%). There were 41 smokers (53.2%), 26 diabetics (33.8%), 23 hypertensives (29.9%), 31 hyperlipidemic (40.3%), 36 patients used to drink alcohol on regular bases within the acceptable average (46.8 %) and 19 patients (24.7%) had family history of coronary artery diseases. Thirty-three patients (42.9%) had myocardial infarction before the procedures. The left coronary system was dominant in 24 patients (31.2%) and the right coronary system was dominant in 53 patients (68.8%).

Ulcerative colitis under medical therapy was present in one patient (1.3%), obesity in one patient (1.3%), calcific aortic stenosis with ascending aortic aneurysm in one (1.3%), left ventricular aneurysm in one (1.3%) and aneurysm with thrombus in another one (1.3%), emphysema in 2 patients (2.6%), one of them has chronic HbB, chronic peptic ulcers in 2 patients (2.6%), mitral valve incompetence grade I to II was present in 3 patients (4%), peripheral arterial diseases were present in 5 patients (6.5%), with obvious carotid stenosis in 3 (4%), with Leriche syndrome in one (1.3%), hemiparesis in one (1.3%) and left leg claudication in one (1.3 %).

All the studied patients had pre and post-operative cardiac enzymes, chest X rays, ECG, 60% had thallium study pre-operative and all had pre-operative echocardiography and selective coronary angiography. Sixty-

nine 69/77 patients (89.6%) had coronary angioplasty including dilatation and stenting.

The procedures were done on emergency bases in one patient (1.3%), urgent in 6 (7.8%) and elective in 70 patients (90.9%). Four patients had previous CABG in another centre (5.2%). One surgical team performed the procedures. All operations were undertaken through median sternotomy. We used to open the pericardium before harvesting the ITAs to explore the coronaries to match the pre-operative angiography with the operative findings. After exploring the ITAs for length and calibre, the harvesting was performed using pinpoint electro-diathermy trying to restrict devitalization of tissues and tantalic liga clips for the side branches. All patients received pedicled ITAs, which in some cases was elongated by segmental skeletonization.

The procedures were conducted using cardio-pulmonary bypass, two-stage single venous cannula and mild systemic hypothermia (rectal temperature 32°C). Myocardial protection was achieved using intermittent cold antigrade crystalloid cardioplegia and topical cold Hartman's solution.

In this study the regimen was to use the LITA to graft the left coronary system and the RITA to graft the right coronary system. In some circumstances when the RITA was used to graft the left system, the RITA was passed through the transverse sinus posteriorly or in the front just across the midline to graft the proximal LAD, diagonal or the intermediate artery.

We did not use the ITAs to graft calcific or end-arterectomyzed arteries. When the RITA did not reach the target site, the radial artery would elongate it.

At the end of the procedures, the regimen was to drain both pleurae separately from the midline and it was a routine to insert sequential pacing wires. Glycerine trinitrate (GTN) was used intra-operatively and early post-operatively, then replaced by oral nitrates once mechanical ventilation was terminated. In the intensive care unit, it was our regimen to give low molecular weight heparin if there were no signs of bleeding until the patient becomes fully ambulated and to continue aspirin. Deltiazim was used for up to 6 months post-operatively when the radial artery (RA) graft was used. We used to treat heart rate more than 100 beats per minute by metoprolol, atrial fibrillation by amiodarone and lanoxine. If this failed after 7 days, it was the policy to convert them by DC shock if it was affecting the heamodynamic. We considered mechanical ventilation for more than 48 hours as respiratory failure, wound infection limited to the subcutaneous tissues as superficial and reaching the sternum or below as deep infection. Bleeding requiring exploration when the drainage was 100 ml/hour and rising. Infarction usually documented by ECG with S-T segment changes supported by cardiac enzymes.

Statistical analysis: Continuous data are expressed as means (± standard deviation or values with 70% CLs) and categorical variables as percentage. Means were compared with unpaired t-test and proportions with Chi-square or Fishers exact test as appropriate. Risk factors for early, late and over all mortality were examined using multivariate logistic regression. Kaplan-Meier estimator and actuarial method estimated Time related events (dichotomous variables). A probability value of $P< 0.05$ was considered as significant.

Table 1: Relation of post-operative bleeding to the risk factors.

Pt no	Age	Sex	Smoking	Diabet	Hypert.	Hyperl	F.h.	LV. F.	No. G.
27	62	M	No	No	No	Yes	No	M	4
30	46	M	Yes	Yes	No	No	No	G	4
58	63	M	No	No	No	Yes	No	M	3
75	64	M	Yes	Yes	Yes	No	No	G	4

Table 2: Relation of post-operative infection to the risk factors.

Pt no	Age	Sex	Smoking	Diabet	Hypert.	Hyperl	F.h.	LV. F.	No. G.
4	56	M	No	Yes	Yes	No	No	G	3
7	55	M	No	Yes	No	No	Yes	M	4
8	54	M	Yes	No	Yes	Yes	Yes	M	3
34	68	M	No	No	No	No	No	M	2
39	55	M	Yes	No	No	No	No	M	3
40	62	M	Yes	Yes	No	No	No	M	4
52	52	M	Yes	No	No	Yes	No	M	2
57	64	M	No	No	No	Yes	Yes	M	5

Results

There were no operative mortalities nor during hospital stay which ranged from 5 to 9 days including 18 to 38 hours in adult cardiac intensive care unit. One patient 1.3% (No. 4) remained in the hospital for 20 days. This 56 years old male was diabetic, hypertensive and on psychotic drugs preoperatively. He had good LV function, dominant RCA with complete obstruction of the LAD down to the apex. He required three grafts diagonal-(LITA), first obtuse marginal-(RSVG) and posterior descending-(RITA). He required 2 DC shock to come back from ventricular fibrillation (VF) after declamping of the aorta and hardly his sinus tachycardia was controlled by metoprolol and terminated in the fifth post-operative day. Subsequently he developed deep wound infection and mediastinal dehiscence.

The total number of grafts was 259, 77 LITA, 77 RITA, 4 radial arteries and 102 RSVG. The mean number of grafts per patient was 3.35 ± 0.7. Seven patients required 2 grafts, 39 required 3, 28 required 4 and 3 required 5 grafts. End-arterectomy was done for 9 arteries 3.4%. Three out of them were done for the RCA. The LITA was grafted to 70 LAD 91%, 2 intermediate 2.6%, 2 diagonal 2.6% and 3 to the OM1 artery 3.8%. The RITA was grafted to 2 OM1 2.6%, 2 OM2 2.6%, 3 distal LCX 3.8%, 4 diagonal 5.2%, 5 AM 6.5%, 6 intermediate 7.8%, 6 LAD 7.8%, 10 PDA 13% one of them elongated using radial artery and 39 to the RCA 51%.

Table 3: relation of post-operative dysrythmia to the risk factors.

Pt no	Age	Sex	Smoking	Diabet	Hypert.	Hyperl	F.h.	LV. F.	No. G.	Dom. Syste.
4	56	M	No	Yes	Yes	No	No	G	3	R
7	55	M	No	Yes	No	No	Yes	M	4	L
10	55	M	No	Yes	Yes'	No	No	M	3	L
12	54	M	Yes	Yes	No	No	No	M	4	L
15	46	M	No	No	No	No	No	G	3	R
22	40	M	Yes	No	No	No	No	G	3	R
24	64	F	No	No	No	No	No	G	4	R
27	62	M	No	No	No	Yes	No	M	4	R
33	62	M	No	Yes	No	Yes	No	M	4	R
38	35	M	No	No	No	No	Yes	G	2	L
53	55	M	Yes	No	Yes	No	No	G	3	R
59	72	F	No	Yes	No	No	No	M	3	R
67	56	M	Yes	Yes	No	No	No	P	5	R
76	61	M	Yes	No	Yes	Yes	No	G	3	R

Table 4: relation of post-operative pain to the risk factors.

Pt no	Age	Sex	Smoking	Diabet	Hypert.	Hyperl	F.h.	LV. F.	No. G.
34	68	M	No	No	No	No	No	M	2
61	66	M	Yes	Yes	No	No	No	M	3
65	35	M	Yes	Yes	No	No	No	P	3

Abbreviations: Pt no: patient number Diabet: diabetes Hypert: hypertension Hyperl: hyperlipideamia F.h: family history LV.F: left ventricular function. No.G: number of grafts.

Six patients 7.8% developed AF postoperatively and four 5.2% had sinus tachycardia all had been controlled by our protocol. Three 3.8% had sinus bradycardia treated by sequential pacing for 48 hours. One- patient 1.3% went to nodal rhythm managed by atrial pacing for 36 hours.

Two patients 2.6% required exploration for surgical bleeding from the right mammary bed. Another 2 patients 2.6% had bleeding controlled by optimising the coagulation profile.

One patient 1.3% developed deep wound infection controlled by open drainage and triple IV antibiotics, 5 patients 6.5% had superficial lower end sternal wound infection and 2 had superficial lower end leg wound infection 2.6%. The over all percentage of infection was 10.4%. Two patients 2.6% developed mediastinal dehiscence did not affect the respiration and managed by chest belt.

Three patients 3.8% had moderate non-cardiac pain required combination of tramadol and non-steroidal anti-inflammatory drugs (diclofenac).

Five patients required intra-aortic balloon pump (IABP) 6.5%; 1 preoperative 1.3%, 2 intra-operative 2.6% and 2 postoperative 2.6%.

Left Lower lobe lung collapse occurred in 2 patients 2.6%. Blood reaction was manifested in 1 patient 1.3% due to presence of abnormal antibodies, protamine reaction in 1 patient 1.3% and poor appetite in another patient 1.3%.

Correlating the relation of the present risk factors as age, sex, smoking, diabetes, hypertension, hyperlipidemia, family history of coronary diseases, LV function, number of grafts done in each patient and the dominant right or left coronary system to the resulting complications as bleeding (table 1), infection (table 2), dysrythmia (table 3) and pain (table 4). It has been found statistically that LV function had a significant effect on wound infection P=0.01, however it could not be proved statistically any significant effects of the mentioned factors on post-operative bleeding, dysrhythmia or pain.

Discussion

The strategy of using the LITA as a graft to the LAD coronary artery has become a standard part of coronary bypass surgery. This graft has high long-term patency rates, graft atherosclerosis is rare and clinical studies demonstrated improved long-term survival and fewer repeat procedures and cardiac events (6,7). Logic seems to dictate that adding the use of the RITA as a bypass graft might further improve the long-term out comes.

Some studies found that using BITA grafts as an in situ coronary artery anastomoses achieves a significant higher repeated CABG free rate compared to the use of single ITA (16,17,18). Exercise thallium scintigraphy for assessment of myocardial revascularization after using BITA and gastro-epiploic artery (GEA) showed satisfactory myocardial perfusion in the majority of the studied cases (19). Until approximately 1980 the use of BITAG was limited to situations in which venous conduits were not available or for very young patients (11).

The current study showed that it was crucial to draw firm guidelines for using BITAG. The major issue based on patient and graft selection. In general, there was no age limit. However, we tried to avoid female gender for two reasons, small calibre and short RIMA in the majority of referred patients to our centre. Some authors prohibit using BITAG in women in the presence of diabetes or obesity (20). The combination of diabetes and obesity are potentiating risk factors for complications in using BITAG. To some extend this combination was excluded in the current study. One patient had this combination with acceptable other risk factors. Fortunately, he had no complications but this represented 1.3% of the studied patients. We found that the majority of patients of age less than 45 years had diffuse disease with increased incidence of calcifications. In our experience we don't use ITAs to graft sites of previous stenting or had end-arterectomy. Poor LV function and emergency procedure were another challenges. Six and half percent of the studied patients had poor LV and 9.1% had their operations as urgent or emergency. We do prefer to avoid the combination of both situations in BITA grafts procedures. It is easy for these patients to drop their systemic pressure or to bleed during harvesting BITAG worsening the border-line physiological reserve of ischaemic myocardium.

In the past, both ITAs were used to graft the important left sided vessels (11). Chow and colleagues (21) reported lower patencies

of both IMAs when coronary arteries other than the LAD were the target vessels. In the current study, the RITA was used in 51% to graft dominant non-calcific RCA. In the presence of calcification or atheromatous vessel radial artery or RSV graft could be used. However, the total percentage of using RIMA to the right coronary system in this study was 70.5%. Galbut and colleagues (22) reported 84.9% patency of RIMA to RCA anastomoses which was lower than 92.1% patency of LITA to LAD. Few RITA grafts were used in this series to bypass the left coronary system. We usually cross the transverse sinus to avoid re-operation injury by laying the graft in front of the aorta if the vessel to be grafted other than the LAD. Endo et al, (3) reported the same experience and added wrapping the RIMA graft with thymic tissues in his experience for the same reason if RIMA has to cross the front of the aorta.

In our experience LITA was the most suitable graft to the LAD and represented 91% in the current study. Chow and colleagues (21) reported the same experience in 413 patients. They found that, although the RITA can reach the LAD in many patients and has good patency to this vessel, the LITA allows more flexibility in bypass of the distal LAD and is less vulnerable to injury if re-operation is necessary. Endo et al, (3) reported in 443 patients 98.5% patency of IMAs which were grafted to LAD and 98.2% to IMAs grafted to RCA. There were also no difference in patency of IMAs grafts used for LAD or LCX.

However, using BITAG as routine procedures has raised some concern. The possibility of hypotension or bleeding during harvesting the ITAs has occurred in some cases of the study. In avoiding such problems, it was our policy to insert Swan janz catheter for monitoring LV performance in every patient subjected to BITAG. Cosgrove and associates (23) documented a significant increased incidence of blood transfusion among patients with BITAG compared with patients with single IMA graft and those with RSVGs only. Uva et al, (24) reported the same experience and they found that there was no difference in the incidence of re-opening for bleeding in both groups. The current study recorded 2.6% incidence of reopening for control bleeding. Both patients were bleeding from the RITA bed. It seemed that this was the side that haemostasis was done by the first assistant at the time of closure.

Increased incidence of early post-operative sternal wound infection is another major concern in using BITAG. Sternal wound infection represents one of the most devastating complications (25). Despite our precautions to ensure an aseptic procedure and the routine use of broad spectrum prophylactic antibiotics, the current study recorded 1.3% deep and 6.5% superficial sternal wound infection. The patient who developed deep sternal wound infection was diabetic and hypertensive. The study could not prove specific risk factor to be responsible about the phenomena. Moderate LV function was the only significant risk factor inspite of presence of other patients with poor LV function and they had no wound infection. The result has led to the presence of crucial factors, which possibly increase wound infection and could not be proved statistically due to the small number of the studied patients. The reported incidence of sternal wound infection in BITA grafting has ranged from 1.6% to 8.5% (20). This range was higher than the range of 0.8% to 2.4% in single IMA graft or RSVGs (25).

Mobilization of IMA leads to devascularization of the ipsilateral hemisternum; if both arteries are mobilized the entire sternum is significantly devascularized (26). Using sternal radionuclide tomography, Carrier and co-worker (27) showed that ITA mobilization caused an important but transient decrease in the sternal blood flow. Parish and associates (25) have shown in canine model that the hemisternum from which the ITA was harvested by skeletonization had a significant higher residual sternal blood flow than that dissected as a pedicle graft. Uva et al, (24) reported absent incidence of deep wound infection in BITAG which were harvested by skeletonization technique.

Because devascularization itself is a risk factor for wound infection or wound dehiscence, BITAG takedown in diabetics and obese patients could be considered hazardous. Grossi et al, (12) reported five fold increase in infection rate of the sternal wound in diabetic patients receiving BITAG, others recorded incidence of 5.7% in non diabetic and 10 % in diabetic (28). However, it was twice as high among the obese and nearly three times higher among the severely obese patients (29). In general Thourani et al, (30) found that diabetes was an independent factor in prediction of morbidity and mortality and diabetes have a worse hospital and long-term outcome after coronary artery bypass grafting.

It has been found in the current study that the incidence of pain among the studied patients was a bit higher than that in other patients underwent CABG in our centre. We believe it might be related to using the diathermy in harvesting the IMAs, which irritates the inter-costal nerves. Probably using the mammary retractor during harvesting in both sides induces fracture or dislocation of the costo-conderal joint creating prolonged pain. On the other hand we tried to avoid using separate chest tube to drain the opened pleurae for the same reason. Bonacchi et al, (14) reported increased incidence of pain among patients underwent BITAG. He demonstrated that the chest tubes inserted in the opened pleurae after harvesting IMAs was a supplementary factor inducing pain post-operatively.

Despite that the regimen used in this study for control of dysrthymia seemed to work well, the incidence was higher in comparison to the other CABG procedures performed in the same centre. It was found that the incidence was more common in grafting dominant right coronary system or after end-arterectomy of the right coronary artery branches. Young patients were more liable to have atrial fibrillation than sinus tachycardia. In general atrial fibrillation was more common in incidence than any other sort of dysrhythmias.

Conclusion

Bilateral internal thoracic artery grafting would be preferred in elective situation for selected patient, in whom arterial revascularization would last optimum and difficult to be repeated (young age, family history, hyperlipidemia and diffuse disease). Grafting LITA to left coronary and RITA to right coronary system without crossing the heart is recommended. Still wound infection in BITAG is a risk factor.

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PREDICTORS OF MORTALITY IN MITRAL VALVE REPLACEMENT

ABSTRACT

This prospective and retrospective study was done to evaluate the predictors or risk factors of mortality in mitral valve replacement (MVR) in the Cardiothoracic Surgical Department, Mansoura University, between January 1994 and December 2001. It included 70 patients divided into two groups. Group (A) included all patients with MVR who died throughout the period of the study whether intraoperatively, early or late postoperatively. This group included 35 patients, 19 males and 16- females with mean age of 34.92 ± 10.50 years. Group (B) or control group included the last consecutive 35 patients who survived after MVR. It included 12 males and 23 females with mean age of 31.34 ± 7.59 years.

Careful clinical examination, ECG, chest X-rays, hematologic investigations and echocardiography were done for all patients. MVR was done for all patients. The risk factors for MVR were compared in both groups.

Preoperative risk factors were low EF and FS (82.9%, in group A and 11.4% in group B with highly significant difference, P = 4.23372E-014, P = 5.5866E-05 respectively), right ventricular dilatation (57.1% and 17.1% in group A and B respectively with highly significant difference P = 8.11343E-06). Other preoperative risk factors included previous mitral valve surgery, low cardiac output (COP), and myopathic right ventricle (P<0.05).

Intraoperative risk factors included severe pulmonary hypertension (80% in group A and 2.8% in group B) with highly significant difference (P = 8.12647E-013), prolonged ischemic time (40% in group A and 0% in group B) with highly significant difference (P = 8.90134E-09) and prolonged pump time (28.6% in group A and 2.8% in group B) with highly significant difference (P = 3.36424E-07). Other intraoperative risk factors included left atrial thrombus, left ventricular posterior wall rupture, thrombosed mitral valve prosthesis, endocaraitis of the mitral valve (MV), low COP, native MV endocarditis and uncontrolled intraoperative bleeding (P<0.05).

Postoperative risk factors included conventional MVR (74.2% in group A and 0% in group B) with highly significant difference (P<0.01), atrial fibrillation (AF) (60% in group A and 37.1% in group B) with significant difference (P<0.05), tricuspid regurgitation (TR) (20% in group A and 8.7% in group B) with significant difference (P<0.05). Other postoperative risk factors included low COP, mediastinitis, diabetic ketoacidosis and ventricular arrhythmia (P<0.05).

We conclude that there are many risk factors for mortality in MVR. Results of MVR could be improved by adequate patient selection and timing for MVR, proper surgical

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Cumulative experience with bileaflet valves has shown very good long-term results in term of low rate of complications, long-term survival, quality of life and low mortality (12). Atrial fibrillation, mediastinitis. ventricular arrhythmias increase the rate of mortality after MVR (1,13,14).

The aim of our study is to determine the predictors of mortality or risk factors in mitral valve replacement and to evaluate the effect of these factors in preoperative, intraoperative, and postoperatvie mortality in mitral valve mortality. This will allow adequate patient selection for MVR. This will also allow suitable expectation of the results of MVR regarding mortality.

Patients and Methods

This randomised prospective and retrospective study included seventy patients submitted for mitral valve replacement (MVR) in the Cardiothoracic Surgery Department between January 1994 and December 2001. The patients were divided into two groups:

Group A: Included all patients with MVR who died between January 1994 and December 2001 whether intraoperatively, early, or late postoperatively throughout the whole period. The total number in this group was 35 patients. This group included 19 males and 16 females. The age range was 15 and 43 years (mean 34.92 + 10.50 years).

Group B: Included the last consecutive 3 5 patients who survived after MVR. It included 12 males and 23 females. The age range was 1 and 51 years (mean 31.34 ± 7.59 years).

Table (1) shows the demographic data in both groups.

The indications for MVR in group A included calcific mitral stenosis (MS) (9 patients), double mitral (DM) (5 patients), calcific MS, previous closed mitral valvotomy (CMV) and left atrial thrombus (LA thrombus) (5 patients), thrombosed mitral valve (MV) and low cardiac output (COP) after MVR (3 patients), MV endocarditis after MVR (2 patients), mitral restenosis after CMV (2 patients) mitral restenosis and severe tricuspid regurge (TR) after CMV (1 patient), severe MR immediately after CMV with low COP (1 patient), severe MR, LA thrombus, and MV vegitations after MV repair (1 patient), severe MR, LA thrombus, severe right ventricular (RV) dilatation and severe TR (1 patient), severe MS, TR, and myopathic RV (1 patient), native MV endocarditis (1 patient), severe MS and severe pulmonary hypertension (PH) (1 patient), severe MR and severe PH (1 patient), and DM and severe TR (1 patient). The indications for MVR in group A are shown in table (2).

The indications for MVR in group B included calcific MS (12 patients), severe MR (8 patients), severe NM and mild MS (6 patients), moderate MR, MS, TR and PH (2 patients), moderate to severe MS and TR (2 patients), moderate to severe MS, and LA thrombus (2 patients), mitral restenosis (1 patient), MV endocarditis and severe TR after MV repair (1 patient) and severe MR, and LA thrombus (1 patient). The indications for MVR in group B are shown in table (3).

Inclusion and exclusion criteria:

Group A: included all patients who died during MVR and in the early or late follow up period from the begining till the end of the period of the study. Excluded from this group all patients who survived after MVR.

Table (1): Demographic data in both groups.

	Group A	Group B
Male	19 (54.3%)	12 (34.3%)
Female	16 (45.7%)	23 (65.7%)
Total	35 (100%)	35 (100%)
Minimal age (years)	15	1
Maximal age (years)	43	51
Mean age (years)	34.92 + 10.50	31.34 + 7.59

Group B: Included the last consecutive 35 patients who survived after MVR and this group is considered as the control group. Excluded from this group are any patient who died in relation to MVR and any patient who survived MVR but not in the last consecutive 35 survived patients after MVR.

Careful history taking and clinical examination were done for all patients. Routine laboratory and hematologic investigations were done for all patients. Chest X-rays, ECG, and echocardiography were done for all patients. All patients were operated upon using standard cardiopulmonary bypass with non pulsatile perfusion. Cold blood cardioplegia with local cooling with ice were used for myocardial protection. Systemic hypothermia was routinely used with a degree of 28-300C. MVR was done for all patients. Ischemic and pump times were recorded for all patients. The patients were refered to the intensive care unit (ICU) and extubated after all criteria for extubation were fulfilled. Discharge was allowed after removal of all lines with clean wound and adjusted coagulation profile. Follow-up was done in the out patient clinic.

Statistical analysis:

All values were expressed as means ± standard deviation (SD). The student t-test was used to compare parametric data and Chi-square test was used to compare nonparametric data. Statistically significant values (S) was assumed if P value was <0.05, highly significant (HS) if P value was <0.01 and non significant (NS) if P value was >0.05.

Results

The preoperative echocardiographic data in both groups are shown in table (4). The statistical differences in the preoperative echocardiographic data and value of significance between both groups are shown in table (5). There were no significant difference between both groups regarding MVA, LVESD, and LVEDD. There was significant difference between both groups regarding LAD. There were highly significant difference between both groups regarding RVD, PAP, EF and FS for evaluation of the risk factors or predictors of mortality in MVR, these risk factors were divided into preoperative, intraoperative, and postoperative risk factors. There may be interference in some factors for example low cardiac output may be a risk factor

Table (2): Indications for MVR in groups A.

Indication	No. of patients	%
Calcific MS	9	25.9
DM	5	14.4
Calcific MS, previous CMV and LA thrombus	5	14.4
Thrombosed MV and low COP after MVR	3	8.7
MV endocarditis after MVR	2	5.7
Mitral restenosis after CMV	2	5.7
Mitral restenosis and severe TR after CMV	1	2.8
Severe MR immediately after CMV with low COP	1	2.8
Severe MR, LA thrombus and MV vegitations after MV repair	1	2.8
Severe MR, LA thrombus, severe RV dilatation and severe TR	1	2.8
Severe MS, TR and myopathic RV	1	2.8
Native MV endocaridtis	1	2.8
Severe MS and severe PH	1	2.8
Severe MR and severe PH	1	2.8
Double mitral and severe TR	1	2.8

Table (3): Indications for MVR in group B.

Indication	No. of patients	%
Calcific MS	12	34.4
Severe MR	8	22.9
Severe MR, and mild MS	6	17.2
Moderate MR, MS, TR, and PH	2	5.7
Moderate to severe MT, and TR	2	5.7
Moderate to severe MS, and LA thrombus	2	5.7
Mitral restenosis	1	2.8
MV endocarditis, severe TR after MV repair	1	2.8
Severe MR and LA thrombus	1	2.8

MS: Mitral stenosis DM: Double mitral. CMV: Closed mitral valvotomy. LA: Left atrial. MV: Mtral valve. COP: Cardiac output. Mitral valve replacement. TR: Tricuspid repair. Mitral regurgitation. RV: Right ventricle. PH: Pulmonary hypertension.

preoperatively, intraoperatively, or postoperatively.

A) Preoperative risk factors:

These are shown in table (6). Low EF and FS were found in 82.9% in group A and 11.4% in group B with highly significant values between both groups (P = 4.23372 EO-14 and 5.55866 E-05 respectively).

RV dilatation was found in 57.1% in group A and in 17.1 % in group B with highly significant difference in both groups (P = 8.11343 E06). Previous MV surgery

Table (4): Preoperative echocardiographic values in both groups.

Factors	Group A	Group B
MVA	1.394 + 0.485	1.514 + 0.433
LVESD	3.597 + 0.960	3.634 + 0.825
LVEDD	5.448 + 0.932	5.748 + 1.062
RVD	2.848 + 0.809	2.085 + 0.478
LAD	7.037 + 1.488	6.24 + 1.411
PAP	60.8 + 17.502	33.285 + 5.998
EF	43.142 + 14.760	65.542 + 6.730
FS	31.314 + 3.340	36.085 + 5.689

Table (5): Statistical differences between preoperative echocardiographic values in both groups.

Factors	Statistical difference between both groups	Value
MVA	0.279539	NS
LVESD	0.836025	NS
LVEDD	0.209943	NS
RVD	8.11343E-06	HS
LAD	0.024582	S
PAP	8.12647E-013	HS
EF	4.23372E-014	HS
FS	5.55866E-05	HS

MVA: Mitral valve area. LVESD: Left ventricular end-systolic diameter. LVEDD: Left ventricular end-diastolic diameter. RVD: Right ventricular diameter. LAD: Left atrial diameter. PAP: Pulmonary artery pressure. EF: Ejection fraction. FS: Fiber shortening.

Table (6): Preoperative risk factors in both groups.

Factors	Group A	Group B
Low EF and FS	29 (82.9%)	4 (11.4%)
RV dilatation	20 (57.1%)	6 (17.1%)
Previous MV surgery:	13 (37.1%)	2 (5.6%)
CMV	9	1
MVR	3	-
MV repair	1	1
Low COP	3 (8.7%)	0 (0%)
Myopathic RV	1 (2.8%)	0 (0%)

Table (7): Intraoperative risk factors in both groups.

Factors	Group A	Group B
Severe pulmonary hypertension	28 (80%)	1 (2.8%)
Prolonged ischemic time (more than 120 min.)	14 (40%) mean (111.3 min.)	0 (0%) mean (56.7 min.)
Prolonged pump time (more than 180 min.)	10 (28.6%) mean (162.0 min.)	1 (2.8%) mean (96.1 min.)
Left atrial thrombus	7 (20%)	3 (8.7%)
LV posterior wall rupture	3 (8.7%)	1 (2.8%)
Thrombosed MV prosthesis	3 (8.7%)	1 (2.8%)
Endocarditis after MVR	2 (5.7%)	1 (2.8%)
Low COP	2 (5.7%)	0 (0%)
Native MV endocarditis	1 (2.8%)	0 (0%)
Uncontrolled bleeding from atriocaval junction and LA appendage	2 (5.7%)	0 (0%)
CABG	0 (0%)	1 (2.8%)

Table (8): Postoperative risk factors in both groups.

Factors	Group A	Group B
Conventional MVR	26 (74.2%)	- (0%)
Tricuspid regurgitation	7 (20%)	3 (8.7%)
Atrial fibrillation	21 (60%)	13 (37.1%)
Low COP	6 (17.1%)	- (0%)
Mediastinitis	6 (17.1%)	- (0%)
Diabetic ketoacidosis	1 (2.8%)	- (0%)
Ventricualr arrhythmia	1 (2.8%)	- (0%)

Table (9): Causes and timing of - death in group A.

Cause of death	No. of patients	%
Low cardiac output	11	31.6
Thrombosed mitral valve	6	17.2
Mediastinitis	6	17.2
MV endocarditis	3	8.5
Posterior LV wall rupture	3	8.5
Uncontrolled operative bleeding	2	5.8
Hepatorenal failure	1	2.8
Cerebral hemorrhage	1	2.8
Congestive heart failure	1	2.8
Uncontrolled diabetic tetoacidosis	1	2.8
Total	35	100:0
Timing of mortality	8	22.9
Early mortality	9	25.7
Late mortality	18	51.4
Total	35	100.0
Overall mitral valve mortality	7.7%	

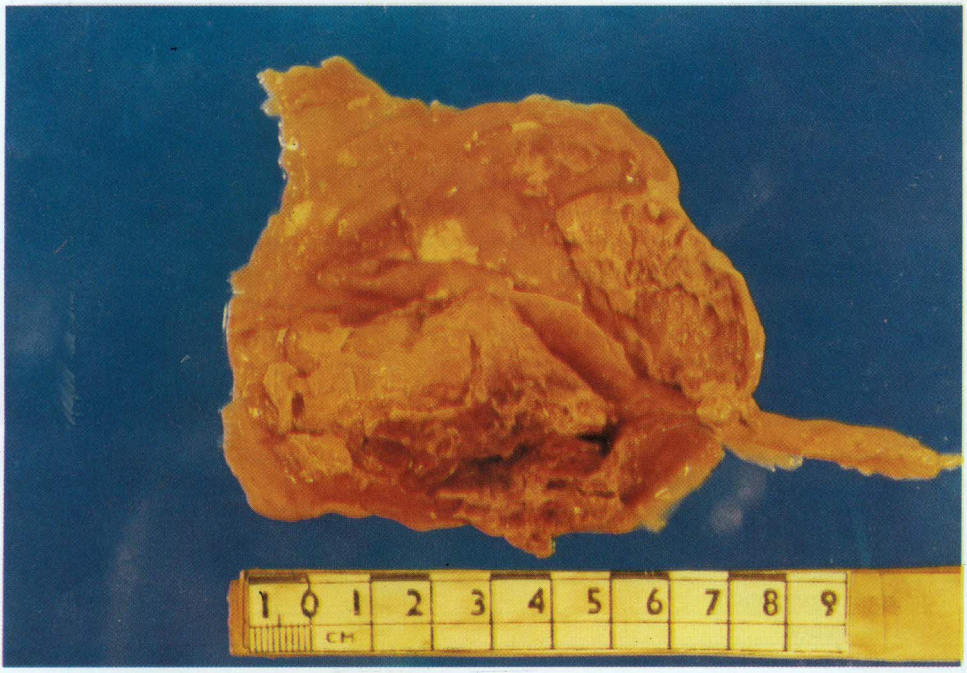

Fig. (l): Huge left atrial thrombus after excision from a patient in group A.

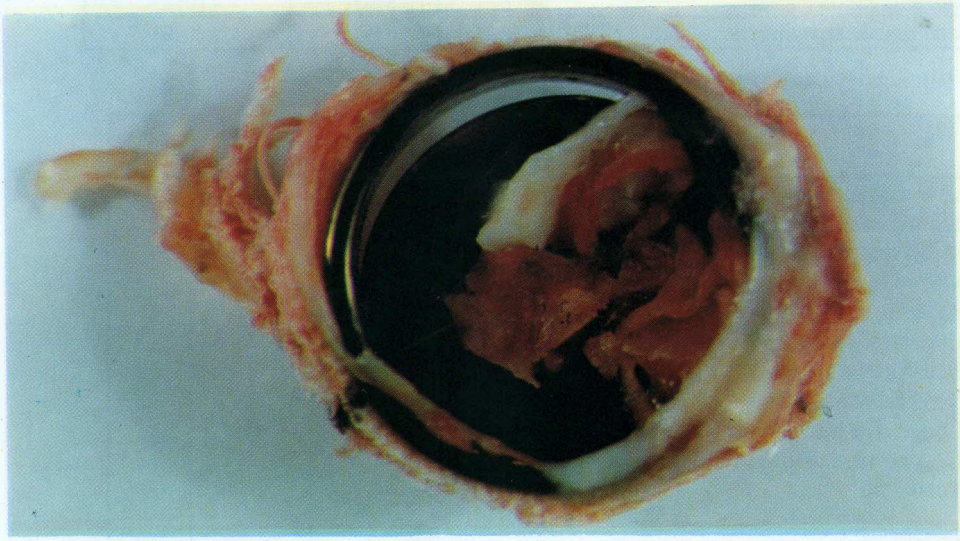

Fig. (2): Thrombosed MV prosthesis after redo MVR in a patient in group. B with central pannus obstructing the valve.

was found in 37.1% in group A and in 5.6% in group B with highly significant difference between both groups. Preoperative low COP was found in 8.7% in group A and myopathic RV was found in 2.8% in the same group with none of these factors in group B.

B) Intraoperative risk factors:

These are shown in table (7). Severe pulmonary hypertension (PH) was found in 80% of patients in group A and in 2.8% of patients in group B with highly significant difference between both groups (P = 8.12647E-013). Prolonged ischemic time was found in 40% of patients in group A (mean 111.3 min.) and in no patient in group B (mean 56.7 min.) with highly significant difference between both groups (P = 8.90134E-09). Prolonged pump time was found in 28.6% of patients in group A (mean 162.0 min.) and in one patient in group B (mean 96.1 min.) with highly significant difference between both groups (P = 3.3642E-07). Left atrial thrombus was found in 20% of patients in group A and in 8.7% of patients in group B with significant difference between both groups (P<0.05). Figure (1) shows a huge left atrial thrombus in a patient in group A after excision. Rupture of LV posterior wall and thrombosed MV prosthesis were found in 3 patients for each of them in group A with none of patients in group B. Figure (2) shows thrombosed mitral valve after excision in a patient in group B. Prosthetic MV endocarditis was found in 5.7% of patients in group A and in 2.8% of patients in group B. Native MV endocarditis was found in 2.8% of patients in group A and uncontrolled intraoperative bleeding was found in 5.7% of patients in the same group with none of patients in group B.

C) Postoperative risk factors:

These are shown in table (8). Conventional MVR was a postoperative risk factor and was found in 74.2% of patients in group A and in 0% of patients in group B with highly significant difference between both groups (P<0.01). Tricuspid regurgitation was also a postoperative risk factor and was found in 20% of patients in group A and in 8.7% of patients in group B with significant difference between both groups (P<0.05).

Atrial fibrillation (AF) was found in 60% of patients in group A and in 37. 1 % of patients in group B with significant difference between both groups (P<0.05). Atrial fibrillation is a postoperative risk factor as it directly lowers the cardiac output. It is also considered as preoperative and intraoperative risk factor. Postoperative low COP, mediastinitis, diabetic ketoacidosis, and ventricular arrhythinia were found in 6, 6, 1, and 1 patients in group A respectively with none of patients in group B with highly significant difference between both groups (P<0.01).

Low COP was the most common cause of death in group A and was found in 31.6% of patients in this group. This was followed equally by thrombosed MV prosthesis and mediastinitis and both were responsible for death in 17.2% of patients in this group. The other causes of death in this group are shown in table (9). In group A, the operatvie, early and late mortality were 22.9%, 25.7% and 51.4% respectively. The overall mortality in implanted MV prosthesis in our department is 7.7%.

Discussion

Age remains one of the most potent predictors of mortality after mitral valve replacement (MVR) or repair (5). Younger

patients subjected for MVR have lower mortality than older patients(I5). There was no significant relationship between age and mortality below the age of 60 years in MVR (P>0.05) (8). Our results cope with those of Ruvolo et al, (1992) because all our patients were below the age of 60 years. MVR in small children carries a high risk, but the long-term results are satisfactory (16). Mechanical MVR carries an accepted operative risk across the spectrum of pediatric age. Operative mortality in MVR in infants and children less than 5 years was 0% (0 out of 6 patients), and 6.2% in children between 5-16 years (1 out of 16 children) (17). The number of patients in Alexiou et al., (2001) study below 5 years is very low (6 patients) and this is also the same in our study where we had one patient in group B aged 1 year who survived MVR for severe congenital mitral regurgitation and pulmonary hypotension. With larger series; Gunther et al., 2000, studied mortality in 35 children under 6 years of age and found it to be 17.1% with improved results in the last 10 years of the study (16). Morbidity and mortality following MVR in elderly (75-82 years) were high, although the follow up showed significant improvement in both symptoms and quality of life of survivors (18). MVR in octogenarians produces a satisfactory early postoperative outcome and moderate medium-term benefit (19). In geriatric age, the operative mortality was 16% (for 70 years or more) (20), 10.4% (for 80 years or more) (19), and 38% (for 72 years - 82 years) (18).

Late mortality after MVR in geriatric age was 33% (for 70 years or more) (20) and 36% (for 80 years or more) (19). In a multivariate study including 67.760 patients, Alexender et al., 2000, found higher mortality in octogenarians undergoing MVR and CABG than younger age group (19.6 Vs 12.2%)(3).

Low cardiac output and acute presentation is a predictor of mortality in MVR (P<0.05). Impaired left ventricular ejection fraction (LVEF) and increased LV diastolic pressure are predictors of mortality (P<0.05) after MVR (15). Severity of mitral regurgitation and type of pathology in the MV are not related to the outcome after MVR while LV dysfimction is related to mortality (8). Patients with LVEF between 10-30% have a 50% operative Mortality (21). Right ventricular ejection fraction (RVEF) </=20% significantly predicted postoperative mortality after MVR (P = 0.0320) (4). Right ventricular failure is a predictor of preoperative mortality in MVR (P<.05) (15). In our study right ventricular dilatation was present in 57.1% of patients in group A and in 17.1% in group B with significant difference between both groups (P<0.05).

Low preoperative functional capacity is linked to higher mortality rate (22). Higher preoperative NYHA functional classification was associated with higher mortality after MVR (1). Patients with higher preoperative fimctional class and higher LV motion score (increased score indicates impaired LV fimction) in MVR and CABG are associated with higher mortality (8). Patients with preoperative functional classification stage III or IV NYHA have high operative mortality (19%) and high overall mortality (41.3%) after MVR (10). In our study low cardiac output was found in 8.7% in group A preoperatively, 5.7% intraoperatively and

17.1% postoperatively. On the other hand none of our patients in group B had low cardiac output ($P<0.05$).

Hospital mortality is significantly higher in redo MVR (24.1%) than MVR for the first time (6.8%) (22). Previous cardiac surgery increases mortality for MVR. The rate of patients referred to mitral or tricuspid surgery after previous cardiac surgery is expected to increase. Preoperative median sternotomy has know risks including injury to or embolism from prior grafts, sternal dehiscence, phrenic nerve injury, excessive haemorrhage and inadvertent cardiac injury leading to morbidity and mortality (23). In our study previous MV surgery was a predictor of mortality as it was done in 37.1% of patients in group A and in 5.6% of patients in group B with significant difference between both groups ($P<0.05$). Right thoracotomy for MVR was found to be a safe and feasible alternative to median sternotomy with hospital mortality rate of 6.4% (23). Transversal trans-septal bilateral approach was used for MVR in 11 patients with no operative mortality (24). The determinants of early mortality for port access (ministernotomy) MVR were redosurgery, age and other patient-related factors (25). In our study, right thoractomy with transversal-trans-septal approach for MVR was used in 3 patients in group B with no mortality. Aris and Cgmara, (1996) studied the effect of severe pulmonary hypertension (PH with pulmonary artery systolic pressure 94 ± 23 mmHg) on MV surgery in 88 patients. Of those patients 64 patients underwent MVR and 24 patients underwent open mitral valvotomy. They found 5.6% operative mortality not related to the degree of pulmonary hypertension. They also found 7.2% late mortality. They found significant drop in systolic PA pressure from 101 + 22 mmHg to 40 + 7 mmHg. They concluded that patients with mitral valve disease may benefit from surgical treatment regardless of the degree of pH (6).

Pulmonary hypertension increases perioperative risk in patients having MVR. Mitral valve replacement could be done in severe PH (pulmonary artery systolic pressure > or = 60 mmHg or mean pulmonary artery pressure > or = 50 mmHg) with an acceptable mortality (15).

Vincens et al. (1995) in their series of 43 patients with MS and severe pH fotuid that perioperative mortality in MVR was 11.9%. They found that the 5 and 10 years mortality in MVR and severe pH was 20% and 36% respectively (15). The late deaths after MVR in pediatric patients was caused by pulmonary vascular disease and congestive heart failure (20). Our results cope with those of Vincens et al. (1955) and Cabablka et al., (1995) as PH was found in 80% of patients in group A and in 2.8% of patients in group B with highly significant difference between both groups ($P<0.01$). So we found that severe PH is a predictor of mortality in MVR. The effect of severe PH is mainly intraoperative, but may be also seen postoperatively. Severe PH leads to congestive heart failure and low cardiac output.

Ruvolo et al., (1995) studied 67 patients with MVR and CABG and found that longer aortic cross clamp time was associated with higher mortality (8). This was also true in our study where we found that prolonged ischemic time (more than 120 min.) was found in 40% in group A and in 0% in group B with highly significant difference between both groups ($P<0.01$). Also prolonged pump time (more than 180 min.) was found in 28.6% in group A and in 2.8%

in group B with highly significant difference between both groups ($P<0.01$). So prolonged ischemic and pump times are predictors of mortality in MVR.

Left atrial (LA) thrombus was a predictor of mortality in MVR in our study. This is true when it is large, firmly adherent to the left atrial wall and 'With fresh friable parts. The large ones take long time for removal and this increases the ischemic time. Firmly adherent ones also increase the ischemic time and predispose to injury of the left atrial wall. Friable parts predispose to systemic embolisation. In our study LA thrombus was found in 20% of patients in group A and in 8.7% of patients in group B with significant difference between both groups ($P<0.05$). Also we had one patient in group A who was lost from uncontrolled bleeding from injured left atrial append age after excision of a firmly adherent huge (more than 12 cm. in diameter) LA thrombus. Figure (1) shows this huge thrombus after excision.

A rare but usually fatal complication of MVR is LV posterior wall rupture. The most frequent cause is partial avulsion of the mitral annulus from the underlying ventricular muscle from application of excessive traction during removal of the valve or insertion of the prosthesis (27). This was true in our study where all four cases were due to partial avulsion of the mitral anulus and three died on table and were in group A. The last one survived after repair and was in group B. The second cause of LV rupture is due to insertion of a large prosthesis (28). The third cause of LV rupture is form changes in the tensile forces after excision of the chordae of the mural leaflet (29). In our study left ventricular wall rupture is a predictor of mortality in MVR ($P<0.05$) and our results cope with those of Zacharias et al., 1995.

Valve thrombosis is linked to higher mortality rate (22). Myken et al. (1995) found that structural valve deterioration was responsible for 5.5% of mortality after MVR (30). In our study MV thrombosis was responsible for 8.7% of mortality in group A and this matches with the results of Myken et al., (1995). Group B had only one patient (2.8%) with thrombosed MV prosthesis who was managed by urgent MVR through right antrolateral thoracotomy. He is doing well after surgery. Figure (2) shows the thrombosed MV prosthesis with central pannus obstructing the valve. Patients with prosthetic valve thrombosis present with progressive left heart failure and cardiogenic shock. Most of them are in NYHA class III-IV. The overall mortality rate is high (41.3%) and the operative mortality is also high (19%). This high mortality is related to difficulty in diagnosis, delay to hospitalization and severe clinical condition on admission (10). This was also true in our study where 3 patients presented with cardiogenic shock, LV failure, and were in NYHA class IV and all died and were in group A and only one patient was in severe hypotension and NYHA class III and this patient survived MVR and was in group B. Prosthetic valve endocarditis was a predictor of mortality in our study ($P<0.05$) and our results cope with those of Buttard et al., 1997.

Myken et al. (1995) found that infective endocarditis is responsible for 7.7% of mortality after MVR (30). In our study, infective endocarditis was responsible for 5.7% of mortality after MVR. Prosthetic

valve endocarditis was associated with more that 60% mortality (31). This was also true in our study where it was 66%. On the other hand Olaison et al., (1996) found lower mortality after MVR for infective endocarditis 8% compare to 11% for those not undergoing surgery. They also found that the adjusted 5-year survival rate of acute surgically treated patients was 91% compared to 69% for the medically treated patients (11). The marked discrepancy between those results is explained by the condition of the patients on admission. Those patients with early disease, normotensive with lower NYHA class, have better prognosis. On the otherhand, patients with delayed discovery, with higher NYHA class and who are in cardiogenic shock have poor prognosis. Our patients belonged to the last category. This was also supported by Detry et al., 1995 where they found that early surgical management of infective endocarditis of the MV will lead to satisfactory results (32).

Native valve endocarditis, although less common than prosthetic valve endocarditis, but it is also a predictor of mortality in MVR. It was found in only one patient in our study in group A.

Uncontrolled bleeding is a predictor of mortality in MVR. It was found in two patients in our study in group A. In one patient the bleeding was from the back of the atriocaval junction and was in the early days of our experience. In the second patient the bleeding was from the LA appendage following the removal of a firmly adherent huge LA thrombus. Fig. (1) shows this huge thrombus after excision.

MR secondary to ischemic heart disease carries a significant mortality after MVR or repair (14,21). Patients with highly impaired LV function and ischemic MR are at great risk for MVR (21). The operative mortality in MVR for ischemic MR is 14.6% (33) and 13.3% (21). In Dion et al. series, 1995 of MVR and CABG (41 patients), 4 patients underwent MVR and CABG for at least 3 vessels and all died due to severe anular dilatation, impaired LV function and restricted leaflet Motion (33).

Mortality was higher in MVR with coronary artery bypass grafting (CABG) than each operation alone and this is true for both mechanical and biological valves (34). The hospital mortality for MVR and CABG was 13.4% (8). CABG is a predictor of mortality and valve related reoperation in MVR (34). Our results regarding CABG and MVR do not cope with other series because our patients are young and we had no patient with ischemic heart disease in group A and one patient in. group B and this is not statistically significant.

Myken et al., (1995) found 13% early and 32% late mortality after MVR using Bicarbon Porcine bioprosthesis in 137 patients with 10 year long-term follow-up (30). The 10 year mortality after MVR using Ionescu-Shiley pericardial valve in 252 patients was 42 ± 4% (35). Monoleaflet mechanical valves have the highest operative mortality (22). Hyashi et al. (1996) implanted Starr-Edwards valve in 106 patients and found that the valve type and year of operation were discriminative predictors of thromboembolic complications in MVR (30) Valve related mortality after MVR using Starr-Edwards valve was 14.3%. After 30 years experience with the' Starr-Edwards valve in the mitral position, it represents a standard that still needs to be achieved by newer prosthesis (37).

Clinical results of Omnicarbon prosthetic valve over 10 years period of follow-up are excellent for MVR (38,39).

St. Jude Medical prosthesis in MVR has excellent functional results with low morbidity and mortality in both pediatric and geriatric age with low thrombosis and thromboembolic rates (20,26,40). Using St. Jude Medical valve for MVR, the early hospital mortality was 2.2% and late mortality was 8.4%. There was no significant difference between St.Jude Medical valve and Sorin Bicarbon valves in MVR over a 4-year follow-up (41). Carbo-Medics valve is a relatively new, low profile, bileaflet mechanical prosthesis. The overall hospital mortality using Carbo-Medics valve for MVR was 9% (in 167 patients). When high-risk urgent cases were excluded, the operative mortality fell to 4.5% (42). The results of Carbo-Medics valves are satisfactory for the mitral, aortic and multiple positions with ealry mortality 3.7%, late mortality 3.7%, and valve related mortality 1.1% / Pt.-Yr (43). The early results of Mosaic Medtronic bioprosthetic valve are very satisfactory with no hospital mortality and 100% 3 years survival (44). Early mortality in MVR using On-X prosthetic heart valve is 6% and the valve is safe and effective (45).

Cumulative experience with bileaflet valves (St.Jude, Carbo-Medics, Duro-Medics, Bicarbon, Jyros) has shown very good long-term results in term of low rate of complication, long-term survival, and quality of life (12) Type of valve used was not a predictor of mortality in our study because we used only St.Jude and Carbo-Medics valves with satisfactory results for both valves and the old generations of valves were not used in our study. Our data cope with the results of Renzulli et al., (1997).

MVR with preservation of the chordae tendineae (MVRP) improves early and late postoperative left ventricular ftinction after MVR. The incidence of low output syndrome and operative mortality with preservation of chordae tendineae were 16.7% and 7.4%. When the chordae tendineae were not preserved (conventional MVR), the incidence of low output syndrome and operative mortality were 27.3% and 13.4% respectively (46). In severe rheumatic MR, the outcome of MVR with preservation of subvalvular apparatus is superior to conventional MVR in terms of mortality, postoperative care needs, LV function and heart dimensions (47)

Five years after surgery, MVRP have better exercise capacity, and better LV systolic function and performance (48).

Overall seven year survival was better with MVRP than conventional MVR (49). The ten year mortality were 20% and 37% in MVRP versus conventional MVR respectively (48). Refixation of the anterior mtral leaflet in MVRP resulted in smaller LVESD, LVEDD, improved LVEF, and improved segmental myocardial performance in all segments (50).

Preservation of the posterior leaflet during MVRP did not cause additional " complication or obstruction, and reduces the risk of early and late mortality (8 years) to 12.4% (51). Complete excision of the mitral valve (conventional MVR) is a predictor of late mortality (48). Our results cope with those of David et al., (1995) where conventional MVR was a predictor of late mortality. Conventional MVR was done in 74.2% of patients in group A and MVR was done in all patients in group B with

significant difference between both groups ($P<0.05$).

Atrial fibrillation (AF) decreases cardiac output by about 15% (52). Atrial fibrillation increases mortality after MVR (1). In our study atrial fibrillation was found in 60% of patients in group A and in 37.1% of patients in group B with significant difference ($P<0.05$). So AF is a predictor of mortality in MVR and our results cope with those of Bassel et al. (1996).

Porter et al., (1999) studied the effect of tricuspid regurgitation (TR) after MVR. They found that it was present in 67% of cases and they recommended that tricuspid repair should be considered when MVR is carried out (9). This was also true in our study where TR was found in 20% of patients in group A and in 8.7% of patients in group B with significant difference between both groups ($P<0.05$). Uncorrected tricuspid regurgitation is considered a predictor of mortality after MVR.

Deep median sternotomy infection is a significant source of morbidity and mortality after open cardiac surgery. Of 28 patients with mediastinitis, 8 patients (38%) suffered from mediastinitis after MVR (13). In our study mediastinitis is considered a predictor of mortality after MVR as it was found in 17.1% of patients in group A and in no patient in group B with highly significant difference between both groups ($P<0.05$). In our study diabetic ketoacidosis was responsible for one mortality in group A.

Mortality rate after MVR for ischemic MR was 20% and was caused by ventricular arrliytlimia, infection, and renal failure due to severe cardiogenic shock (14). This was true also in our study where ventricular arrhythmia was responsible for one mortality in group A.

Pintor et al., (1997) found that, the institution can affect the mortality of patients undergoing MVR regardless the influence of the surgical team. They found 2.3% and 4% hospital mortality in two different institutions while the surgical team was the same. However, the difference was statistically not significant ($P = 0.16$)(2). In our study this item could not be evaluated because the study was done in one centre.

Conclusion

1 - Low cardiac output, right ventricular impairment, and redo surgery are important preoperative risk factors for MVR.

2- Severe PH, prolonged ischemic and pump times, left atrial thrombus. posterior wall rupture, thrombosed MV, endocarditis of MV, low COP and uncontrolled bleeding are important intraoperative risk factors for MVR.

3- Conventional MVR, AF, TR, low COP, mediastinitis, diabetic ketoacidosis, and ventricular arrhythmia are important postoperative risk factors for MVR.

4- To improve the results of MVR, adequate patient selection should be done. Timing of MVR should be determined before development of LV and RV functional impairment, severe PH, left atrial thrombus, and AF. The benefitis and hazards of redo MVR should be thoroughly evaluated.

5- MVRP should be chosen whenever possible with shortening of the ishcemic and pump times. Tricuspid repair when indicated, adequate surgical technique and hemostasis should be done to get the best results in MVR.

6- Adequate adjustment of the coagulation profile should be done to all patients with mechanical prosthesis to

minimize thromboembolic events and low dose, anticoagulation should be considered for all fibrillated patients preoperatively.

7- Absolute aseptic techniques should be undertaken throughout the whole perioperative period to decrease the incidence of endocarditis and mediastinitis. If this happened, early surgical intervension should be considered before development of low COP.

8- Careful postoperative care is very important with more attention to cardiac output adjustment, inotrops, vasodilators, fluid and electrolytes, blood gases and control of diabetes mellitus and arrhythmias.

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BIDIRECTIONAL CAVOPULMONARY GLENN SHUNT WITHOUT CARDIOPULMONARY BYPASS (EARLY RESULTS)

ABSTRACT

Background: Various methods have been described for fashioning of the superior bidirectional cavopulmonary shunt. We report here our early experience for performing this procedure without cardiopulmonary bypass in some selected patients.

Patients and Methods: From June 1997 to Nov. 2002, 26 patients with single ventricle anomaly with pulmonary stenosis underwent bidirectional Glenn shunt (BDG) without cardiopulmonary bypass (CPB). The patients were divided into two groups:

Group I. Included 14 patients who underwent BDG without CPB and by using temporary veno-atrial shunt. Group II. Included 12 patients who underwent BDG without CPB and without temporary shunt.

Results: Group I: The outcome was favorable with mean systemic oxygen saturation increased from 70.85 ± 2.58% to 87.35 ± 1.69%. Mean SVC clamp was 15.92 ± 1.97 minutes (range from 12 to 20 minutes). Mean internal jugular pressure during clamping was 20.07 ± 2.55 mmHg (range 17 to 26 mmHg). There was no observable Clinical neurological deficit after operation with no post-operative mortality and smooth postoperative course. Group II: The mean systemic oxygen saturation increased from 71.66 5.54% to 86.5 ± 2.5%. Mean SVC clamp was 17.16 ± 3.37 minutes (range from 13 to 24 minutes). Mean internal jugular pressure during clamping was 29.5 ± 8.66 mmHg (range 19 to 45 mmHg). There were two postoperative deaths from major neurological damage.

Conclusion: The use of a temporary extra cardiac veno-atrial shunt when performing BDG shunt without cardiopulmonary bypass is safe and offers better results than when no shunt is used. It avoid the problems of cardiopulmonary bypass, is easily reproducible and recommended in a selected patients population. At the same time if the veno-venous shunt is not used during the procedure, assessment of brain function during SVC clamping by transcranial Doppler, evoked potential, electroencephalography is recommended to detect any abnormalities during SVC clamping.

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INTRODUCTION

Bidirectional Glenn shunt is one of the palliative procedures for single ventricle patients. Various techniques have been described for performing this cavopulmonary anastomosis with or without the use of cardiopulmonary bypass (CPB).

The pediatric cardiac surgery unit, Ain Shams University Hospital, Cairo, Egypt.

There were no proper guidelines for who are candidates of bidirectional Glenn (BDG) shunt without CPB. We report here our early experience in performing this procedure without CPB at the pediatric cardiac surgery unit, Ain Shams University hospital.

Material and Methods

From June 1997 to Nov. 2002, 26 children with single ventricle and pulmonary stenosis anomaly underwent a superior bidirectional cavopulmonary Glenn shunt without CPB.

They were divided into two groups, group I where veno atrial shunt was used during the procedure and group II where no shunt was used.

The criteria to select patients for BDG with out CPB were: mean pulmonary artery pressure $\leq$ 15 mmHg, good ventricular function, no atrioventricular AV valve regurgitation, unrestrictive atrial septal defect (ASD) and non restrictive pulmonary arterial architecture.

The pre operative, operative and post operative details for the patients are shown in table (1) and (2).

Procedure I:

A median sternotomy was performed in all patients. The thymus gland was removed completely and pericardium was opened. The right and left superior vena cava (if present) were dissected and mobilized up to the innominate vein. Also the right and left pulmonary arteries were dissected and mobilized. Previous B-T shunt or P.D.A. were dissected and looped. Azygos vein was doubly ligated and divided.

After systemic heparinization (2mg/kg) a veno-venous (veno-atrial) shunt was established between the distal SVC and innominate vein and the right atrium using two right-angled metal tipped canulae after de-airing the circuit. After establishing the shunt, the canulae were placed parallel to the patient for better drainage without rising them above the patient body level.

At this stage, BDG was performed as usual where the SVC was clamped and divided just above the cardiac end. The proximal end of the divided SVC was over sewn with 6/0 prolene suture. The right pulmonary artery was partially occluded with large C shaped Cooley vascular clamp and opened at its superior aspect. The distal end; of the SVC was anastomosed end to side to the right pulmonary artery incision using, polypropylene 6/0 suture creating a very wide anastomosis as much as possible.

After establishing the shunt, the clamps were removed, B-T shunt or PDA was ligated and the temporary veno-venous shunt was disconnected and general homeostasis achieved. During the entire procedure, the patient's heads were elevated to minimize the brain congestion by more venous drainage.

Procedure 2:

BDG was performed without cardiopulmonary bypass and without using any venovenous shunt

Results

26 patients with single ventricle with pulmonary stenosis underwent BDG

Table (1): Shows the preopative, operative and postoperative data for patients in group I.

No	Age	BW	Sex	Pre Op. diagnosis	Pre op. o2 sat	Previous op.	I.J.V.P.	Cross Clamp	Post op o2 sat	Vent.	Complication
1	1.5y	8kg	male	T.atresia,ASD,VSD,PS	65%		18	16 min	85%	3Hours	
2	2.5y	11kg	male	Double inlet LV, ASD ,PS	78%	RMBT shunt	19	14min	88%	4Hours	
3	2y	10kg	girl	Double outlet RV, VSD, straddling AV valve, PS	70%		25	15min	90%	3.5Hours	Right Side pleural effusion
4	3y	12kg	Male	T.atresia,ASD,VSD,PS	80%	RMBT shunt	18	17min	85%	5Hours	
5	5y	13kg	girl	Complete AVcanal, hypoplasticRV,PS	75%		19	12min	87%	6Hours	Right Side Chylothorax
6	1.9y	10kg	Male	Double inlet LV, ASD	65%	PA band	26	18min	90%	4Hours	
7	2y	10kg	girl	T.atresia,ASD,VSD,PS	68%		20	16min	87%	10Hours	
8	9y	20kg	male	TGA, VSD,PS	73%	RMBT shunt	19	16min	85%	2.5Hours	
9	12y	30kg	male	Double outlet RV, sub pulmonary VSD, straddling AVV, PS	70%		21	14min	86%	3Hours	
10	1.4y	9kg	girl	T.atresia,ASD,VSD	65%	PA band	17	15 min	89%	5Hours	Right Side pleural effusion
11	2.5y	10kg	girl	DILV,DOLV,PS	65%		19	18 min	88%	6Hours	
12	5y	18kg	male	PA,VSD	75%	RMBT shunt	20	16 min	87%	4Hours	
13	4y	16kg	male	TGA, VSD,PS	65%		19	16 min	88%	5Hours	
14	3.5y	13kg	girl	T.atresia,ASD,VSD,PS	78%	LMBT Shunt	21	20 min	88%	8Hours	

Table (2): Shows the preopative, operative and postoperative data for patients in group II.

No	Age	BW	Sex	Pre Op. diagnosis	Pre op. o2 sat	Previous op.	I.J.V.P.	Cross Clamp.	Post op o2 sat	Vent.	Complication
1	2y	10kg	male	TA,ASD,VSD,PS	78%	RMBT shunt	28	14 min	86%	3Hours	
2	3y	11kg	male	Double inlet LV, VSD,ASD , PS	75%	RMBT shunt	25	13min	87%	4Hours	
3	4.5y	15kg	girl	T.atresia,ASD,VSD,PS	78%		29	17min	84%	7Hours	
4	5y	14kg	Male	T.atresia,ASD,VSD,PS	78%		22	20min	85%	36Hours	Died
5	1.5y	9kg	girl	Double inlet LV, ASD	70%	PA band	34	24min	90%	7Hours	
6	2.5y	11kg	Male	TA,ASD,VSD,PS	78%	RMBT shunt	19	16min	88%	10Hours	
7	2.5y	11kg	girl	CAVA canal,PA,PDA	75%		22	15min	86%	4Hours	
8	2y	10kg	male	DILV,DOLV,PS	65%		28	19min	87%	48Hours	Died
9	12y	35kg	male	DORV, Sup pulmonary,VSD Straddling AV valve , PS	68%		42	16min	84%	2Hours	
10	7y	20kg	girl	CCTGA,VSD,PS	65%		45	15 min	85%	2Hours	
11	1.5y	9kg	male	TA,ASD,PS,VSD	65%		25	22 min	92%	5Hours	
12	1.9y	10kg	girl	DILV,VSD,PS	68%		35	15 min	89%	4Hours	

TGA: Transposition of great arteries. T. atresia: Tricuspid atresia.
DILV: Double inlet left ventricle. DORV: Double outlet right ventricle.
CAVSD: Complete atrio-ventricular septal defect.

without CPB. The age ranged from 11/2 to 12 years with a mean of 3.93 ± 3.07 for patients in group I and from 1½ to 12 years with mean of 3.76 ± 3.08 for patients in group II Group I patients had temporary venoatrial bypass shunt during the anastmosis while group II patients had the anastmosis constructed without bypass shunt. After establishing the temporary venoatrial shunt in the first group and clamping the SVC, the venous pressure increased to a mean of 20.07 ± 2.55 mmHg . In group II the venous pressure increased to a mean of 29.5 ± 8.66 mmHg after cross clamping the SVC.

The details of the operative measurements before and after establishing the BDG were shown in table 1 and table 2. In group I, there were no operative mortalities, oxygen saturation improved to mean of 87.35 ± 1.69 %, the mean cross clamping time was 15.92 ± 1.97 minutes, and the mean postoperative mechanical ventilation was 2.06 ± 2.1 hours. Two patients developed right sided pleural effusion and one patient developed chylothorax. Those 3 patients managed conservatively with chest drain insertion, diuretics and fat free diet and discharged free with clear chest Xray. In group II, 2 patients died postoperatively from major neurological damage. Oxygen saturation improved from 71.66 ± 5.54 % preoperatively to 86.5 ± 2.50. The mean cross clamping time was 17.16 ± 3.37 minutes and mean postoperative mechanical ventilation was 10.91 ± 28.62 hours.

Discussion

Bidirectional Glenn procedure, that is, an end-to-side anastomosis of the superior vena cava (SVC) to the right or left pulmonary artery, is now routinely performed for various congenital heart defects mainly involving an eventual 1-ventricle repair. It may be performed as an interim step in the pathway to a Fontan-type circulation, as part 1 of a 1.5-ventricle repair, and sometimes to reduce right ventricular volume overload. (Jahangiri et al 1999). The classic Glenn shunt has been performed for nearly 40 years and has provided excellent long-term palliation of complex cardiac malformations associated with low pulmonary blood flow, low pulmonary arterial pressure, and low pulmonary vascular resistance. This procedure improves oxygen, saturation by increasing effective pulmonary blood flow without increasing, total pulmonary blood flow, pulmonary artery (PA) pressure, or cardiac work and it does not produce PA distortion as with the systemic-pulmonary shunt. After initial widespread use, the disadvantages of this procedure became evident with the discovery of pulmonary arteriovenous fistulas on the side of the Glenn anastomosis, and difficulties in application of the technique in small children. Thus, it was largely replaced by the classic Fontan operation in the mid 1970s. However, some patients are not ideal candidates for the Fontan operation. To overcome these problems, a modification of the Glenn shunt, bidirectional cavopulmonary anastomosis, has been widely used. Like the classic Glenn shunt, it improves systemic arterial oxygen saturation and volume unloads the ventricle by increasing the effective pulmonary flow; it also alters ventricular geometry whether it is of right or left ventricular morphology. In the 1980s, there were several favorable reports on the bidirectional Glenn shunt, stressing that the pulmonary arteries were left in continuity and could be easily incorporated into a Fontan or modified Fontan procedure. Cavopulmonary anastomosis was identified as a natural step in these procedures. It decreases operative

risk in a subsequent Fontan procedure and ensures better long-term ventricular function. Recently, cavopulmonary anastomosis has been included as part of total right heart bypass in both the intracardiac and extracardiac procedures. In this setting, superior vena cava-pulmonary artery anastomosis could be considered both as an intermediate step and as part of the procedure of total right heart bypass. (Xie et al 2001). (2).

When first performed, cardiopulmonary bypass was an essential part of the procedure in 1990, Lamberti and associates (3) reported new technique of performing BDG without CPB by establishing a temporary veno-atrial shunt between SVC and right atrium for decompression the systemic venous hypertension during clamping the SVC. Another technique also reported by Lal and Mahant (4) who described another veno-atrial bypass by draining the SVC blood into a venous reservoir which then pumped into the right atrium with the help of a roller pump.

At the pediatric cardiac surgery unit of Ain Shams University hospital, we started to perform BDG for single ventricle patients using fully bypass initially and then using partial bypass and we published the first Egyptian experience with such procedure in 10 patients in 1994 (5). In 1998, we published the second group of patients who underwent BDG using only partial CPB as the main surgical procedure in such group of patients (6). Recently over the last 5 years and parallel with experience of other centers, we started to select some patients to perform BDG without CPB using a temporary venovenous (veno-atrial) shunt or without shunt (l), (3).

The technique of BDG without CPB with or without temporary venoatrial shunt was selectively used in patients with unrestrictive ASD who do not need atrial septectomy, in patients with no AV valve regurgitation who do not require valve repair and in patients with non restrictive pulmonary arterial architecture who do not need pulmonary artery reconstruction. The criteria of selection in our series was similar to other published series in which no intracardiac repair was needed (7), (1).

In contrast to our veno-venous temporary shunt, Murthy et al., (7) reported a different temporary bypass shunt which is a veno-arterial shunt between the SVC or innominate vein and the main pulmonary artery using two venous metal canulae and closed circuit directing the tip of pulmonary artery canula toward pulmonary artery branch on the opposite side of the BDG. They believe that this shunt not only decompress the venous blood during the SVC clamping but it also improve the pulmonary blood flow there by increasing the oxygen saturation during the procedure (6).

In this series our main concern during the BDG procedure was the high venous pressure not the systemic arterial oxygenation as those patients are usually severely cyanotic and can tolerate another period of 15 or 20 minutes of low oxygen saturation during SVC clamping. We think that distal SVC pressure or jugular venous pressure is the most important item to be monitored during BDG without CPB to avoid the problem of the brain congestion and brain edema with subsequent delayed recovery or others neurological complications. In our series we have

observed a 10 mmHg drop in jugular venous pressure after using the temporary bypass veno-venous shunt. This was similar to Lamberti and Co-workers who reported a 15 mmHg drop in internal jugular pressure when they used the same temporary venovenous shunt to prevent systemic venous hypertension during SVC clamping (3).

The primary aim of the operation was achieved in our patient s as arterial ,oxygen saturation increased from a mean of 70.85 ± 5.58 % pre-operatively to 87.35 ± 1.69% post-operatively in group one and from 71.66 ± 5.54% preoperatively to 86.5 ± 2.5% postoperatively in group two. Group one patients had no postoperative mortalities. At the same time, two patients from group two died early postoperatively from major neurological damage and this didn't coincide with the results obtained by other researchers like Jahanjiri and associates whom reported the results of bidirectional

Cavopulmonary Glenn shunt without cardiopulmonary bypass in seven patients with single ventricle anomaly PS; With no neurological damage, (1). Also the results obtained by Xie et al whom reported 170 cases of bidirectional Glenn shunt without cardiopulmonary bypass with no incidence of neurological impairment (2).

They used pressor agents to increase the systemic arterial pressure to increase the transcranial pressure to a mean of 71 mmHg to insure good cerebral blood flow during SVC clamping also they tried to complete the anastomosis in the shortest possible time with a maximum of 17 minutes At the end they stated that in selected patients bidirectional Glenn could be done without cardiopulmonary bypass safely (1). In a reply to that paper Rodriguez et al 2000 (7) stated that clamping the superior vena cava (SVC) without decompressing the internal jugular system exposes the brain to the effects of reduced cerebral perfusion pressure. And they have used electrophysiological indices of cerebral function (electroencephalography or evoked potentiais) and transcranial Doppler during bidirectional Glenn shunts in patients with pulmonary atresia without support (n=2) or through the use of CPB (n=4). During clamping of the SVC without CPB, major reductions (>50%) in the diastolic, mean, and peak systolic blood flow velocities of the middle cerebral artery were identified, which were followed by mild electrocortical alterations as indicated by longer latencies of the cortically generated evoked potentials. In contrast, this situation did not occur or was minimal in those cases in which clamping of the SVC was done with the support of CPB. They recommended the use CPB and intraoperative brain function monitoring by transcranial Doppler, near-infrared spectrophotometry, and electroencephalography for children undergoing these procedures, as the absence of gross neurological deficit is not an indicator that the brain is free of potential alteration during SVC clamping without bypass. Furthermore, under conditions of normothermic ischemia, the brain does not receive the protective benefit of hypothermia. Without brain protection, even short intervals of low cerebral perfusion could generate minor or subclinical deficits that might be detectable only through detailed cognitive testing.

In Conclusion

Performing the superior BDG for single ventricle patients without cardiopulmonary bypass by using temporary extracardiac venovenous shunt is safe and offers good

results and better brain protection during SVC clamping. It avoids the problem of cardiopulmonary bypass and it's more economical. It is easily reproducible and recommended in selected patient population without compromising the Competence of the repair. At the same time if the veno-venous shunt is not used during the procedure assessment of brain function during SVC clamping by transcrainial Doppler, evoked potential, electroencephalography is recommended to detect any abnormalities during SVC clamping.

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Moftah H, Azab S, El Helw M, El Sebaie A, Abd Elgawad M,Yazid H, Shoeb A,Mostafa EA.

SURGICAL TREATMENT OF PARTIAL ATRIO-VENTRICULAR SEPTAL DEFECTS. THIRTEEN YEARS EXPERIENCE WITH ANALYSIS OF RISK FACTORS FOR OPERATIVE MORTALITY AND REOPERATION

ABSTRACT

Background: partial atrio-ventricular septal defects are usually electively repaired with good results. Our aim is to determine the risk factors of operative mortality and reoperation after primary repair.

Patients and Methods: Between January 1990 and December 2002, 136 children were operated for partial atrio-ventricular septal defects. The mean age at repair was 5.6 years (range 9 months to 12 years). Twenty patients were infants less than 1 year old. Congestive heart failure was noted in 20 patients (14.7%) while the rest of our patients (116 patients) were asymptomatic or had mild signs or symptoms of repeated chest infections at the time of operation.

Results: There were 8 hospital deaths (5.9 %), four of which were less than 1 year of age. Follow up was 89.8% complete and ranged from 3 months to 13 years (mean, 6.5 years). Actuarial survival rate was 93.4 % at 1 year, and 88.2 % at 5 years and 83% at 10 and 13 years respectively. Reoperation was done in 10 patients due to severe left atrioventricular valve regurgitation. The incidence of freedom from reoperation was 98.5% at one year, 96.3% at 5 years, 94.1% at 10 years and 93.3% at 13 years after primary repair.

Conclusion: Partial atrio-ventricular septal defects repair in children is safe. The incremental risk factors for early death were age less than 1 year and severe preoperative left atrio-ventricular valve regurgitation and preoperative congestive heart failure. The predictor of reoperation in our series, is the old concept of leaving the left atrioventricular valve as a tri-leaflet structure, at primary repair.

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INTRODUCTION

Partial atrio-ventricular septal defects are part of a wide spectrum of a specific cardiac anomaly. It is characterized by deficiency in the atrial component of the atrio-ventricular septum, a right and left functionally distinct atrio-ventricular valve, an abnormal conduction axis, and unwedging of the aortic valve with a complete sub-aortic muscular infundibulum, prone to obstruction.

Surgical correction of the simple atrio-ventricular septal defect is usually safe [1, 2]. Urgent surgical intervention in the sick infant with congestive heart failure has been the exception to this rule [1].

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The aim of this retrospective study is to review our results in the surgical treatment of partial atrio-ventricular septal defects, over the last 13 years with analysis of the risk factors for early and late postoperative morbidity and mortality.

Patients and Methods

An elective surgical repair of partial atrio-ventricular septal defects was carried out in 136 patients from January, 1990, to December, 2002. The present study is a retrospective analysis. We defined partial atrio-ventricular septal defects as congenital anomalies comprised of an ostium primun defect and a cleft in the left, right or both atrio-ventricular valves. Complete or intermediate form of atrio-ventricular septal defects was not included in this study. The age of our patients at time of surgery ranged from 9 months to 12 years (mean, 5.6 years), while the body weight ranged from 5.5 Kg to 45 Kg (mean, 17.5 Kg). Thirty patients were below the age of 1 year (22 %), while 106 patients were older than 1 year (78 %). Sixteen patients were diagnosed as Down syndrome (11.7 %). Congestive heart failure was present in 20 patients (14.7 %). Preoperative investigations included chest roentgenograms, M-mode and Doppler echocardiography, and electrocardiograms. Only 16 patients underwent cardiac catheterization. The left atrio-ventricular valve was found to be severely regurgitant in 38 patients (28 %), moderately regurgitant in 66 patients (48.5%), and only mildly regurgitant in 32 patients (23.5 %). The mean pulmonary vascular resistance of the patients who were catheterized was 1.5 units (range 1-4.3 unit.m^2). Associated cardiac anomalies were present in 25 patients (18.5 %) (Table 1) .

Surgical technique:

Standard cardiopulmonary bypass with moderate hypothermia was used in 127 cases (93%). Nine patients required a combination of cardiopulmonary bypass and total circulatory arrest due to the presence of multiple systemic venous anomalies (interrupted inferior caval vein and major hepatic veins draining directly into the right atrium). Cardiac arrest was achieved by intermittent cold antegrade crystalloid cardioplegia. The competency of the valve was first assessed under cardioplegic arrest by inspection after injection of cold saline into the left ventricle. The cleft was then closed by interrupted 5/0 polypropylene suture anchored onto the rolled opposing edge of the leaflet. In 115 patients (94 %), the cleft was closed completely up to the free edge of the leaflet at the junction with the major chordae. In seven patients the cleft was partially closed when the surgeon felt that closure would have resulted in valvar stenosis. Fig.3. It is noteworthy to point out that most of the cases in which the cleft was left open completely (14 patients) were operated in the early part of the series, when we were influenced by the Carpentier school which advocated dealing with the left atrio-ventricular valve as a tri-leaflet structure [3]. A Wooler annuloplasty [4] was necessary in 13 patients, following persistent significant leak following cleft closure. The ostium primum defect was closed in all cases using native untreated pericardium by interrupted 4/0 ethibond sutures under the septal leaflet of the right atrio-ventricular valve, and continuous 5/0 polypropylene around the free edge of the defect. The septation was done leaving the coronary sinus to drain into the right atrium in 125 patients. Thirty two associated procedures were done in 25 patients. Fig.4. These were persistent arterial

Figure (1): Preoperative left atrio-ventricular valve regurgitation (Lavv, left atrioventricular valve).

Lavv regurgitation	No. of patients	percentage
Mild	32	23.5%
Moderate	66	48.5%
Severe	38	28%

Figure (2): Operative technique used in left atrio-ventricular valve repair.

Technique	No. of patients	percentage
Closure of cleft	122	89.5%
Wooler annuloplasty	13	9.5%

Figure (3): Associated cardiac anomalies.

Anomaly	No. of patients	percentage
Persistent arterial duct	9	6.6%
Single atrium	5	3.7%
Partial anomalous pulmonary venous return	6	4%
Ventricular septa; defect	7	5%
Pulmonary stenosis	5	3.7%
Total	32	

duct ligation in 9 patients, single atrium septation in 5 patients, redirectioning of partial anomalous pulmonary venous drainage in 6 patients, ventricular septal defect closure in 7 patients and pulmonary valvotomy in 5 patients.

Results

There were 8 hospital deaths (5.8 %) out of 136 patients. Fig. 4 Four deaths (50 %) occurred in infants less than one year of age, presenting with congestive heart failure and severe left atrioventricular valve regurgitation. These infants died in the early postoperative period due to myocardial failure. Among the other 4 deaths, two patients died intraoperatively; the first patient was 2.5 years old who failed to come off bypass following an unremarkable repair. Post mortem examination revealed a hypoplastic right ventricle. The second patient, four years old, died intraoperatively due to biventricular failure, following revision of the intracardiac repair due to patch dehiscence. One patient died on the 15th postoperative day following a cerebrovascular accident. One patient died 21 days postoperatively from acute mediastinitis and overwhelming sepsis.

Early postoperative morbidity occurred in 30 patients (22 %). Fig 5.; Eight patients developed atrial dysrythmias (5.8%), 6 patients developed transient heart block (4%), 2 patients developed complete heart block requiring permanent pacemaker implants (1.4%), 3 patients developed mediastinitis (2.2 %), 5 patients developed pleural effusions (3.7 %), and 2 patient had phrenic nerve palsy requiring diaphragmatic placation and renal shutdown in 4 patients (2.8%).

Figure (4): Hospital mortality; (8/136, 5.8%).

Age	Pre-operative presentation	Cause of death
< 1 year	Congestive heart failure	Myocardial failure
< 1 year	Congestive heart failure	Myocardial failure
< 1 year	Congestive heart failure	Myocardial failure
< 1 year	Congestive heart failure	Myocardial failure
1-12 year		Hypoplastic right ventricle
1-12 year		Atrial patch dehiscence
1-12 year		Cerebrovascular accident
1-12 year		Overwhelming sepsis

Figure (5): Causes of early morbidity.

Cause	No. of patients	Percentage
Atrial flutter / fibrillation	8	5.8%
Transient heart block	6	4%
Complete heart block	2	1.4%
Mediastinitis	3	2.2%
Pleural effusion	5	3.7%
Phrenic nerve palsy	2	1.4%
Renal shutdown	4	2.8%

Figure (6): Follow up echocardiography findings (mean 2.5 +/- 1.0 years)

Follow up echocardiography finding	No. of patients	percentage
Absent-mild Lavv regurgitation	79	68.4%
Moderate Lavv regurgitation	26	22.8%
Severe Lavv regurgitation	10	8.8%
Residual atrial septal defect	3	2.3%

Out of 128 patients who survived the operation, 115 patients were followed up. However Thirteen patients were lost to follow up. Follow up was 89.8 % complete, and ranged from 2 months to 13 years (mean, 6.5 years). The echocardiograph follow up data was available for all patients at a mean 2.5 ± 1.0 year after repair. Fig.6. Left atrio-ventricular valve regurgitation was found to mild or absent in 79 patients (68.4 %), moderate in 26 patients (22.8 %), and severe in 10 patients (8.8 %). A small residual interatrial shunt was detected in 3 patients.

During the follow up period, 10 patients underwent reoperations (8.8%) due to severe LAVV regurgitation. Fig. 7. The median

Figure (7): Detail of reoperation (Lavv, left atrioventricular valve; MV, mitral valve; MVR, mitral valve replacement).

Serial No.	Age at primary operation	Operative finding	Severe Lavv annular dilatation	Operative procedure
1	< 1 year (infant)	Cleft not closed	Present	MV repair
2	> 1 year	Cleft not closed	Present	MV repair
3	> 1 year	Cleft not closed	Present	MV repair
4	> 1 year	Cleft not closed	Present	MV repair
5	> 1 year	Cleft not closed	Present	MVR
6	> 1 year	Cleft not closed	Present	MV repair
7	< 1 year (infant)	Residual cleft	Present	MVR
8	< 1 year (infant)	Residual cleft	Absent	MVR
9	> 1 year	Residual cleft	Present	MVR
10	> 1 year	Residual cleft	Absent	MVR

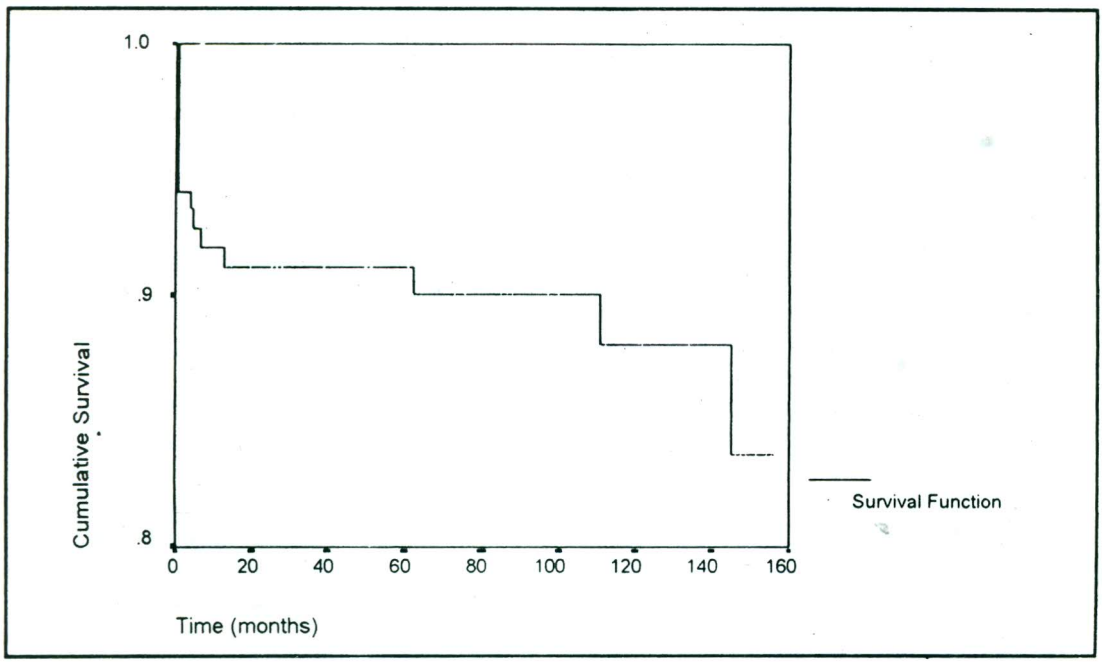

Figure (8): Cumulative survival in studied patients group (Kaplan-Meier Curve)

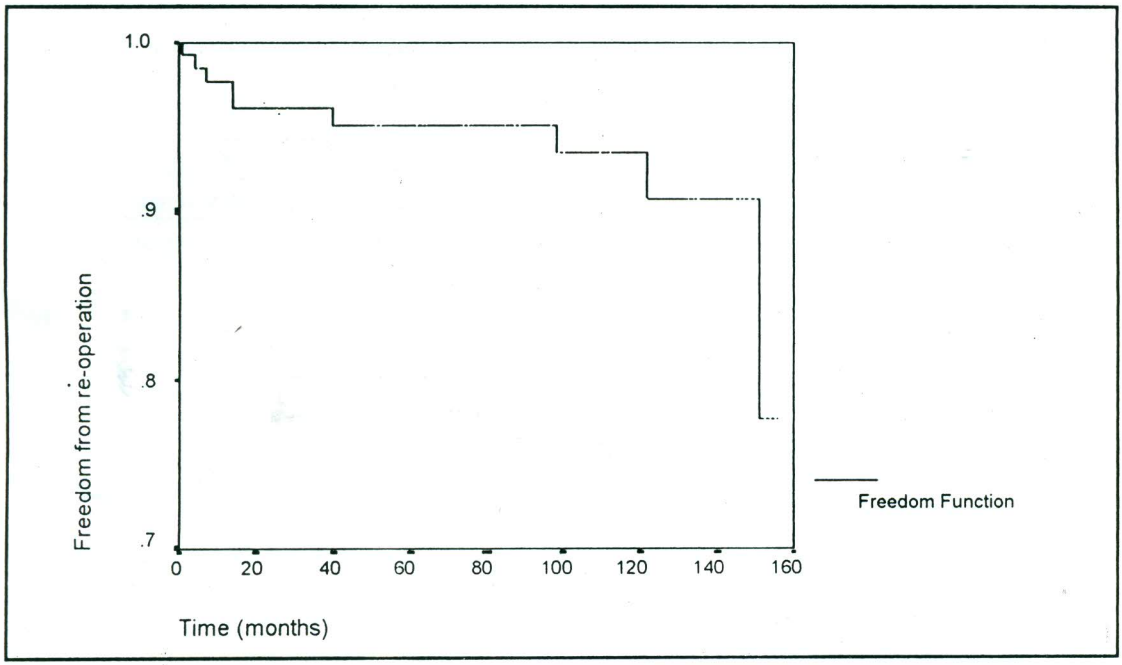

Figure (9): Freedom from re-operation in studied patients group (Kaplan-Meier Curve)

interval from the initial procedure was 5.8 years, and ranged from 2.5 to 8.7 years. The estimated incidence of freedom from reoperation was 98.5% at one year, 96.3% at 5 years, 94.1% at 10 years, and 93.3% at13 years after primary repair. Among the patients who required reoperation, all had preoperative severe left atrioventricular valvular regurgitation. During reoperation a residual cleft in the left atrio-ventricular valve was found in 4 patients, and the cleft was found completely open in 6 patients. Severe annular dilatation was present in 8 patients. Five patients underwent valvar replacement by a mechanical prosthesis (3 St.Jude Medical H-P® valves, and 2 CarboMedics Standard Mitral® valves). The other 5 patients underwent cleft closure and annuloplasty. There was no early or late mortality in this group of patients requiring reoperation.

Discussion

Partial atrio-ventricular septal defect is a congenital malformation that is sometimes taken lightly. Surgical repair is always indicated for all patients with this anomaly. The natural history of this condition leads to progressive left atrioventricular valvar regurgitation, serious dysrythmias, pulmonary vascular disease, and eventually death in the fourth or fifth decade of life [2,5]. Operative repair at an early age is a safe and effective procedure, and may

prevent the progression of left atrioventricular valvar regurgitation and aid in achieving a better long-term result and quality of life [2]. Determinants of early and late mortality in most series have been age younger than one year, children presenting with congestive heart failure, and residual left atrioventricular valvar regurge [6,7,9]. Regarding the cleft of the left atrioventricular valve, we have changed our policy from leaving it as a tri-leaflet structure without closure of the cleft early in the beginning of our series(14 cases) as we were influenced by Carpentier school which considered the left AVV as a normal tri-leaflet valve. Now it is a part of our surgical practice to close the cleft routinely in every patient with Partial AVSD except some rare cases with small annulus or very small posterior leaflet where we prefer to do partial closure rather than complete cleft closure which may create a stenotic mitral valve. As a result of that the incidence of significant residual or recurrent regurgitation of the LAVV have markedly decreased from 25.7% in the first 35 patients to 3% in the rest of our patients (3/101). Mortality for operative repair has ranged from 1.6% to 10% [1,7]. In our series, the results have improved from 12.5% mortality in the first forty patients (5/40) to 3.1 % mortality in the remaining 96 patients included in this study (3/96) . The overall mortality in all our patients during the last five years is 2.5%. It must be stressed that the mortality rate among infants (< 1 year old) was 10%, while that among children (> 1 year old) was only 3%. Furthermore all infants who died as a result of operative intervention presented preoperatively with congestive heart failure. None of the older patients had congestive heart failure. This statistically significant difference shows that operative repair in infants less than 1 year with congestive heart failure is a major risk for death in our population.

Follow up was 89.8% complete. Follow up ranged from 2 months to 13 years (mean 7.25 years). The echocardiograph follow up data was available for all patients at a mean 2.5 ± 1.0 year after repair. Left atrioventricular valvular regurgitation was found to mild or absent in 68.6% of cases, moderate in 22.8%, and severe in 8.8%. During the follow up period, 10 patients underwent reoperations (8.8%). The mean interval from the initial procedure was 5.8 years. Indication for reoperation was severe left atrioventricular valvular regurgitation following primary operative repair. The incidence of reoperation is similar to other series like El Nagdawi et al. (10) who reported an incidence of 6% of reoperation at 5 years and 8% at ten years.

There was no reported left ventricular outflow tract obstruction after operative repair in our population. Many authors reported that subaortic obstruction is the second most common cause of reoperation after repair of PAVSD, like El Nagdawi and his colleagues who reported subaortic obstruction in 36 patients among 343 patients followed up after repair of PAVSD and 7 out of them required reoperation to relief subaortic obstruction. Others reported that subaortic obstruction after repair of PAVSD can remain clinically silent for many years and is often not recognized (11)

Early morbidity in our studied population was comparable to most published reports [7],

In this study, the predictors of severe left atrioventricular valvular regurgitation and reoperation, in our patients, were severe preoperative left atrioventricular valvar

regurge (100%), a cleft that was left open during the primary operative repair (50%), and young age (<1 year) at primary operation (in 10.3%, in comparison to 3% of older children).

These findings were consistent with other published reports [6,8]. There was no early or late mortality in this group of patients requiring reoperation.

In conclusion partial atrio-ventricular septal defects repair in children is safe. The incremental risk factors for early death were age less than 1 year and severe preoperative left atrio-ventricular valve regurgitation. The predictor of reoperation in our series, is the old concept of leaving the left atrioventricular valve as a tri-leaflet structure, at primary repair.

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ROLE OF PULMONARY ARTERY BANDING (PAB): IN MANAGEMENT OF THE HIGH RISK EGYPTIAN PATIENTS WITH HYPERTENSIVE VSD

ABSTRACTS

Background: Pulmonary artery banding (PAB) is an effective palliative surgical procedure in patients with congenital heart defects associated with increased pulmonary blood flow. Although primary VSD closure is the surgical treatment of choice in most of cardiac centers all over the world, yet in Egypt P.A.B still has a very important role in surgical management of hypertensive VSD patients who are referred late to surgery and considered at high risk for primary VSD closure.

Methods: 98 patients with hypertensive VSD underwent PAB as they are considered at high risk for primary VSD closure. A retrospective analysis of hospital, echocardiographic, chest x-ray and catheterization data were analysed together with the indications of PAB, operative and post operative data.

Results: 98 infants of children underwent PAB between 1998 and 2002. Age ranged from 3.5 month to 28 month and the body weight ranged from 3.75 to 12.5kg. 92 patients (92%) received good adequate banding in contrast to 4% (4 patients) who received and tolerated only loose band and 2 patients (2%) with failed trial of banding due to fixed pulmonary hypertension. Intraoperatively pulmonary artery pressure (PAP) ranged form 60-95 mmHg with a mean of 66.25 ± 12.89 mmHg prebanding to 30-63 with a mean of 42.36 ± 12. 63 mmHg post banding on 50% oxygen. There were 6% early operative mortalities in this series (6/98) and 3.5% of late operative mortalities (3/85). The risk factors for early operative mortality included Down's syndrome, older age at the band (>1 year), PAP>75 mmHg, cardiac cachexia, poor chest condition and prolonged mechanical ventilation and low cardiac output. The risk factor for late death after PAB was loose or inadequate PAB. 92% of the patients (85/92) who survived PAB could be followed up with marked clinical improvement in 94% of the patients (80 patients) and 32 patients underwent P.A. debanding and VSD closure at a time ranging from 12 to 24 month (mean 16.5 ± 3.5 month) after the banding. 5 patients out of the 85 patients who could be followed-up in this study (5.8%) had a poor prognosis after PAB due to inadequate PAB with 60% late death and failed trial of rebanding in 2 patients.

Conclusions: Patients with VSD should be followed up very carefully for any signs of congestive heart failure or pulmonary hypertersion. Hypertensive VSD patients not responding to medical treatment should be referred immediately to surgery. If primary VSD closure is not possible or if it carries a high risk due to small body weight, cardiac cachexia or poor chest conditions, PAB should be the second option. At the time of banding every effort should be made to have good adequate banding to prevent progression of pulmonary hypertension and to have a good prognosis on the second operation (VSD closure and pulmonary artery debanding).

Key words: Pulmonary artery banding (PAB) Pulmonary artery pressure (PAP).

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INTRODUCTION

• Since the first report of pulmonary artery banding (PAB) was reported by Muller and Dammann in 1951 (1), this procedure became an effective palliative surgical technique in infants and children with congenital heart disease associated with increased pulmonary blood flow. The rational of PAB is to protect the pulmonary vascular bed from irreversible obstructive pulmonary vascular disease until such time of definitive repair of the underlying cardiac lesion can be done with minimal operative risk (1) (2).

• Although primary VSD closure now is the surgical treatment of choice in most of cardiac centers allover the world, yet in Egypt we are confronted with hypertensive VSD patients referred late to surgery with poor general and cardiac conditions with high operative mortality if primary VSD closure is performed. In these high risky patients P.A.B is considered to be a good alternative until the time of definitive repair. In this series, we will review our results in diagnosis and surgical management in 98 patients with hypertensive VSD who underwent PAB at Ain Shams University and Abu El Reesh Student hospitals from 1995 to 2002.

Patients and Methods

• During the period from Febr. 1998 to Oct. 2002, 98 infants and children with hypertensive VSD were operated upon for palliative pulmonary artery banding (P.A.B) at Ain sham University and Abu Elreesh Student hospitals. The age of these patients ranged from 3.5 to 28 month with a mean of 7.5 ± 2.75 month while their body weight ranged from 3.75 to 12.5 k.g with a mean of 5.867 ± 1.72 kg.

• Preoperatively, all patients were subjected to full clinical examination, chest X-ray, complete laboratory investigation and serial echocardiographic studies. In 20 patients cardiac catheterization was performed due to suspected severe or fixed pulmonary hypertension. The echocardiographic examination before the banding, included full segmental analysis and complete delination of anatomy regarding, the VSD, the number, site, size, restriction, pressure gradient, pulmonary artery pressure (PAP), flow direction and associated anomalies.

• The indication for pulmonary artery handing in addition to severe pulmonary hypertension were congestive heart failure with failure of medical treatment, repeated chest infection, failure to thrive, cardiac cachexia and poor general conditions. Intraoperatively, all patients were subjected to the following measurements before and after the banding:

- Systemic arterial blood pressure (systolic, diastolic and mean).

- Pulmonary artery pressure (systolic, diastolic and mean).

- Oxygen saturation (on 100% and 50% FIO2)

- Heart rate (tachycardia, bradycardia or E.C.G. changes).

- Any other intraoperative events or complications were also recorded including bradycardia, desaturation cardiac arrest, low cardiac output or hypotension.

• During the postoperative I.C.U stay the following data were recorded systemic blood pressure, oxygen saturation, arrhythmia, any signs of low cardiac output

or pulmonary hypertensive crisis or cardiac arrest.

- Echocardiography was performed for every patient before discharge from the hospital, after 2 month from the discharge then every 4 months until the time of VSD closure and debanding. The post band echocardiographic examination was directed at: site of band, distance from pulmonary valve, any migration or obstruction to pulmonary artery branches, pressure gradient across the band and direction of blood flow across the VSD. The patients who survived the procedure were followed up at out patient clinic for evaluation for signs of congestive heart failure, pulmonary hypertension in addition to follow up by serial echocardiography.

Surgical technique of pulmonary artery banding:

- Two main surgical incisions for P.A.B, were used in this study: left anterolateral thoracotomy in the second or third intercostal space (45 patients) and median sternotomy (53 patients). We start our technique by dissection and taping the ascending aorta, dissection of main pulmonary artery, dissection and ligation of P.D.A. or ligamentum arteriosus (you have to be sure from right and left pulmonary arteries before this step). Using a big right angle clamp, the same tape around the ascending aorta is passed around pulmonary artery taking care of left atrial appendage and circumflex coronary artery.

- An appropriate position of pulmonary artery banding is 15 mm distal to pulmonary valve with routine fixation of the band to the adventia of the pulmonary artery using ethibond 4/0 stitches to avoid migration of the band toward bifurcation. We used different material for P.A.B. in this study which included Nylon tape in 65 patients, 4 mm wide cotton umblical tape in 27 patients, braided silk ligature in 3 patients and Gore-tex tape in 3 patients.

- A different surgical methods for applying the band were used in this study including:

1. In 65 patients we started the band by applying Trusler's formula which is 20 mm + 1 mm for each kg body weight, depending on distal pulmonary artery pressure where our object was to decrease systolic pulmonary artery pressure to normal (25 to 30 mmHg) or less than half (50%) of systemic arterial blood pressure without producing bradycardia or desaturation (02 saturation less than 90%). If distal P.A. pressure is still high, more stitches can be added to make band more tight without producing hypotension, bradycardia or hypoxia taking into consideration that these measurements were taken on FIO2 50% and not on 100% oxygen.

2. In 22 patients, adjustable band was used using Nylon tape and smugger around the pulmonary artery and then by applying 2 or 3 large or medium legaclip on the tape below the snuger which was removed after that. Depending on the desired distal pulmonary artery pressure one legaclip can be added or removed and by using this technique, the band can be easily loosened or tightened intraoperatively and postoperatively depending on the hemodynomic situation.

3. Another technique for PAB was used in 11 patients in whom PAB was performed without Trusler's formula. Starting this technique by direct and continuos monitoring of distal pulmonary artery pressure together with systemic arterial blood pressure. After taping the pulmonary artery the band was applied empirically and more stitches were continuously added until

Table (1): Indications of pulmonary artery banding in 98 patients.

No.	Indication	Number	Percentage %
1	Severe pulmonary hypertension	82/98	83.67%
2	Congestive heart failure	75/98	76.5%
3	Repeated chest infection	48/98	49%
4	Cachexia or failure to gain weight	42/98	42.85%
5	Poor general conditions	38/98	38.77

Table (II): Preoperative echocardiographic data.

	Average	Mean	St. deviation
Right ventricular pressure	55-95 mmHg	69.50	12.69
Pulmonary artery pressure	52-90 mmHg	67.68	10.55
Pressure gradient across VSD	5-30	20.35	6.22

the desired distal pulmonary artery pressure is reached (on FIO2 50%).

- Band adjustment is judged by distal pulmonary artery pressure, oxygen saturation, systolic B.P. and any E.C.G. changes. In these patients with hypertensive VSD, if distal PAP decreases to below than 50% of systemic arterial B.P. this should be considered satisfactory. If patient hemodynamics can't tolerate band, a loose band can be applied or removed completely and the patients considered inoperable or unfit for PAB due to severe fixed pulmonary hypertension.

Results

- This study was carried on 98 patients who underwent pulmonary artery bandings as an initial palliation for hypertensive VSD before definitive closure. Age of the patients ranged form 3.5 months to 28 months with a mean 7.5 ± 2.7 months while their body weight ranged form 3.75 kg to 12.5 kg with a mean of 5.86 ± 1.72 kg.

- The indications of pulmonary artery banding in these 98 patients were shown in table (1) which included severe pulmonary hypertension, congestive heart failure, repeated chest infection, failure to thrive and poor general conditions with failure of medical treatment. Clinical examination of these patients revealed signs of severe pulmonary hypertension with absence of VSD murmer in 29 patients, short systolic murmer with accentuated second heart sound in 45 patients and classic VSD murmer in 24 patients.

- Chest x-ray examination showed severe cardiomegaly in 60 patients moderate cardiomegaly and pulmonary plethora in 38 patients. Preoperative echocardiographic examination of these patients revealed left to right shunt in 63 patients (64%), Bidirectional shunt in 35 patients (36%). Pulmonary artery pressure was also evaluated by echocardiography in all patients (Table II). It ranged from 52 to 90 mmHg with a mean of 67.68 ± 10.55

Table (III): Preoperative data in 20 patients who underwent cardiac catheterization.

No	Direction of the shunt	PAP		Qp/Qs		PVR	
		Before02	After 02	Before02	After 02	Before02	After 02
1	Lt-Rt	79	70	1.9:1	2.1:1	6.5	4.3
2	Lt-Rt	80	80	1.3:1	1.5:1	5.2	4.0
3	Lt-Rt	90	75	2.5:1	3.2:1	5.6	3.3
4	Bi-directional	95	90	1.3:1	1.6:1	6.5	5.0
5	Bi-directional	89	70	2.2:1	2.9:1	6.0	4.3
6	Lt-Rt	75	70	1.5:1	2.1:1	5.5	3.2
7	Lt-Rt	76	65	1.9:1	2.5:1	6.3	4.7
8	Bi-directional	87	85	1.4:1	2.4:1	8.0	6.1
9	Lt-Rt	74	70	1.7:1	1.9:1	5.5	3.9
10	Bi-directional	88	80	1.4:1	1.6:1	6.6	4.7
11	Lt-Rt	75	70	1.8:1	2.1:1	5.2	3.1
12	Lt-Rt	78	70	2.2:1	3:1	6.1	4.2
13	Bi-directional	86	74	1.6:1	1.8:1	6.0	4.9
14	Bi-directional	90	85	1.2:1	2.1:1	8.5	6.1
15	Lt-Rt	78	78	1.4:1	3:1	7.5	5.1
15	Lt-Rt	82	80	1.9:1	2:2:1	6.8	4.3
17	Lt-Rt	80	75	2.1:1	2.5:1	5.4	3.7
18	Bi-directional	90	80	1.7:1	2:1	7.3	5.2
19	Bi-directional	95	95	1.3:1	1.9:1	8.1	7.1
20	Lt-Rt	78	68	1.9:1	2.3:1	3.3	3.7

Table (IV): Intraoperative measurement before and after pulmonary artery banding.

	Before P.A.B		After P.A.B	
	Average	Mean	Average	Mean
- Systolic pulmonary artery pressure PAP	60-95 mmHg	66.25±12.895	30-63 mmHg	42.36±12.63
- Systemic arterial B.P	70-115mmHg	95.69±10.32	80-125 mmHg	110.66±12.75
- Oxygen saturation	93%-100%	98.62±1.03	89-100%	96.56±15.75
- Heart Rate	110-180 per minute	135±20.65	105-165	130±15.75

Table (V): Risk factors for operative death after P.A.B.

	Risk factors	No.	%
1	Down's syndrome	4/6	66.6%
2	P.A.P.>75 mmHg	5/6	83%
3	Age > 1 year	4/6	66.6%
4	Cardiac cachxia	4/6	66.6%
5	Repeated preoperative chest infection	3/6	50%
6	Prolonged mechanical ventilation	2/6	33.3%
7	Postoperative low cardiac output needed inotropic support	3/6	50%

pressure gradient across the VSD was also measured and it ranged from 5 to 30 mmHg with a mean of 20.35 ± 6.22.

- The type of VSD was also diagnosed by echocardiography It was perimembranous VSD in 62 patients (63%) Double outlet right ventricle (DORV) with subaortic VSD in 15 patients (15%) isolated inlet VSD in 6 patients (6%), multiple muscular VSDs in 4 patients. (4%), isolated muscular VSD in 6 patients (6%) and doubly committed subarterial VSD in 5 patients (5%). Cardiac catheterization was performed in 20 patients. These patients were referred, late to surgery (older than one year) with signs of severe pulmonary hypertension. P.A. pressure, Qp/Qs and pulmonary vascular resistance were measured before and after 02 inhalation to test the reversibility of the pulmonary hypertension. Data of cardiac catheterization of these 20 patients were shown in details in Table (III).

- Intraoperative systemic arterial B.P. and systolic pulmonary pressure, oxygen saturation, heart rate were recorded in all patients before and after the pulmonary artery banding (Table IV).

- On FIO2 50% oxygen, pulmonary artery band was initially applied according to Trusler's formula (20 mm + 1 mm for each kg body weight) to the majority of patients. 4 patients (4%) tolerated only loose band due to hypotension and desaturation while in 2 patients (2%) trial of pulmonary artery banding failed due to marked desaturation, bradycardia and hypotension even with loose band and the band was taken off again and the patients transferred to ICU and considered to be unfit for any surgical intervention.

- Out of 98 patients who underwent P.A.B., there was 6% operative or hospital moralities (6/98). One patient died intraoperatively after loose band was applied but the patients arrested after sternal closure, sternum was reopened, band was removed but resuscitation failed. The other 5 patients died in the postoperative period at an interval of 6 hours to 32 days postoperatively after P.A.B. Among these 5 mortalities, there were the 2 patients in the group who could not tolerate any trial of banding even loose bond. The risk factors of operative death after P.A.B. were analysed in our patients (Table V). These risk factors included: Down syndrome, pulmonary

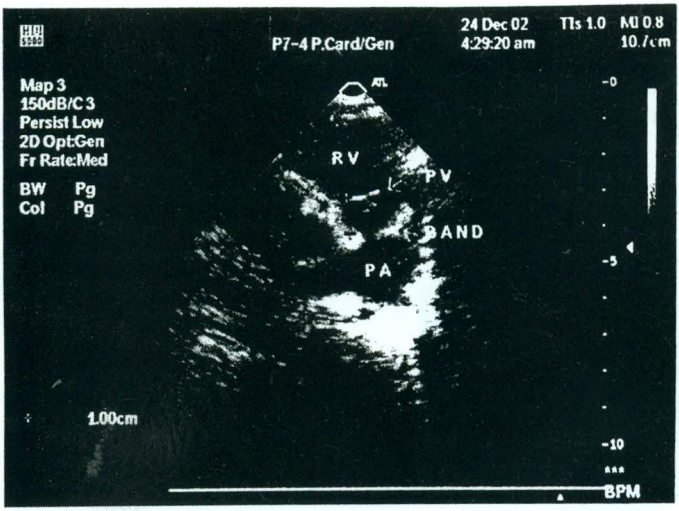

Fig. (1): Postoperative echocardiography 8 months after P.A.B with short axis parasternal view at the great vessel level showing a rather tight pulmonary artery band present 12 mm distal to the pulmonary valve.

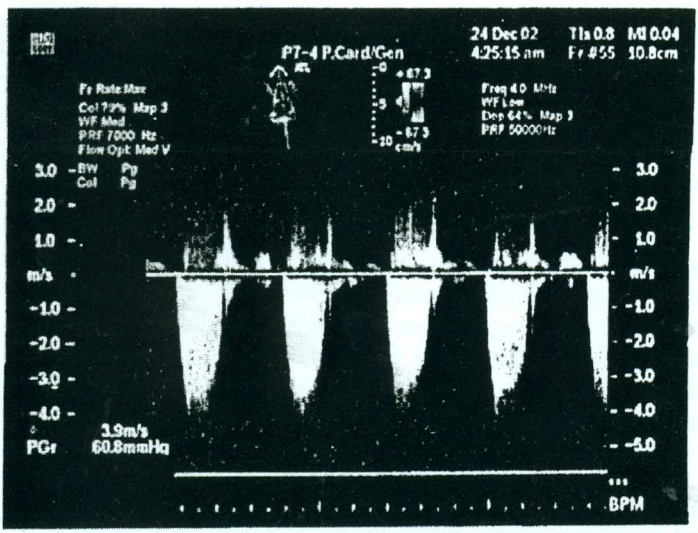

Fig. (2): Continuous wave recording of the across the P.A band showing significant obstruction to pulmonary flow with peak systolic pressure gradient of 64 mmHg.

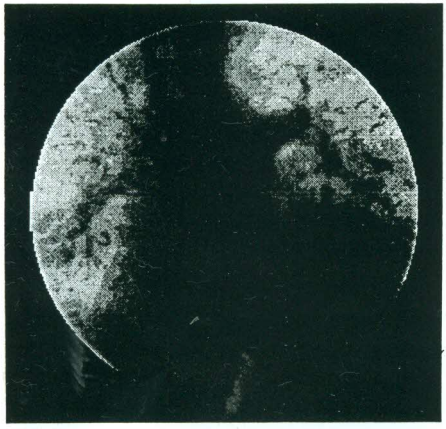

Fig. (3): Pulmonary angiogram of 2 years old child one year after the band showing good position of the band in the middle of the main pulmonary artery

artery pressure> 75 mmHg, Age is > 1 year at the time of banding, preoperative cardiac cachexia, repeated preoperative chest infection, prolonged mechanical ventilation (>3days) and postoperative low cardiac output and need for inotropic support.

- Out of the 92 patients who survived the pulmonary artery banding, 85 patients (92%) were followed up at out patient clinic. The period of follow up ranged from 2 months to 26 months with a mean of 13.5 ± 4.6 months while in 7 patients (7.6%), the follow up was lost completely with no available data.

- **Among these 85 patients who were followed up we could reach the following data:**

1. The general condition was markedly improved in 80 (94%) patients with no signs of congestive heart failure or chest infection and the patients started to gain weight very nicely.

2. Postoperative echocardiography showed good pulmonary artery banding with good protection (Fig. 1). Pressure gradient across the band varies from 35 to 60 mmHg with a mean of 46 ±10.56 mmHg while the pulmonary artery pressure varies from 25to 62 mmHg with a mean of 38±12.556 mmHg.

3. Cardiac catheterization and angiography was performed only in 6 patients after prolonged PAB before definitive repair for confirmation the diagnosis and to diagnose any pulmonary artery distortion or bifurcation stenosis by the band. In those patients no pulmonary artery problems detected and the band was situated in an optimal position (Fig. 2)

-So for 32 patients underwent pulmonary artery debanding and V.S.D closure with two operative mortalities. The period between P.A.B. and P.A. debanding and VSD closure ranged from 12 months to 24 months with a mean of 16.5±3.56 months.

-In 5 patients out of 85 patients who were followed up after P.A.B, the outcome was poor as the following data showed. Signs of congestive heart failure or severe pulmonary hypertension were evident in all patients (100%). 3 patients (60%) died in the late postoperative period at an interval ranged from 6 months to 1.5 years after the PAB. These 3 patients were initially received loose band during the operation due to severe pulmonary hypertension. 2 patients underwent trial of pulmonary artery rebanding 8, 10 months after the initial banding. In the two patients, the trial of rebanding failed and the patients still

surviving with sings of severe and fixed pulmonary hypertension.

Discussion

- Whereas pulmonary artery banding (PAB) was at one time frequently used in patients with uncomplicated VSD and was the most frequent indication for P.A.B in most series allover the world. Today PAB is a rare indication in surgical treatment of VSD because primary VSD closure is recommended in most centers with excellent outcome (3) (4). In the literature nowadays, P.A.B is reserved only for patients with multiple muscular VSDs (Swiss cheese septum), apical muscular VSD that may require left ventriculotomy or for severe aortic coarctation and VSD in the first two months of life (3). Even with multiple muscular VSDs some authors (4) prefer primary VSD closure as they believe that two staged repair (PAB followed by debanding and VSD closure) may induce severe hypertrophy of the right ventricle with severe diastolic noncompliance in addition to distortion of the branch pulmonary arteries after period of prolonged banding which might need pulmonary arteries reconstruction (3) (4).

- In Egypt, our situation with the VSD patients is somewhat different. Due to lack of regular routine medical examination after birth and lack of specialized pediatric cardiac centers, we still confronted by children with VSD referred late to surgery with severe pulmonary hypertension, congestive heart failure with poor cardiac and general conditions. Unfortunately, primary VSD closure in these patients especially if associated with small body weight (<6 kg) and preoperative repeated chest infection has a very high operative mortality in Egypt due to lack of well trained staff nurse, pediatric intensivists and pediatric perfusionists in addition to lack of the pharmacological agents strongly needed in such cases, like the selective pulmonary Vasodilators (phenoxybenzamine and nitric oxide). For the previous reasons we started again to think about the option of P.A.B as an initial palliative step in surgical management of hypertensive VSD patients.

- PAB is considered by many authors to be a good option as it decreases over perfusion of pulmonary circulation in these patients with left to right shunting lesions and hence reduce shunt volume. With successful P.A.B, signs and symptoms of congestive heart failure are expected to improve, cardiac size decrease and eventually the development or progression of irreversible pulmonary vascular disease is prevented (5). As, we mentioned before, the indications of P.A.B in this series are different from other series (3)(4), our indications included small body weight children with hypertensive VSD, congestive heart failure not responding to medical treatment with failure to thrive or repeated chest infection and poor general conditions.

- Echocardiography was the main investigating tool in this study. It was very sensitive in detecting chamber dilatation, hypertrophy and any abnormalities in valve motion. Using Doppler echocardiography, gradient and shunts across the VSD was estimated. Pulmonary hypertension pattern was detected by pulmonary acceleration time and severity of pulmonary hypertension was also evaluated on regular echocordiograpy. Other series also reported the important role of Echocardiography as the main item in evaluation of pulmonary hypertension and pressure gradient after the banding (6).

- Cardiac catheterization was needed only in 20 patients preoperatively in this study (20%) for more assessment of the degree of pulmonary hypertension and to

measure the pulmonary vascular resistance. Postoperatively only 6 patients underwent cardiac catheterization and angiography after prolonged P.A.B for exclusion any pulmonary artery distortion by the band.

- Two main surgical approaches for P.A.B were used in this series. Either left anterolateral thoracotomy in the second or third intercostal space in 45 patients (46%) and median sternotomy approach in 53 patients (54%). We believe now that median sternotomy is the best surgical incision for P.A.B as it leaves the patient with only one surgical scar after the debanding instead of two surgical scars in case of with thoroctomy. Also it avoids any traumatic injury or laceration of left lung from compression during thoracotomy which may be the cause of postoperative lung atelectasis and ventilatory problems especially in children with poor chest condition before the P.A.B.

- The object of P.A.B. as reported by many authors (7)(8) is to decrease systolic pulmonary artery pressure either to normal (25-30mmHg) to less than half of systemic arterial blood pressure without producing bradycardia, hypotension or desaturation (defined as oxygen saturation less than 90% in non mixed lesion). In our series of P.A.B in 98 patients, we could achieve our object from the band in 92 patients (92%) as the pulmonary artery pressure decreased from a mean of 66.25 mmHg before the band to a mean of 42.36 mmHg after the banding. The rest of patients included in this study either received loose band (4%) or they could not tolerate any trial of banding due to very severe pulmonary hypertension (2%).

- In 1972, Trusler and his colleagues (5) reported an equation for the pulmonary artery banding which is 20 mm plus one mm for each kilogram of the body weight. Our policy in banding the VSD patients is to start with this equation initially with further adjustment by tightening or loosening the band depending on the patient hemodynamics and oxygen saturation.

- The position of the band in relation to the main pulmonary artery is very important as the band placed too distally can lead to bifurcation stenosis of both pulmonary artery branches while the more proximally situated band can lead to pulmonary valve distortion and regurgitation (7). We usually prefer to put the band at a distance of 15 mm from the pulmonary annulus and so for in our patients who underwent debanding and VSD closure after P.A.B. in this series, we did not see any patient with pulmonary artery distortion after PAB.

- We totally agree with other investigators that inadequate pulmonary artery banding is a very serious problem after PAB (9). Pulmonary artery banding is defined as inadequate whenever there is persistence of refractory congestive heart failure (clinical evaluation) or there is an ineffective protection of pulmonary circulation (systolic P.A.P>45 mmHg). A loose band is usually the most common cause of an inadequate band. At the time of definitive repair, an adequate band is associated with lower mortality compared with an inadequate band (7)(9).

- In this series. The worst prognosis after PAB were seen in patients who tolerated or received only a loose band and in patients with postoperative inadequate band as diagnosed by serial echocardiographic examination after the operation.

• In 1999, Hillel Laks and his colleagues (10) reported that PAB that is adequate at the time of operation may become too loose over weeks or months after banding. They attributed this finding to resorption of internal folds of the pulmonary artery wall that initially were present when a constricting band is placed. These acute infoldings of the pulmonary artery further decrease, the cross-sectional area of the pulmonary artery. With time, however, these infoldings resorb, restoring a greater internal cross-sectional area, a greater pulmonary blood flow and thus a "looser" pulmonary artery band (10).

• To overcome this problem, they reported a new technique for banding called the incisional pulmonary artery band in which a perpendicular incision is made into the excluded portion of the artery. The deep V shaped arteriotomy is closed with 5/0 polpropylene suture effectively reducing the diameter of the vessel by approximately 40%. Then an umbilical tape 4 mm wide is placed around this groove in the main pulmonary artery, further Tightened and secured with sutures and hemoclips (10).

• Postoperative follow up after PAB by the pediatric cardiologist and cardiac surgeon is very important by clinical evaluation and serial echocardiography to follow up the gradient across the banding and to diagnose and pick up cases with loose or inadequate PAB. Management of patients with inadequate PAB is very difficult because the options are limited which either to do a trial of rebanding or to do a definitive surgical repair with debanding and VSD closure but usually the prognosis is poor with both options. There were two patients in this series who underwent a trial of P.A rebanding after inadequate P.A.B. In both patients, the trial failed again due to very severe pulmonary hypertension and very unstable hemodynamics. Also in this series, late operative death was very high among the patients with inadequate PAB (60%) which indicates the severity of this problem.

• Although PAB is a simple surgical procedure but, it is associated with high operative mortality. In the literatures mortality after PAB ranged from 6.3% to 45.8% (11) (12). Many authors reported that this high operative mortality after PAB was clearly associated with the overall condition of the patient rather than with procedure itself. Patients who are selected for PAB and staged repair often chosen because they are considered too ill to safely undergo definitive repair (6), (11) (13). In our series, the risk factors for operative mortality after PAB were similar to other series (11) (13) which included Down's syndrome, age older than 1 year, P.A pressure more than 75 mmHg, cardiac cachexia, repeated preoperative chest infection and postoperative low cardiac output and prolonged mechanical ventilation.

In Conclusion

We conclude from this study that:

(1) Patients with VSD should be regularly followed up for signs of pulmonary hypertension or congestive heart failure.

(2) Patients who are not responding to medical treatment should be immediately referred to surgery without unnecessary prolonged follow up.

(3) Primary VSD closure is preferred except if the situation is suboptimal or there is a risk factor for primary closure & P.A.B should be considered as an alternative, temporary palliative option.

(4) Good adequate P.A.B can prevent the progression of irreversible pulmonary hypertension with excellent outcome after pulmonary artery debanding and VSD closure.

- Finally, we believe that PAB in certain circumstances is a better option compared to primary VSD closure with high operative mortality or unnecessary wrong or prolonged follow up which can change VSD from simple congenital cardiac defect into fatal lesion due to irreversible pulmonary hypertension.

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SURGICAL MANAGEMENT OF CRITICAL AND SEVERE AORTIC STENOSIS IN INFANTS AND CHILDREN EARLY AND MID-TERM RESULTS

ABSTRACT

Objectives: Congenital valvular aortic stenosis is a challenging entity. Treatment modilities ranges from purely interventional to purely surgical. The aim of this research was to evaluate the early and mid term results of surgical open aortic valvotomy to provide an optimal protocol for management of neonates infants or children with critical or severe aortic stenosis.

Methods: From 1996 to 2002, 32 neonates, infants and children underwent surgical aortic valvotomy for critical or severe valvular aortic stenosis. These 32 patients were divided into two group: The first group included 8 patients (neonates or infants) with age ranging from 1.5 to 6 months with critical aortic stenosis. The body weight in this group ranged from 4.5 to 6.8 kg (mean 5.58 kg). The second group included 24 children aged from 7 months to 8.4 years with severe valvular aortic stenosis. The mean aortic valve pressure gradient was 90 mmHg in the first group and 85 mmHg in the second group. Two patients in the first group and 7 patients in the second group underwent balloon aortic valvuloplasty before the surgery.

Results: All patients underwent open aortic valvotomy on cardiopulmonary bypass. There was only one operative mortality 15 days postoperatively with picture of low cardiac output. At discharge the mean aortic valve pressure gradient dropped from 90 to 33 mmHg in the first group and from 85 to 29 mmHg in the second group: Late deaths occurred in 2 patients at a period of 4 to 24 months after the operation. Six patients required reintervention in the form of balloon aortic valvuloplasty (4 patients) at a median of 24 months from the initial valvotomy and two patients required surgical reintervention 2 and 5 years from the initial procedure. The actuarial survival including operative mortalities was 97% at one month 94% at 1 year and 91% at 5 years while the actuarial freedom from reintervention was 96.8% at 1 year, 84 % at 3 years and 81% at 5 years. All survivors are in NYHA class I with normal daily activities. Two patients have moderate aortic regurgitation while mild or trivial degree was detected in another 5 patients during the follow up period of this study.

Conclusion: Surgical aortic valvotomy is found to be valuable tool in the treatment of neonates or infants with critical aortic stenosis and children with severe valvular aortic stenosis. It offers many advantages over balloon valvuloplasty with the ability to inspect directly the valve and incise commissures accurately with resection of dysplastic tissue or nodules which may contribute to better long term outcome. The actuarial survival and freedom from reintervention is comparable even better than the balloon aortic valvuloplasty.

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INTRODUCTION

▪ The optimal management of severe aortic stenosis in infants and children remains controversial. Although percutanous balloon valvuloplasty is currently advocated by several centers as the procedure of choice, open surgical valvotomy using cardiopulmonary bypass remains our standard approach in the management of infants and children with severe or critical aortic stenosis at our unit.

▪ The aim of this research was to analyze the early and mid term results achieved by surgical aortic valvotomy regarding the survival, functional results and reintervention which allow a reference point for comparison with the balloon volvuloplasty which has become an accepted form of therapeutic intervention for congenital aortic stenosis.

Patients and Methods

▪ Between January 1996 and July 2002, 32 consecutive patients underwent surgical aortic valvotomy at the Cardiac Unit of Ain Shams University and Abu EL Reesh Student hospitals. These 32 patients were divided into two groups: the first group included 8 patients (neonates or infants) less than 6 months of age with critical aortic stenosis. The second group included 24 patients with severe congenital aortic stenosis and their ages ranged between 7 months and 8.4 years. The patient's characteristics are shown in Table (I) and Table (II).

▪ Preoperatively, routine evaluation included full clinical examination, chest X ray and two-dimensional echocardiography with Doppler studies. The presentation in the first group (8 patients) was congestive heart failure while in the second group, the clinical presentation was exercise intolerance with chest pain in 10 patients (41%), palpitation in 4 patients (17%). 10 patients were asymptomatic and they underwent aortic valvotomy due to presence high pressure gradient across the left ventricular outflow tract and severe left ventricular hypertrophy on echocardiographic examination.

▪ Two patients in the first group and 7 patients in the second group underwent balloon aortic valvuloplasty at an interval ranging from 15 days to 3.5 years prior to the surgical aortic valvotomy.

Surgical Technique:

▪ The operation was performed through a standard median sternotomy. After the pericardium is opened, minimal manipulation of the heart before going on bypass is essential especially in neonates with critical aortic stenosis to avoid the ventricular arrhythmia especially ventricular fibrillation.

▪ We prefer to use single venous metal tip canula for the venous drainage and the aorta is usually canulated as high as possible. Standard cardiopulmonary bypass technique is used with moderate hypothermia (Temperature from 30-32°C). A cold blood cardioplegia (30 mls/kg in neonates and 25 mls/k,g in children) was used routinely in all patients. This big dose of blood cardioplegia is very important to achieve a good myocardial protection for the hypertrophied left ventricle.

▪ After the aorta is cross clamped and the cardioplegia is infused, an oblique or transverse aortotomy is done and the aortic valve is inspected very well. The fused commissure is incised to stop 1-2 mm before

Table (I): Patient characteristics of group I (Critical Aortic Stenosis).

No	Age (months)	Body Weight (kg)	Presentation	Previous Balloon	Preoperative Pressure gradient	L.V EF	Ao. annulus diameter in mm
1	6	6.8	Congestive heart F	Yes	90 mmHg	0.56	8.5 mm
2	4	5	"	No	78 mmHg	0.47	7.5 mm
3	5	5.9	"	No	110 mmHg	0.58	8 mm
4	6	6.5	"	No	88 mmHg	0.43	9 mm
5	2.5	5.4	"	No	92 mmHg	0.59	6.5 mm
6	3	5	"	No	75 mmHg	0.65	7.5 mm
7	4	5.6	"	No	85 mmHg	0.68	8 mm
8	1.5	4.5	"	Yes	102 mmHg	0.55	7 mm

LVEF: Left ventricular ejection fraction.

annulus. Any fibrotic nodules or dysplastic tissue under the valve leaflets are gently shaved and removed with knife. We don't touch the raphe of the bicuspid valve to avoid severe aortic regurgitation. After performing the aortic valvotomy, the subvalvular area is inspected for any associated subvalvular obstruction and Hegar dilator is passed gently across the valve opening into the left ventricle. Finally, aortotomy is closed with 5/0 or 6/0 polypropolene and the patient weaned from the cardiopulmonary bypass in the usual way.

- Postoperative follow up was obtained in all patients at out patient clinic with regular two-dimensional and Doppler echocardiograms were obtained in all survivors. Clinical information and echocardiographic data were available for all survivors at the closing date of this study (July 2002). Follow up was 100% complete and it ranged from 3 to 75 months (mean of 42 months). Reintervention was defined as any reoperation or balloon aortic valvuloplasty after the surgical aortic valvotomy. Freedom from time related events and survival are calculated and presented by the method of Kaplan-Meier.

Results

Operative results and early outcome:

- Operative mortality was low in this study (3.1%). Only one patient died 15 days postoperatively from picture of low cardiac output with prolonged mechanical ventilation. This patient was 4 months old boy with critical aortic stenosis, moderate mitral regurgitation and mitral stenosis. He underwent open aortic valvotomy and his immediate postoperative echocardiography showed drop of pressure gradient across aortic valve from 85 to 37 mmHg with severe mitral regurgitation. He needed prolonged mechanical ventilation but he died from low cardiac output 15 days after operation.

- Postoperative morbidity in the form of low cardiac output which required inotropic support for more than 3 days occurred in two patients in the first group of neonates and infants with critical aortic

Table (II): Patient characteristics of group II (Severe Aortic stenosis).

	Range	Mean ± SD
- Age (months)	7 – 100	46± 7.35
- Body weight (Kg)	6-5 – 35	19 ± 6.65
- Ao. annulus diameter (mm)	6 – 18	12 ± 3.75
- Press. Gradient (mmHg)	69 – 120	85 mmHg
- LVEF	0.45 – 0.86	0.72 ± 0.12

LVEF: Left ventricular ejection fraction.

Table (III): Pressure gradient across the aortic value pre and after open aortic valvotomy.

	1st group (critical aortic stenosis)	2nd group (severe aortic stenosis
Preoperative		
Range	- 75- 110 mmHg	- 69 – 120 mmHg
Mean	- 90 mmHg	- 85 MMhg
Postoperative		
Range	- 25 – 37 mmHg	- 19 – 6- mmHg
Mean	- 33 mmHg	- 29 mmHg

stenosis. One patient required diphragmatic plication for right phrenic nerve paralysis one month after the operation with full recovery after the plication.

- Before discharge complete echocardiographic examination was done for all patients and revealed good left ventricular function in all patients except in 2 patients in the first group of neonates of infants with critical aortic stenosis, ejection fraction before discharge was fair but it was better than the preoperative status. Pressure gradient across the aortic valve was reduced in the first group of patients critical aortic stenosis) from a mean of 90 mmHg to a mean of 33 mmHg. In the second group (severe aortic stenosis), pressure gradient decreased from a mean of 85 mmHg preoperatively to a mean of 29 mmHg postoperatively.

- Aortic regurgitation was also evaluated carefully by echocardiography before discharge. In the first group, 2 patients had mild or trivial degree and 5 patients had no aortic regurgitation at all. In the second group 15 patients showed no aortic regurgitation 6 patients had a mild degree while in 3 patients aortic regurgitation was evaluated to be of moderate degree.

Late follow up:

31 patients who survived the procedure were followed up. This follow up was

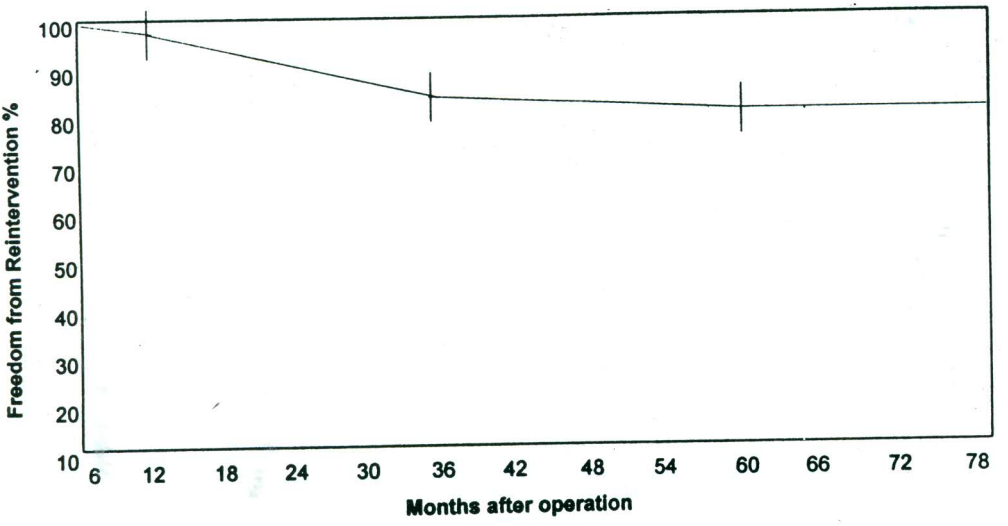

Fig. (1): Kaplan-Meier freedom from reintervention for the 32 patients underwent surgical aortic valvotomy.

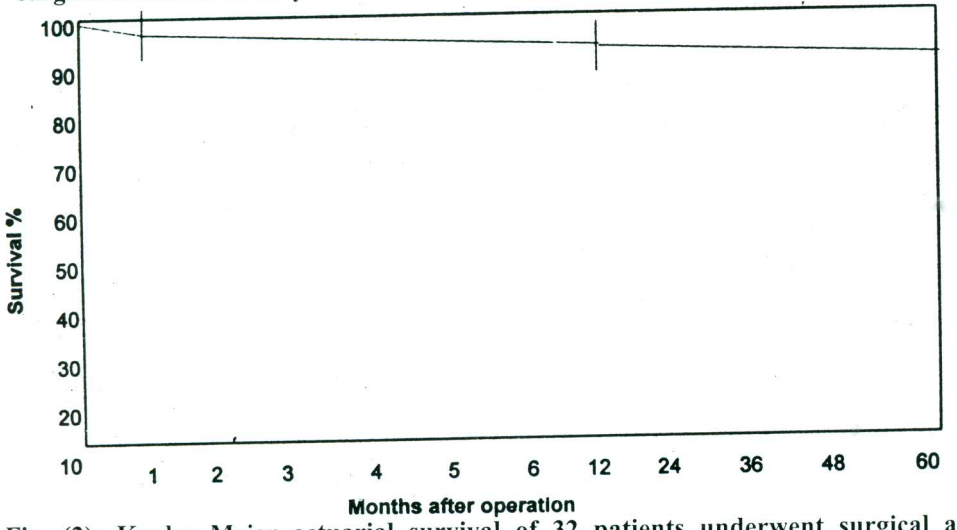

Fig. (2): Kaplan-Meier actuarial survival of 32 patients underwent surgical aortic valvotomy.

complete (100%). The duration of follow up ranged from 3 to 75 months (mean of 42 months).

- There were two late operative deaths during the follow up period of this study (6.4%). One late death occurred 4 months after the open aortic valvotomy in 10 month old patient who was discharged with only mild aortic valve regurgitation but residual gradient of 65 mmHg across the aortic valve developed on serial echocardioigraphic examination. This patient developed endocarditis across the aortic valve 3 months postoperatively and he died 1 month later with picture of Bacterial endocariditis and congestive heart failure. The second patient who was 7 years old

when he underwent surgical aortic valvotomy with recurrent aortic stenosis (P.G: 90 mmHg) two years after the initial procedure. At age of 9 years he underwent aortic valve replacement with aortic root enlargement using Kono procedure (Aortoventriculoplasty) but he died intraoperatively from severe uncontrollable bleeding.

- Reintervention during the follow up period in this study included both surgical intervention and balloon aortic valvuloplasoty was required in 6 patients. Balloon aortic valvuloplasty was required in 4 patients at a median of 24 months (range 8-33 months) from the initial open valvotomy. Surgical intervention was required in two patients due to recurrent aortic stenosis in the second group of patients with severe aortic stenosis. One patient underwent aortic valve replacement (for recurrent aortic stenosis and severe aortic regurgitation) at age of 12 years, 5 years after his open valvotomy with (St. Jude medical prosthesis size 21 mm) and the second patient who had Kono procedure 2 years after his initial open aortic valvotomy and he died intraoperatively from severe bleeding.

- The actuarial freedom from reintervention was illustrated in Fig (1) and it was 96.8% at one year, 84% at 3 years and 81 % at 5 years. Also the actuarial survival of the 32 patients included in this study is illustrated in Fig (2) and it was 97% at 1 month and 94% at one year and 91 % at 5 years. Late clinical follow up and serial echocardiographic examination has been performed for all survivors. All survivors (29 patients) were in NYHA functional class I with normal daily activities with a mean aortic valve gradient of 29.5 mmHg on most recent echocardiography. Also aortic valve regurgitation was evaluated in all patients and it was trivial or mild in 5 patients and moderate in 2 patients only.

Discussion

- Congenital valvular aortic stenosis in neonates, infants or children is a challenging entity. There is an ongoing debates as to which approach provides optimal palliation. Treatment modilities ranging from purely interventional to purely surgical (1). Balloon valvuloplasty has become an accepted form of therapeutic intervention for congenital valvular aortic stenosis since first reported in children by Lababidi et al in 1981 (2) and in neonates in 1986 (3). Although balloon aortic valvuloplasty appears to offer good early results but there is a little information about the long term follow up and need for reintervention (4). Also the procedure of balloon aortic valvuloplasty is associated with major complications in the neonates and infants including transection of the femoral artery, perforation of the aorta, severe aortic regurgitation, injury or perforation of the mitral valve and complete avulsion of the aortic valve (5)(6).

- The clinical presentation of patients in this series was different in the two groups of patients included in this study. All neonates and infants (8 patients) with critical aortic stenosis presented with congestive heart failure, while, in children with severe aortic stenosis, many patients were asymptomatic or having a mild symptoms in form of exercise intolerance chest pain or palpitation.

- Although in the recent years, the standard treatment for critical aortic stenosis in neonates and infants has changed from surgical aortic valvotomy to balloon aortic

valvuloplasty in many series (7), Yet in our center the early results of balloon valvuloplasty were disappointing with high rate of complications including cardiac arrest and death. This experience led us to rethink about surgical aortic valvotomy as a first option in neonates or infants with critical aortic stenosis especially that we do not have available homorgraft to do Ross procedure if the balloon aortic valvuloplasty complicated with severe aortic regurgitation. We believe that if the cardiologist is not having a wide experience to deal with such small body weight of neonates or infants, the safest option is to do surgical aortic valvotomy.

- In our series, only 2 patients with critical aortic stenosis underwent a trial of balloon aortic valvuloplasty in contrast to 7 cases in the second group or older patients with severe aortic stensosis who underwent a previous balloon valvuloplasty at an interval of 2 to 30 months before the surgical valvotomy. These 7 patients had an initial relatively good result after balloon valvuloplasty with recurrent aortic stenosis which necessitated an open aortic valvotomy.

- In contrast to our situation here in Egypt, percutaneous balloon valvuloplasty is currently advocated by several centers abroad as the primary procedure of choice mainly because of the perceived lesser invasiveness of the interventional approach. Avoidance of a sternotomy and direct manipulation of the heart are worthwhile goals in sick neonates (7). Although of these previously mentioned advantages but many authors reported that percutaneous approaches in small neonates and infants have a significant complication rate such as the catastrophic occurrence of mitral valve injury by guidwire under tension which can result in severe mitral regurgitation which can be fatal in sick neonates with critical aortic stenosis (6) (8).

- Perioperative care of the infants and children with critical aortic stenosis represents a challenge to the anesthesiologist and cardiac surgeon and the meticulous anesthetic management is essential to minimize the perioperative morbidity and mortality in infants with critical aortic stenosis. Intravascular hypovolemia must be avoided because under filling of the left ventricle result in a decrease in cardiac output (7). It has been reported that maintenance of normal heart rate is very important because tachycardia increases myocardial oxygen consumption and decreases oxygen delivery to the heart and increasing the risk of myocardial ischemia (7). Also systemic vascular resistance should be maintained to optimize coronary perfusion. The use of Ketamine should be avoided (increases heart rate and decreases the systemic vacular resistance. Morphine may induce bradycardia with reduction of cardiac output which may worsen the coexisting congestive heart failure. Inhalation anesthetics which may cause myocardial depression should be avoided except in a very low concentration (7). The anesthetic management protocol in this series was similar to other series (3) which depends mainly on using a narcotic based technique using Fentanyl or remfentanyl as the first drug of choice with small doses of inhalation anesthetics.

- In agreement with other investigators we believe that certain distinct physiologic and anatomic advantages remain in favour of open aortic valvotomy on cardiopulmonary bypass (4) (9). Cardiopulmonary bypass in this setting (neonates with critical aortic stenosis) is not only safe but it is also beneficial in that it unloads the ventricle and allows for end–

organ function such as renal function to recover because of improved perfusion. It also allows for direct inspection of the aortic valve with performance of proper, anatomically corrected commissurotomy and excision of the obstructive nodules and fibers. It also permits precise measurements of the aortic annulus which is sometimes difficult by echocardiography or catheterization because of the crowded or thickened aortic valve (7).

- The early mortality rate for surgical aortic valvotomy has a wide range in the literature which ranged between 9% and 59% even in the recent years (10) (11). Many studies have found that small patient size or young age and endocardial fibroelastosis to be the strongest predictors of mortality either early or late (11). The mortality rate in our series is low with only 3.1% operative mortality and 6.4% late mortality have been recorded. This low mortality are attributed to that the main bulk of our patients 24/32 (75%) were older than 6 months and only 8 patients (25%) were neonates or infants in contrast to other series where they reported their high mortality rate among neonates or infants mainly with small body weight. Also in our series we have excluded any patient with aortic annular diameter less than 5 mm and no cases of endocardial fibroelastosis were included. Other studies reported also similar low rate of operative and late mortality after open aortic valvotomy like Hawkins et al (4) who reported 11% early mortality and Alexious et al (9) who reported no operative mortality and 5.5% late mortality in their series with 18 neonates and infants with critical aortic stenosis who underwent aortic valvotomy.

- The actuarial freedom from re-intervention for patients in this series was 97% at one year, 84% at 3 years and 81% at 5 years. This actuarial freedom from reintervention was better than other series like Karl et al (11) and HawKins et al (4) who reported 68% at 5 years and 55% at 10 years. Reintervention after open aortic valvotomy is mainly for recurrent aortic stenosis with balloon aortic valvuloplasoty is the first option for reintervention as reported by our series and other series (12) and the surgical reintervention is kept for patients with recurrent aortic obstruction associated with moderate or severe aortic valve regurgitation. It is difficult to compare directly the outcome of both open aortic valvotomy and balloon valvuloplasty as the results of both techniques are influenced by patient selection, anatomy of the aortic valve and experience of the center. McCrindle et al (13) described outcomes of surgical versus balloon valvotomy in neonates with critical aortic stenosis out of 110 neonates surgical aortic valvotomy was done in 28 patients and balloon valvotomy in 82 patients. They found that mean percentage reduction in systolic gradient was significantly greater with balloon (65%) than surgical valvotomy (41%) but significant aortic regurgitation tended to be more common after balloon valvotomy (18%) compared only 3% only with surgical aortic valvotomy.

Conclusion

Based an our results and on other series we believe that surgical aortic valvotomy using cardiopulmonary bypass is good and safe option for both neonates and infants with critical aortic stenosis and children with severe aortic stenosis. This option can give results that compares very favorably with balloon valvuloplasty with low incidence of

recurrent aortic stenosis and very low incidence of significant aortic regurgitation.

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S. Azab and H. ElGhetany

MODIFIED BLALOCK–TAUSSIG SHUNT IN INFANTS AND CHILDREN WITH CYANOTIC HEART DISEASE CLINICAL AND CATHETERIZATION ASSESSMENT OF 385 SHUNTS IN 350 PATIENTS

ABSTRACTS

Background: The modified Blalock–Taussig shunt is becoming now the surgical procedure of choice for the cyanotic congenital heart disease if palliation rather than primary correction is to be done. This report details our experience in 385 modified BT shunt with evaluation of the early and late morbidly and mortality discussing the advantages and disadvantaged of this surgical technique.

Methods: Between March 1996 and Dec. 2001, 385 modified BT shunts were performed in 350 patients with cyanotic congenital heart disease. The mean age at operation was 8.5 months and the mean weight was 7.6 kg. The modified BT shunt was performed through a right thoracotomy in 180 patients, left thoracotomy in 165 patients and median sternotomy in 40 patients. Patients were followed up clinically, echocardiographically and in most cases by cathereterization as well.

Results: There was 5.7% operative or hospital mortality and 2.4% late operative mortality during the follow up period. Early related shunt complications occurred in 29 patients (9.5%) which included acute shunt thrombosis on total occlusion (16 patients), overflow and pulmonary edema due to excessive shunt flow (8 patients), seroma developed in 2 patients and partial obstruction and narrowing of the shunt in 3 patients. Preoperative oxygen saturation was significantly increased from a mean of 64.5% to 85.6% ($p<0.05$) postoperatively which reflects the marked improvement in the oxygenation and general conditions of the patients. The follow up in this study ranged from 3 to 45 months (mean 18.5 months and cardiac catheterization and angiography was performed in 205 patients during the follow up period with a mean interval of 19.5 months between the BT shunt and cardiac catheterization. Among the 205 patients who underwent cardiac catheterization and angiography, the late shunt related complications were diagnosed in 35 patients (17%) which included total shunt occlusion (4.4%), pulmonary artery distortion (3.9%), total occlusion of the pulmonary artery opposite to the site of shunt (1.4%), distal implantation of the shunt (4.3%) and wrong implantation of the BT shunt into upper lobe branch in 1%. 35 patients required second shunt during the follow up period due to progressive oxygen desaturation and the mean interval between the first and second shunt was 12.5 months. 165 patients underwent definitive repair or total correction at a mean period of 18.5 month from the modified BT shunt (range 13 to 32 months).

Conclusion: The modified BT shunt continues to be an effective surgical option for initial palliation of cyanotic congenital heart disease. It allows improvement in oxygenation and general symptomatic status of the patients. The early and late shunt

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related complications can be minimized by meticulous shunt reconstruction into proximal pulmonary artery branch with median sternotomy approach is becoming now the new approach of choice to avoid these shunt related complications.

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INTRODUCTION

• The modified Blalock Taussig shunt which was developed by De leval and his associates in 1981 (1) is becoming now the standard aortopulmonary shunt because of its reliable flow and ease of construction. This systemic-to-pulmonary shunt continues to play an important role in palliation of infants and children with cyanotic congenital heart disease leading to decreased pulmonary blood flow. If palliation rather than primary correction is to be done, the procedure should allow adequate development of the pulmonary arteries as well as improvement in oxygenation and the general symptomatic status of the patient (2).

• However, certain complications and disadvantages relating to the use of systemic-to-pulmonary shunt are of concern including early and late shunt thrombosis and occlusion, technical limitations of its use in neonates with small main branch pulmonary arteries pulmonary artery distortion and Kinking and inadequate growth of the pulmonary arteries. (3). In this retrospective study, we review our experience in 385 modified BT shunt performed in 350 neonates, infants and children with cyanotic congenital heart disease over a period of 6 years from 1996 to 2001 with analysis of the early and late shunt related complications which was performed through the follow up period and evaluation of cardiac catheterization and angiograms after the shunt.

Material and Methods

• Three hundred eighty five modified B-T shunts were performed in three hundred fifty neonates, infants and children at the cardiac unit of Ain Shams University hospital between March 1996 and December 2001. The mean age at operation was 8.5 months (range 3 days to 42 months) and the mean body weight was 7,6 kg (range 2.5 kg to 11.5 kg).

The underlying lesions of the patients were shown in table (1). The indications for shunt procedure in Fallot's tetrology patients included small body weight < 7Kg with severe cyanosis, small pulmonary arteries with MGoon ratio less than 1.5 and anomalous coronary artery (anomalous origin of LAD from right coronary artery). In 52 patients with pulmonary Artesia and duct dependant 35 patients (76%) received prostaglandin E1 (Prostin) infusion with mechanical ventilation required in 9 patients before the shunt procedure.

• One hundred eighty (180) patients underwent modified B-T shunt through a right thoracotomy (46.7%), 165 patients (43%) underwent the shunt through a left thoracotomy and median sternetomy was used in 40 patients (10.3%). Of the 40

patients who underwent median sternotomy 2 patients had a central shunt (from the aorta to main pulmonary artery) and the rest of the patients underwent right subclavian to right pulmonary artery modified B-T shunt using Gore-tex tube.

Surgical technique:

- The standard modified B-T shunt through left or right thoracotomy approach has been described before. It requires interposition of Gore-tex tube between subclavian artery and right or left pulmonary artery using partial occlusion clamps and continuous monofilament suture every effort should be made to put the shunt in the proximal pulmonary artery branch and to avoid distal implantation or wrong implantation into upper lobe branch (Fig. 1) to minimize pulmonary artery distortion and to make the shunt take down more easy during definitive repair.

- Here we will describe the new technique of the modified B-T shunt through median sternotomy approach (Fig. 2): After the median sternotomy is performed with removal of thymus gland, the brachiocephalic and right subclavian artery are dissected and mobilized freely using either sharp dissection or low diathermy. The pericardium is open in its cephalic portion only and the right pulmonary artery is dissected and fully mobilized. The dissection of right pulmonary artery is helped by pulling the aorta to the left side and the SVC is retracted to the right and right atrium is retracted inferiorly. Once the right pulmonary artery is isolated, it is encircled with heavy silk ligature or silastic tape.

- Gore-tex tube is then anastomosed end to side to both right subclavian or innominate artery and right pulmonary artery using partial occlusion clamps. The Gore-tex tube may pass behind the innominate vein or may cross in front of it to run along side the aorta to reach the right pulmonary artery close to its bifurcation making sure that no Kinging or torsion develops. This final position of the graft close to the aorta allows for easy retrieval of the shunt at the time of the second procedure.

-260 patients had Gore-tex tube size 5 mm (67.5%), 80 patients had Gore-tex tube size 4 mm (20.7%) and in 45 patients (11.6$) had Gore-tex tube sized 6 mm. After operation all patients were mechanically ventilated for a variable time depending on hemodynamic stability and oxygen saturation. In all surviving patients echocardiographic examination was done before discharge to establish shunt patency for comparison on subsequent examination. Follow up was done clinically by observing the degree of cynosis, frequency of cyanotic spells, signs of heart failure, signs of endocorditis and auscultation of the characteristic shunt murmers.

-Echocardiographic evaluation was done to establish and confirm the underlying anatomy before surgery. The shunt evaluation usually performed through the suprasternal window in the short axis view for right MBT shunts and in the long axis view for left MBT shunts

-Additional windows were used for central shunts which were more difficult to visualize by two dimensional examination alone. Color Doppler was used in all cases to confirm flow through the shunt into the pulmonary arteries are continuous mosaic flow. Continuous wave Doppler was also used to confirm the continuous shunt flow.

-Cardiac catheterization was done in some cases before shunt surgery (n= 65) if diagnosis was not confirmed by echo or there was a possibility for total repair. It was done after the shunt surgery in 205 patients.

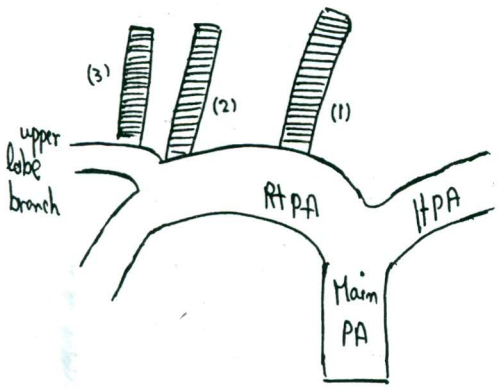

Fig. (1): Different sites of MBT shunt implantation during thoracotomy approach. 1-Ideal shunt implantation site (proximal PA). 2-Distal shunt implantation site (PA bifurcation). 3-Wrong shunt implantation site (upper lobe branch)

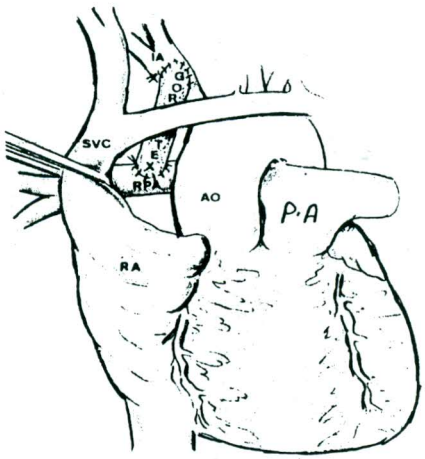

Fig. (2): Technique of MBT shunt through median sternotomy with the Gore-Tex tube between the innominate artery (IA) and the right pulmonary artery (RPA)

-Catheterization was done under deep sedation using the right groin for right and left heart catheterization. Femoral vien access was established using 6F sheath and with femoral artery using 5 or 6 F sheath. Systemic heparin was given in a dose of 50-100 Iu/Kg/Iv.

-Selective shunt angiography was done through the aorta using Judkins right, multipurpose or cobra head catheters. Pressure in the PA was recorded either antegradelly through right ventricular outflow tract or retrogradely after crossing the shunt. Any anatomic or hemodynamic information needed for total repair such as pulmonary artery distortion or total occlusion was then completed. Follow up data were available in all surviving patients through out patient clinic regular visits. The decision to carry out a definitive repair or second shunt was based on oxygen saturation, echocardiographic examination, cardiac catheterization and angiographic findings.

Results

There were 22 operative mortalities (5.7%). The cause of these operative deaths included shunt failure or acute thrombosis with marked oxygen desaturation (10 patients), pulmonary edema with excessive flow and congestive heart failure (5 patients), persistent cynotic spells (with functioning shunt) in 4 patients and sudden unexplained death in 3 patients.

Table (1). The underlying lesions (Indications for the M.B.T shunt).

	Lesions	Number	%
1	Tetrology of Fallot	189	49%
2	Pulmonary artesia with VSD	52	13.5%
3	Double out let right ventricle VSD and pulmonary stenosis	46	11.9%
4	Single ventricle with pulmonary stenosis	48	12.4%
5	Transposition of great arteries, VSD and P.S	25	6.5%
6	Complete A VSD and pulmonary stenosis or F4	12	3.1%
7	Corrected T.G.A, VSD and PS	8	2%
8	Pulmonary artesia with intact septum	5	1.2%

Table (2): Early shunt-Related Complications and its effect on operative mortality.

Complication	Number	Percentage of mortality
1. Acute Thrombosis or total occlusion	16	10/16 (62%)
2. Shunt overflow and pulmonary edema	8	5/8 (62.5%)
3. Partial occlusion or narrowing of shunt	3	-
4. Seroma	2	-

Table (3) Late- shunt- related complications in 205 patients who underwent cardiac catheterization

Complication	Number	Percentage %
Total occlusion or late thrombosis	9	4.4%
Pulmonary artery complication		
- Distortion and severe stenosis	8	3.9%
- Total occlusion	3	1.4%
- Distal implantation	9	4.3%
- Wrong implantation (upper lobe)	2	1%
Endocarditis at the site of shunt	2	1%
Subclavian artery narrowing	2	1%

Early shunt related complications occurred in 29 patients (9.5%) (Table 2). Acute shunt thrombosis and total occlusion occurred in 16 patients and the shunt was revised through the same previous thorocotomy in 13 patients while 3 patients underwent emergency sternotomy and central shunt between the main pulmonary artery and ascending aorta. Overflow and pulmonary edema due to excessive shunt flow was diagnosed in 8 patients. 5 patients required reoperation within 24 to 48 hours with reduction of the diameter of the shunt with the use of a metallic clip while in 3 patients pharmacological manipulation with diuretics and vasodilators was used. Seroma was diagnosed in 2 patients with exploration 24 hours after the shunt. In the 2 patients

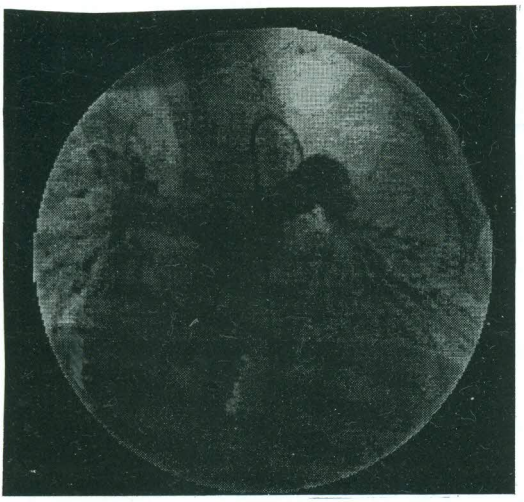

Fig. (3): Angiogram of a non complicated MBT shunt showing normal anatomy of the pulmonary artery with no distortion or Kinking.

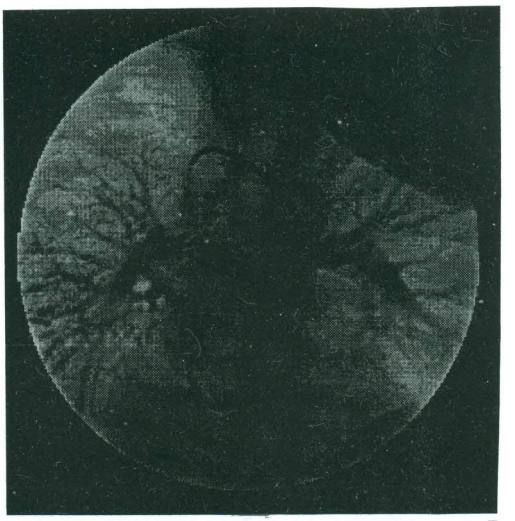

Fig. (4): Pulmonary artery distortion and stenosis after MBT shunt.

shunt was revised and replaced with another Gore-tex tube and the two patients recovered completely. In 3 patients partial occlusion or narrowing of the shunt flow was diagnosed by echocaricgraphy and heparin infusion was immediately started with marked improvement of flow in the shunt was evident by clinical improvement in oxygen saturation and echocardiography.

The postoperative oxygen saturations were significantly higher than the preoperative mean values as the mean preoperative oxygen.

Saturation increased from 64.5% to 85.6% ($p<0.05$) postoperatively. In 35 patients (Neonates) who had B-T shunt while they were on prostin infusion preoperatively, the infusion could be stopped safely in the immediate postoperative period and the patients maintained good oxygen saturation. All the patients who survived the procedure (328 patients) were followed up for a mean period of 18.5 months (range 3 to 45 months) the follow up was terminated in this study if the patient underwent definitive surgical repair either univentricular or biventricular repair.

There were 8 late deaths during the follow up period (2.4%). 4 patients died suddenly after emergency hospital admission before any investigations were done. 2 patients developed endocorditis on the B-T shunt and died 7 and 15 days after hospital admission and antibiotics Therapy from septicemia and low cardiac output. Another 2 patients presented with persistent

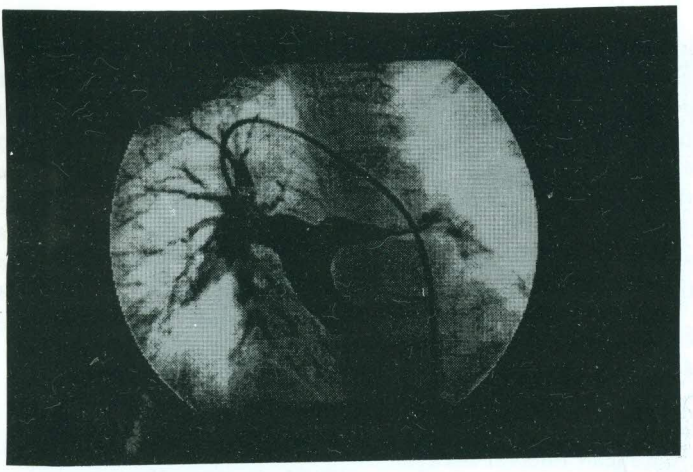

Fig. (5): An angiogram of patient with pulmonary atresia and previous bilateral MBT shunts with severe left pulmonary artery distortion and stenosis together with distal implantation of the right MBT shunt.

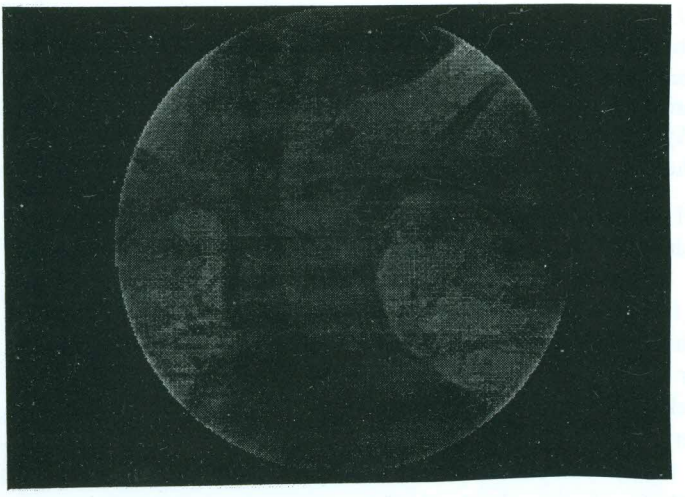

Fig. (6): Subclavian artery narrowing by right MBT shunt with some ischemic manifestations of the right arm seen after the shunt.

cyanotic spells with non functioning shunt on Echocardiagraphic examination and they died 6 and 8 hours after admission before any surgical intervention was done.

During the follow up period, 35 patients (10%) required an additional shunt operation the mean interval between the initial and the second shunt was 12.5 months (rang 8 to 19

months). 28 patients underwent this second shunt on the opposite side and 7 patient underwent second shunt through median sternotany approach. These patients exhibited increasing desaturation and cynosis despite the potency of the previous B-T shunt in 26 patients. In the other 9 patients, no flow could be detected in the shunt (Non functioning shunt).

Postoperative cardiac catheterization and angiography was performed in 205 patients during this follow up period to assess the shunt patency and to diode the next step of definitive repair, the mean Interval between B-T shunt operation and postoperative cineangiographic study was 19.5 months (range 12 to 38 months).

The angiographic findings in these 205 patients ranged from excellent constructed proximally situated shunt (Fig. 3) to severely distorted, kinking or total occlusion of pulmonary artery branch by the B-T shunt Figs. (4), (5) and subclavian artery narrowing by the shunt (Fig. 6).

The overall rate of pulmonary artery distortion which was defined as significant branch artery luminal stenosis (50% or more) close to the shunt was 3.9% (8/205). Other late shunt related complications diagnosed after angiography was shown in table (3) which included in addition to pulmonary artery distortion, total occlusion of pulmonary artery branch (3 patients), distal implantation of the shunt at the bifurcation of right or left pulmonary artery branch (9 patients) or wrong implantation of the shunt into the upper lobe branch (2 patients), narrowing of the subclavian artery by the shunt (2 patients).

Out of these 205 patients who underwent cardiac catheterization and angiographic study, 165 patients underwent definitive surgical repair in the from of total correction of Fallot's tetralogy (108 patients), Bi-directional Glenn shunt (45 patients) and Rastelli repair in 12 patients. Pericardial patch augmentation was required in patients with pulmonary artery distortion of or adjacent to the shunt anostomosis. The period between the modified BT shunt and the definitive repair ranged from 13 to 32 months (mean 18.2 months).

Discussion

The modified Blalock-Tausig (M.B-T) shunt is now the surgical procedure of choice in congenital cyanotic heart disease if palliation rather than primary correction is to be done (2). It allows adequate development of the pulmonary arteries as well as improvement in oxygenation and symptomatic status of the patient (2). This modified B-T shunt has replaced the classic B-T shunt completely since its introduction by De leval et al in 1981 (1). It requires interposition of a segment of Gore-Tex or P.T.F.E. graft material between the subclavian artery and the pulmonary artery using a partial occlusion clamps. The modified BT shunt has several advantages: a technically simple procedure, preservation of the subclavian artery and regulation of the shunt flow by the size of the vascular graft (4). Despite these advantages, the modified BT shunt has the disadvantages of unsatisfactory long-term results especially in using 4mm or smaller grafts.

In our experience we found that staged approach remains an option in a selected group of patients as it allows for total correction in a more stable patient. In this series, the indication for the modified B-T shunt was similar to other series like Alkhulaifi et al (3) who also demonstrated

an early mortality rate of 18% after neonatal repair of Fallot tetralogy which is considerably higher than the mortality with the B-T shunt in their series which was 4% only. Although the most common approach for the modified BT shunt has been the thoracotomy incision, yet the placement of this modified BT shunt through a median sternotomy is gaining increasing favor because it enables the shunt to be placed more centrally on the right pulmonary artery so that it may be less likely to cause distortion and its location will make eventual shunt take down quiet simple (3).

In our series, one of the major problem we discovered in our patients with modified BT shunt in this series during angiographic evaluation and intro-operatively during definitive repair is the distal implantation of the BT shunt either at the bifurcation of right of left pulmonary artery branch (9 patients) or wrong implantation of the shunt into upper lobe branch instead of right main pulmonary artery branch (2 patients). Recently with increasing the experience we have had overcome this problem of distal implantation of the modified BT shunt by dissection the pulmonary artery as proximally as possible especially on right thoracotomy approach by pulling the SVC to the left side and going by dissection under the surface of SVC to put the shunt more proximally on right pulmonary artery branch. In agreement with other series we found that distal implantation of the modified BT shunt carries two main disadvantages:

(1) The chance of pulmonary artery deformity and distortion is higher than when the shunt is proximally implanted.

(2) The take down of the shunt is more technically difficult during definitive repair as the shunt is far away from the median sternotomy.

The problem of distal implantation of the modified BT shunt is no more present when the median sternotomy approach is used for the shunt reconstruction (3). The pulmonary artery is easily dissected between the aorta and superior vena cava and the shunt can be implanted into the proximal right pulmonary artery. Also other investigators reported another advantages of using median sternotomy approach for the modified BT shunt like Odim et al who reported that this approach allows construction of the anostomosis at the side of SVC onto right pulmonary artery thus allowing repair of pulmonary artery at the time of bi-directional Glenn shunt. In addition, anostomosis of the shunt closer to the main pulmonary artery bifurcation allowing even distribution of blood to both lungs which is highly desirable (5). Some series like Laas et al reported that after using thoractomy approach for the modified BT shunt, preferential flow to one or other lung can occur with unequal growth of the pulmonary arteries (6).

In the presenting series, the median sternotomy approach was used in 40 patients, 30 of them had the shunt during the last year in this study which indicates that we have started to use this approach more commonly nowadays due to the previous reported advantages and to overcome the problems we have found with the thoracotomy approach.

The definition of shunt failure includes not only thrombosis and complete obstruction but also the progressive increase in serum hemoglobin levels or cyanosis even with a clinically patent shunt. The thrombosis of the modified BT shunt can occur early after the operation which is usually related to technical problem during shunt construction or late thrombosis due to

intimal peel formation of the Gore-tex which can progress to total occlusion (7).

Early Blalock Taussig shunt failure due to occlusion has been reported to occur in 3% to 5% (8), (9). In our series we had 4% incidence of early shunt thrombosis (16/385) and among 205 who underwent cardiac catheterization and angiography in this study we found 4.4% incidence of late shunt thrombosis (9/205) and the shunt patency percentage was 95.6%.

Other series reports similar percentage of shunt thrombosis like Alkhalaifi et al (3) who reported 5% incidence of early shunt thrombosis in their series of 79 neonates who underwent modified BT shunt. In contrast to our low incidence of late shunt thrombosis (4.4%), some authors reported a higher incidence of late shunt thrombosis or total occlusion like Fermanis et al (10). Who reported 62% actuarial shunt patency rate at 2 years and they attributed this high incidence of late shunt failure to the size of Groe-tex tube in their patients which was mainly 4 mm grafts.

It is well known that graft size affects the modified BT shunt flow several studies on the modified BT shunt have reported better palliation with 5 mm rather than 4 mm graft (11). In our series we have to use 5 mm grafts for the majority of our patients except in neonates with less than 3 months of age where a 4 mm grafts were used. We have observed that about 70% of the patient in our series who need second shunt were those who initially received 4 mm graft (24/35) and we have not observed any case of late congestive heart failure due to excessive pulmonary blood flow by the large side grafts (5 or 6 mm).

The problem of pulmonary artery distortion after the BT shunt have been widely discussed in the literature. Gladman and Colleagues (12) reported significant pulmonary artery distortion after placement of modified BT shunt in 33% of their patients with angiograms showing a tent up of the pulmonary artery at the site of shunt as a result of the prosthetic graft pulling the pulmonary artery upward. Also Alkhulifi et al (3) defined the pulmonary artery distortion after the BT shunt as significant branch artery luminal stenosis of 20% or more close to the shunt. They reported 6.3% incidence of pulmonary artery distortion in their patients. They attributed their low incidence to the smaller tube size used as well as the choice of fine suture material (7/0 or 8/0) (3).

Also in contrast to poor results reported by Gladman and associates, Jahangiri and associates demonstrates the safety and low morbidity of the modified BT shunt in their series (140 infants) with 100% survival both early and late with absence of pulmonary artery distortion.

In the present study, the total incidence of pulmonary artery distortion and total occlusion in patients who had cardiac catheterization was 5.3% (11/205) which is better than other series but the incidence of distal implantation of the shunt into distal pulmonary artery or bifurcation and wrong implantation of the shunt into upper lobe branch is higher than other series.

We believe that these technical problems in our series like distal implantation and pulmonary artery distortion are closely related to the experience of the surgeon and the building up experience of our center. This conclusion was reached after evaluation of the angiograms of the 205

patients in our series who underwent catheterization and angiogram as we found that these complications decreased from 16% in the first one hundred patient to 6% between the second 105 patients included in this series.

During the definitive repair and total correction the presence of pulmonary artery distortion or total occlusion is associated with increased operative morbidity and mortality (13). Usually pulmonary artery reconstruction and augmentation with pericardial patch or hemograft is required in such patients with pulmonary artery distortion. Also many series recommended the division not ligation the modified BT shunt during definitive repair as they believe that if B.T shunt was ligated and not divided the fixed length of graft would remain the same; with growth of the child, the pulmonary artery would therefore become distorted (14).

In conclusion

(1) If palliation rather than primary correction to be done in cyanotic heart disease, the modified BT shunt is the surgical procedure of choice with low operative morbidity and mortality.

(2) This modified B-T shunt allows improvement in oxygenation and general symptomatic status of the patient together with adequate development of pulmonary arteries.

(3) During reconstruction of the modified BT shunt through the right or left thoracotomy approach every effort should be made to minimize the chance of pulmonary artery distortion and to make dissection and take down of the shunt more easy during the definitive repair.

(4) Median sternotomy approach is a nice recent approach for the modified BT shunt especially in neonates or infants with small peripheral pulmonary arteries and unstable conditions as it allows implantation of the shunt into proximal relatively large pulmonary artery without compression of lung tissue.

(5) Cardiac catherization and angiography is essential after the MBT shunt before the definitive repair to visualize the anatomy and exclude any pulmonary artery distortion or total occlusion which might be difficult to diagnose by echocardiography.

(6) The deformity and constriction of pulmonary arteries after the modified BT shunt is higher with the thoracotomy approach than median sternotomy approach which is less likely to cause distortion of the pulmonary artery.

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WARM BLOOD CARDIOPLEGIA VERSUS COLD CRYSTALLOID CARDIOPLEGIA: A PROSPECTIVE STUDY

ABSTRACT

Continuous retrograde warm blood cardioplegia at systemic normothermia was proposed as a new method of myocardial protection. It was postulated that it maintains the myocardium in a strictly aerobic environment during crossclamping and reperfusion, and leads to a superior myocardial preservation, relative to other conventional hypothermic techniques.

This study is a prospective one aimed at comparing the hemodynamic and biochemical effects of both techniques on the outcome of patients after open heart surgery. Fifty-three patients undergoing predominantly valvular surgery, were assigned to one of two groups. The first group (28 patients) received continuous retrograde warm blood cardioplegia. The second group (25 patients) received intermittent cold antegrade crystalloid cardioplegia. Preoperative patients' characteristics were comparable in both groups except for a significantly higher incidence of atrial fibrillation, lower mean left ventricular ejection fraction, more left ventricular dilatation and hypertrophy and more urgent operation in the warm group.

Results showed that mortality was the same in both groups. The warm group experienced a significantly higher incidence of spontaneous resumption of sinus rhythm, a shorter reperfusion interval, a lower incidence of atrioventricular block, less use of inotropic support and lower left atrial pressures immediately after separation from bypass. After 24 hours, ECG recordings yielded a significantly higher incidence of new Q waves, new bundle branch block and atrioventricular block in the cold group. Also, postoperative release of cardiac enzyme CK-MB was significantly higher in the cold group at 6 and 24 hours after surgery.

Biochemical study showed that in the warm group myocardial metabolism remained strictly aerobic and unchanged during the three stages. In the cold group, a reperfusion injury was evidenced by coronary venous acidosis and myocardial accumulation of CO2, lactate and acid metabolites.

So, it was concluded that myocardial preservation was better achieved by warm lood cardioplegia because it maintained the heart in a constant aerobic environment and prevented any reperfusion injury.

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INTRODUCTION

Historical perspective:

In any field, discoveries are frequently made in response to a need, and the chronological evolution of techniques in myocardial preservation is no exception. For example, there was no need to concentrate

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on preserving the myocardium before 1953, when John Gibbon in Philadelphia, successfully closed an atrial septal defect using cardiopulmonary bypass (1). Surgeons soon learned that opening a chamber in a beating heart rapidly led to fatal air embolism, which could be prevented only by stopping the heart. Another problem for the surgeon was poor visibility in a blood-flooded operative field. Both of these problems stimulated efforts to provide a quiet and dry field with the heart standstill and with the circulation to it temporarily stopped. The obvious way to achieve this objective was to cross-clamp the aorta during the time required for the intracardiac repair. However, major concern very soon arose over the considerable perioperative mortality in those days, which led to an acute awareness that inadequate protection of the heart during the procedure was a significant factor in bad outcome. Subsequently, massive effort was directed towards various methods of intraoperative myocardial preservation.

In 1955, Dennis Melrose and colleagues in England achieved rapid and reproducible ventricular arrest on using intracoronary infusion of potassium citrate , with prompt return of sinus rhythm on restoration of coronary perfusion (2). Later, unfortunately extensive damage did occur with their cardioplegia that was attributed to the high concentrations of potassium that produced focal areas of necrosis in the myocardium. This finding served to slow the progress for about 10 years (3).

From 1961 to 1972, intensive studies were being carried out in German cardiac centers, investigating various chemical additives to cardioplegic solutions for a safer arrest. The resulting elaborate infusion, termed Bretschneider's solution, became the standard in many European centers. This solution contains about ten times less potassium than the original Melrose solution (4).

In 1976, Hearse and colleagues in St. Thomas hospital in London discovered the famous St. Thomas solution number 1. More importantly they contributed immensely to our knowledge of physiology and chemistry of myocardial cells subjected to ischemia, cardioplegic arrest and subsequent reperfusion (5).

In 1979, Gerald Buckberg and his group in Los Angeles clearly demonstrated the superiority of blood over crystalloid solutions as a medium for cardioplegia delivery. They noted several advantages including the greater oxygen-carrying capacity of blood, superior buffering action by the blood protein histidine groups, improved microvascular flow, erythrocyte free radical scavengers and less edema (6). Therefore, over the following years surgeons all over the world began to switch to cold intermittent blood cardioplegia. Further modifications appeared later on as warm induction of cardiac arrest and terminal "hot shot" (7). Then the concept of warm heart surgery began to evolve.

Continuous blood cardioplegia at normothermia then evolved starting in Toronto, either by antegrade or retrograde route (8-9).

Pathophysiology of ischemia and reperfusion:

Since cardiac function depends on a continuous supply of oxygen, the conventional definition of ischemia has been an imbalance between myocardial oxygen supply and demand. However, this

definition was broadened to include the sufficient washout of tissue metabolites that can become injurious if accumulated. Ischemia can therefore be redefined as inadequate perfusion to sustain steady state metabolism at a given level of cardiac performance. This concept acknowledges the fact that the accumulation of tissue metabolites (lactates, CO2, H+)may contribute to ischemic dysfunction and metabolic abnormalities (10).

Many patients referred for cardiac operations have a myocardium poised on the brink of ischemiá. For example, patients with diffuse coronary artery disease may have adequate resting levels of coronary blood flow, but under conditions of increased myocardial work or decreased perfusion pressure have large regions of the heart that are potentially ischemic and energy depleted. Patients with hypertrophied ventricles are also susceptible to ischemia.

The degree of myocardial injury is proportional to the duration of ischemia. However, the duration of protected surgical ischemia associated with aortic cross-clamping and cardioplegia does not demand the same anxiety.as techniques of myocardial preservation increase tolerance to ischemia. Nevertheless, the extent of damage incurred by aortic clamping is time dependent (10).

Myocardial metabolism is obligatory aerobic. There is tight coupling between hydrolysis of ATP and myocardial contraction. ATP is required for both contraction and relaxation, as diastolic relaxation is an active process requiring energy. Global ischemia has two basic features, namely poor oxygen delivery and poor washout of metabolites. With the inception of global ischemia, anaerobic glycolysis ia accelerated because the breakdown of ATP and creatine phosphate as well as the increase in inorganic phosphate stimulate the rate-limiting enzyme phospho-fructokinase. Glucose uptake and glycogen breakdown are also stimulated, leading to gradual glycogen depletion (11).

Energy liberated from anaerobic glycolysis is less than 5% of that generated from oxidative metabolism and as the products of glycolysis accumulate (lactate, CO2 and protons), intracellular pH diminishes untill ultimately anaerobic glycolysis is inhibited with resultant accumulation of free fatty acid derivative (acetyl-CoA) with harmful effects including damage to cell membrane (12). This will result in leaking of intracellular enzymes into the serum providing important clinical parameters of cell death. These enzymes include SGPT, SGOT, LDH, & CPK (13).

Reperfusion injury: Following a period of ischemia, re-establishment of coronary blood flow is associated with both resuscitation of myocytes and the induction of reperfusion injury. The balance between the beneficial and harmful effects of reperfusion is related to the duration of the preceding ischemia (14). Reperfusion injury can be manifested by: reperfusion arrythmias, by post-ischemic systolic and diastolic dysfunction" myocardial stunning" and by myocellular necrosis (15).

This is a prospective controlled study aimed at assessing the technique of the normothermic retrograde continuous blood cardioplegia and comparing this with the conventional technique of intermittent antegrade cold crystalloid cardioplegia at systemic hypothermia.

Patients and Methods

During a period of seven months, 53 patients undergoing various open-heart surgeries were assigned to one of 2 groups.

The first or study group (28 patients), received myocardial protection in the form of warm continuous retrograde blood cardioplegia and will be referred to for the sake of simplicity as the warm group. The second group or control group (25 patients), received routine myocardial protection in the form of cold intermittent antegrade crystalloid cardioplegia, and will be referred to as the cold group.

All patients were premedicated with diazepam 5 mg. Oral tablets the night before the operation, then 10 mg. of morphine sulphate were given I.M. 2 hours before operation. Induction of anaesthesia was done using fentanyl citrate 5-15 mg/kg and sodium thiopental 3-5 mg/kg I.V. Muscle relaxation was accomplished by pancuronium bromide 0.1 mg/kg IV. All patients were intubated orotracheally and ventilated with 100% oxygen. Anaesthesia was maintained by additional I.V. doses of fentanyl citrate and / or isoflurane 0.5-1.5% inhalation.

Median sternotomy was the surgical approach in all cases. After adequate heparinization the ascending aorta was cannulated for arterial inflow. Bicaval cannulation for venous return was invariably performed in all cases of the warm group.

Cardioplegic regimen:

A) **Warm group:** The technique of administration of the warm retrograde continuous blood cardioplegia was explained in details in our previous 2 papers (16-17) and in the report of Dr. Menasche et al (18).

B) **Cold group:** Patients in the cold group received crystalloid cardioplegia in a temperature range of 4 – 8 degrees exclusively antegrade. The composition of this cardioplegic solution was as follows:-

Glucose	50 G/L
KCl	40 mEq/L
Mg Cl2	30 mEq/L
Na Cl	77 mEq/L
Ca Cl2	4 mEq/L
NaHCO3	5 mEq/L
Osmolarity	406 mOsm/L

Each patient received an initial dose of 15-20 ml/kg. Subsequent doses were given every 30 minutes or whenever electromechanical activity resumed.

Data collection:

A) Clinical Data:

1- Operative findings:

- The lowest hematocrite value reached during bypass.

- The peak serum potassium level and the serum potassium level at end bypass.

- The cross clamp time and the total cardiopulmonary bypass time.

- Any particular intraoperative events.

2- Cardiac performance parameters:

i) Intraoperative parameters:

*The rate of spontaneous resumption of normal sinus rhythm.

*The reperfusion time, from removal of the cross clamp to separation from bypass.

*The need for prolongation of cardiopulmonary bypass.

*The need for pharmacologic support for more than 30 min. to facilitate weaning from bypass (125).

*The use of ventricular pacing.

*The left atrial pressure immediately after separation from bypass.

ii) Serial hemodynamic recordings:

The systolic blood pressure, heart rate and central venous pressure recorded immediately after successful cessation of cardiopulmonary bypass, at ICU and at 6 and 12 hours postoperatively.

iii) Cardiac mortality and morbidity:

Operative mortality was defined as death of any cause occurring within 30 days of operation or during the same period of hospitalization and categorized as cardiac or non-cardiac.

iv) Electrocardiographic findings:

Examination of a 12-lead ECG on the first postoperative morning, compared to the preoperative ECG for the occurrence of a new Q wave, new bundle branch block or A-V block.

3- Systemic complications:

The following parameters were recorded:

- Non cardiac mortality.

- The period of postoperative mechanical ventilation.

- The total amount of drainage collected from the chest drains.

- The incidence of phrenic nerve palsy.

- The incidence of any neurologic event.

- The occurrence of any systemic complications as re-entry for bleeding, renal failure, wound infection or hepatic dysfunction.

B) Biochemical and metabolic data:

1) CK-MB isoenzyme assay: The total creatine kinase enzyme level in serum and its myocardial band were estimated at 6 and 24 hours from admission to ICU.

2) Blood gas analysis and lactate assay:

a) Global myocardial metabolism: Coronary arterial and venous blood samples were obtained simultaneously at 3 consecutive points intraoperatively:

i) The pre-arrest stage (baseline samples): Samples were taken in both groups after initiation of cardiopulmonary by-pass and before cross-claming. The coronary arterial inflow samples were taken from the oxygenator. The coronary venous samples were taken directly from the orifice of the coronary sinus in the warm group or by direct puncture of the coronary sinus from outside by a hypodermic needle in the cold group.

ii) End-arrest stage: Samples were drawn from the warm group only just before removal of the aortic clamp. Coronary arterial samples were taken from the oxygenator representing the coronary arterial inflow into the coronary sinus and the coronary venous blood were obtained from the aortic root.

iii) The reperfusion stage: Samples were taken in both groups within 2 minutes of removal of the aortic cross clamp. Samples were taken in the same manner as in the pre-arrest stage.

All blood samples were subjected to blood gas analysis and enzymatic lactate assay.

b) Regional myocardial metabolism:

In addition, 2 more samples were taken in 5 cases of the warm group undergoing an aortic valve procedure. These 2 samples

were taken during cross-clamping just before closure of the aortotomy incision; one from the left coronary ostium and the other from the right coronary ostium.

Statistical analysis:

Statistical analysis was done on an IBM compatible computer, using SPSSwin version 5.0.2. Data were summarized as means ± standard error. For skewed data, median, minimum and maximum were expressed. Frequency tables were used for nominal and ordinal data.

Statistical analysis of data with normal distribution was done using student's t-test, for comparison between 2 groups and one way ANOVA (analysis of variance) for comparison of more than 2 groups.

A 95% confidence interval was applied, with $p < 0.05$ to be considered significant and $p < 0.001$ to be considered highly significant.

Results

The preoperative patients' characteristics are summarized in table I. The 2 groups were matched in all variables. Most patients were in NYHA functional class III in both groups. The dominant aetiologic diagnosis was rheumatic heart disease (75% of warm group and 80% of cold group). The only significant difference was a higher incidence of atrial fibrillation in the warm group compared to the cold group.

The preoperative echocardiographic findings are listed in table II. Left ventricular dimensions were significantly larger in the warm group. Also the interventricular septum and the posterior wall were significantly thicker in the warm group. Parameters of left ventricular functions were lower in warm patients.

The operative procedures performed were listed in table III. Ninety percent of all procedures were valvular in both groups. The operative findings are summarized in table IV. There were more procedures performed urgently in the warm group. The urgent indications were unstable angina and left main disease, an acutely malfunctioning mitral valve prosthesis, infective endocarditis of a mitral valve, and severe evolving congestive heart failure resistant to medical treatment in a patient with aortic valve disease.

Cardiac performance parameters:

Intraoperative parameters are listed in table V. The rate of spontaneous return of normal sinus rhythm was higher and the reperfusion time was shorter in the warm group. Moreover the need for inotropes was less in the warm group.

Serial hemodynamic recordings:

There was no difference between the 2 groups in the mean heart rate, systolic blood pressure or central venous pressure. There was no significant difference in these parameters neither immediately off bypass, upon arrival in ICU nor 6 and 12 hours later.

ECG findings:

Electrocardiographic findings are listed in table VI.

Systemic complications:

Systemic complications are listed in table VII.

Biochemical data:

Cardiac enzume assay:

The mean CK-MB serum levels were significantly lower in the warm group at 6

Table I: Preoperative patient characteristics:

Variable		Warm group N = 28 (100 %)	Cold group N = 25 (100 %)	P value
Age (years)		27.6 (+/- 2.6)	26.7 (+/- 2.7)	NS
Sex	Male	18 (64.3 %)	13 (52 %)	NS
	Female	10 (35.7 %)	12 (48%)	NS
Body weight (kg)		59.2 (+/-4.1)	54 (+/-4.3)	NS
Pulmonary hypertension		19 (67.9%)	13 (52%)	NS
Atrial fibrillation		13 (46%)	5 (20%)	0.04
Preop. Use of inotropes		2 (7.1%)	0	NS
Unstable angina		1 (3.6%)	0	NS
Left main disease		1 (3.6%)	0	NS
Previous surgery				
Open		2 (7.1%)	1 (4%)	NS
Closed		3 (10.7%)	1 (4%)	NS
Previous stroke		1 (3.6%)	2 (8%)	NS
Diabetes mellitus		0	1 (4%)	NS

Table II: Peroperative echo findings:

Variable	Warm group	Cold group	P value
LVEDD (cm)	6.4 (+/- 0.2)	5.4 (+/- 0.2)	0.004
LVESD (cm)	4.7 (+/- 0.2)	3.5 (+/- 0.2)	0.001
IV septum (cm)	1.07 (+/- 0.09)	0.83 (+/- 0.05)	0.02
Post. Wall thickness	1.03 (+/- 0.05)	0.84 (+/- 0.04)	0.02
Left atrium	5.4 (+/- 0.2)	5.0 (+/- 0.3)	NS
Right ventricle	2.0 (+/- 0/1)	2.0 (+/- 0.1)	NS
FS (%)	28.7 (+/- 1.4)	34.2 (+/- 1.2)	0.007
LVEF (%)	54.1 (+/- 2.4)	65.7 (+/- 2.0)	0.001
PASP (mmHg)	48.5 (+/- 3.3)	42 (+/- 3.3)	NS

and at 24 hours postoperatively compared to the cold group (table VIII).

Coronary blood gases and lactate assay:

The base line myocardial metabolic profile of both groups were identical (table IX).

Within the warm group myocardial metabolism was unchanged at the end-arrest stage (i.e. just before removal of the aortic clamp) and during reperfusion. Mean myocardial production of lactate and acid metabolites both showed a minor tendency towards positive production but this tendency did not reach statistical

Table III: Operative procedures:

Procedure	Warm group (n=28)	Cold group (n=25)
MVR	5	8
MV repair	7	2
MV repair + AVR	1	3
MV repair + TV repair	2	3
MV repair + septal myomectomy	1	0
MV repair + ASD patch closure	0	1
AVR	5	1
DVR	1	2
DVR	0	1
Redo MVR	1	1
Redo MVR + TV repair	1	0
Redo DVR + TV repair	1	0
Redo MV repair + AVR + TV repair	1	0
CABG	1	2
ASD patch closure	1	0
VSD patch closure	0	1

Table IV: Operative findings:

Variable	Warm group	Cold group	P value
Urgent indication	4 (14.2%)	0 (0%)	0.04
Lowest Hct (%)	28.1 +/- 0.8	24.4 +/- 0.9	0.005
Peak K+ (meq/L)	6.1 +/- 0.2	5.0 +/- 0.1	0.003
End-by pass K+	5.0 +/- 0.1	4.6 +/- 0.1	0.02
CPB time (min.)	145 +/- 32	124 +/- 12	NS
Cross clamp time (min.)	81 +/- 7	84 +/- 5	NS

significance and was rapidly corrected during reperfusion (table IX).

However reperfusion in the cold group was associated with significant changes (table IX).

Regional myocardial metabolism:

The results of the regional metabolic study carried out in 5 aortic valve procedures done with the warm cardioplegia technique are listed in table X.

Discussion

Aortic cross clamping and intermittent antegrade cold crystalloid cardioplegia, coupled with systemic hypothermia and topical cooling became a rock-solid strategy for the safe conduct of cardiac surgery for a

Table V: Cardiac perfoemance parameters:

Parameter	Warm group n = 28 (100%)	Cold group n = 25 (100%)	p value
Spontaneous sinus rhythm	22 (78.6%)	7 (28%)	0.0002
Reperfusion time (min.)	15 (+/- 1)	22 (+/- 1)	0.004
Necessity to prolong CPB	0	1 (4%)	NS
LA pressure (cmH2O)	7.6 (+/- 1.2)	10.6 (+/-0.7)	0.03
Use of inotropes	11 (39.3%)	18 (72?%)	0.01
Intraop. AV block	1 (3.6%)	4 (16.7%)	0.05
Total mortality	3 (10.7%)	2 (8%)	NS
Cardiac mortality	1 (3.6%)	1 (4%)	NS
Non fatal LSHF	0	2 (8.3 %)	NS
Non fatal RSHF	1 (3.6%)	1 (4.1%)	NS

Table VI: Postoperative ECG findings:

Varable	Warm group n = 28	Cold group n 25	p value
AV block	0	4 (16.7 %)	0.02
New Q waves	0	4 (16.7%)	0.02
New BBB	0	10 (41.7%)	0.0001
New RBBB	0	7 (29.2%)	0.0002
New LBBB	0	3 (12.5%)	0.05
Arrhythmias Supraventricular Ventricular	0 1 (3.6%)	3 (12.5%) 0	0.05 NS

Table VII: Systemic complications:

Variable	Warm group n = 28	Cold group n = 25	p value
Non-cardiac mortality	2 (7.1%)	1 (4%)	NS
Mechanical ventillation (hour)	6.7 (+/-0.8)	8.2 (+/- 0.8)	NS
Bleeding / 24 hours	455 (+/- 77) ml.	503 (+/- 72) ml.	NS
Re-entry for bleeding	2 (7.1%)	1 (4.1%)	NS
Neutologic events Total Coma Confusion Focal deficit	 3 (10.7%) 0 3 (10.7%) 0	 3 (12.5%) 1 (4.2%) 2 (8.4%) 0	 NS NS NS NS
Mediastinitis	0	1 (4.1%)	NS
Liver failure	1 (3.6%)	0	NS
Renal failure	1 (3.6%)	1 (4.1%)	NS
Postcardiotomy syndrome	0	1 (4.1%)	NS
Phrenic palsy	0	3 (13%)	0.04

Table VIII: Cardiac enzyme assay:

Parameter	Warm group	Cold group	p value
CKMB serum level			
*At 6 hours	38.09	48.19	0.03
*At 24 hours	39.02	44	NS
CKMB % activity			
*At 6 hours	8.1%	17.3%	0.0001
*At 24 hours	5.9%	15.4%	0.0001

Table IX: Global myocardial metabolism:

Variable		Warm group	Cold group
Cor. Venous pH	Pre X cl	7.39	7.39
	X cl on	7.41	
	X cl off	7.42	7.27
Cor venous pCO2	Pre X cl	42 mmHg	42 mmHg
	X cl on	39 mmHg	
	X cl off	36 mmHg	47 mmHg
Lactate production	Pre X cl	-0.2	-0.2
	X cl on	+0.1	
	X cl off	-0.2	+1.5
Production of acid metabolites	Pre X cl	-0.4	-0.4
	X cl on	+0.2	
	X cl off	-1.2	+0.4

- **Results were significant when comparing the pre-clamp readings with the post-clamp readings within the cold group and also when comparing the post-clamp readings for both groups.**

Table X: Regional myocardial metabolism:

Blood gas parameter	Left coronary ostium	Right coronary ostium
pH	7.41	7.39
PO2 mmHg	24.6	23.8
PCO2 mmHg	42.3	45.0
O2 % saturation	56.0	52.8
Base excess (mmol/L)	-1.6	-1.8

long time. However, as cardiac surgeons are facing a patient population with growing surgical risk and an increasing demand for better results, newer cardioprotective strategies have evolved. A crucial evolution was triggered by the realization that blood is undoubtedly a superior cardioplegic vehicle than any crystalloid solution (19).

It was then reasoned that the ideal state of the myocardium would be to be continuously perfused with warm oxygenated blood throughout the entire period of crossclamping (8). Warm blood cardioplegia represents an endeavor to avoid the following drawbacks of hypothermia: first, hypothermia depresses the ionic pumps responsible for maintaining the integrity of cell membranes. Second, it inhibits the enzyme systems concerned with aerobic energy production. Third, it dramatically reduces the availability of oxygen in the blood cardioplegic vehicle (20).

Several researchers relied on simple clinical endpoints to compare cardiac performance following different cardioplegic techniques. These endpoints include the rate of resumption of normal sinus rhythm, the length of the reperfusion interval, the need for inotropic support or intraaortic balloon pumping, the incidence of perioperative myocardial infarction in coronary artery surgery and the incidence of cardiac mortality and morbidity.

The rate of spontaneous resumption of normal rhythm was markedly higher in the warm group compared to the cold group. The failure of the majority of patients in the cold cohort to regain sinus rhythm without electric defibrillation is an indication of poor myocardial protection either globally or in the area of pacemaker sites (10). The absence of ventricular fibrillation during reperfusion is desirable as it avoids high-energy phosphate depletion and cardiac distension (21).

The use of warm cardioplegia in our study significantly shortened the reperfusion time. The reperfusional interval needed for successful weaning from bypass is an indicator of the degree of postischemic contractile recovery of the myocardium. A shorter reperfusion time was used as an argumant in favour of better myocardial preservation with warm cardioplegia (8-22).

Cardiac mortality was similar in both groups and so was the incidence of non-fatal left sided heart failure and the incidence of right sided heart failure. Also repeated observation of systolic blood pressure, central venous pressure and heart rate failed to demonstrate any clear cut difference with one cardioplegic regimen or the other at one hour, 6 hours and 12 hours of the postoperative period in the present study.

The postoperstive ECG findings showed that in the present study, the use of antegrade cold crystalloid cardioplegia was associated with a significantly higher incidence of atrioventricular block, bundle branch block and new Q waves. These findings were supported by the work of Flack and associates (23), who studied 212 patients who underwent coronary artery bypass grafting and who received either intermittent retrograde cold blood cardioplegia or continuous retrograde warm blood cardioplegia. They found that at postoperative day one, the incidence of new conduction defects was 41.3% in the cold group compared to 9.2% in the waem group. At late follow up, these figures had decreased but were still significantly higher in the cold patients.

The concept of warm heart surgery involves both continuous perfusion of the heart at normothermia and normothermic

cardiopulmonary bypass. Thus a thorough evaluation of warm heart surgery cannot be limited to the assessment of the myocardial effects of warm blood cardioplegia, but must also include that of the systemic effects of warm cardiopulmonary bypass. The clinical relevance of such an issue were brought up by several controversies. In particular, one study aroused concerns about the risk of increased neurologic hazard associated with normothermic perfusion (24). Furthermore, the possibility of a magnified whole body inflammatory response at normothermia stimulated questions about organ dysfunction (25) and postoperative coagulopathy (26). In this study, there was no significant difference in the occurrence of systemic complications between the 2 groups which denotes safe conduct of warm heart surgery.

Biochemical evaluation of continuous warm blood cardioplegia:

While some groups have focused on the clinical and hemodynamic evaluation of warm blood cardioplegia, others resorted to biochemical methods for that purpose. This was done in chiefly two ways. The first is the serial estimation of postoperative release of the cardiac isoenzyme CK-MB. The second method is through the assessment of intraoperative myocardial metabolism at various stages, by blood gas analysis and lactate assay of coronary venous blood (18-27). Such methods usually aim to investigate the theoretic basis of warm blood cardioplegia and whether it does keep the myocardium in a state of constant aerobic metabolism during crossclamping and reperfusion as originally proposed (8).

Cardiac enzyme release: Cotran and associates, in their description of the pathologic events that accompany myocardial cell injury, explained that the leakage of intracellular enzymes across the abnormally permeable plasma membrane and into the serum, provides important laboratory parameters of myocardial cell death. Cardiac muscle containes glutamic oxalic trancaminase (GOT), glutamic pyruvic transaminase (GPT) and creatine kinase (CK). Elevated serum levels of such enzymes and particularly the isoenzyme specific for heart muscle, the CK-MB, are valuable biochemical criteriae of cardiac muscle damage (13).

In clinical studies comparing warm and cold cardioplegic methods, many groups observed lower serum levels of CK-MB during the first 24 to 48 hours postoperatively associated with warm blood cardioplegia (28). In either way, the greater leakage of CK-MB from cold hearts was interpreted to imply either more exyensive myocardial necrosis or more extensive but reversible disruption of sarcolemmal integrity, allowing transient trans-membrane loss of these high molecular weight proteins (29).

In the present study, an investigation was made of both the absolute level of CK-MB in the serum in units/litre and of the level of CK-MB expressed as percentage of the total CK serum levels at 6, and 24 hours postoperatively. The absolute level of CK-MB at 6 hours was significantly lower in the warm group, however, at 24 hours, the difference was no more significant. On the other hand, percent CK-MB activity demonstrated a highly significant benefit with warm cardioplegia at both stages of sampling. Furthermore, within the warm group, CK-MB percent activity dropped significantly at 24 hours compared to the 6 hour value whereas within the cold group,

this percent activity was still ongoing at 24 hours relative to the 6-hour stage.

Our finding of a decreased CK-MB percent activity associated with warm cardioplegia imply better myocardial protection with this technique and are thus in accordance with those of Vaughn et al (30) and Calafiore et al (31).

Coronary blood gas analysis and lactate assay: The whole purpose of contiuous warm blood cardioplegia is to maitain the myocardium in a state of constant aerobic metabolism, first by diminishing its oxygen requirements with the induction of electromechanical arrest, then by supplying the heart with oxygen and substrates in a continuous and uniform pattern to meet its residual needs, and at a temperature that would optimize oxygen consumption and allow all the enzyme systems responsible for ionic homeostasis and aerobic energy production to function (32). If this purpose fails, the heart is then subjected to a state of normothermic ischemia or hypoperfusion during cross clamping (33). Such an insult would translate in metabolic terms into detectable markers of anaerobiosis in coronary venous blood like acidosis, CO2 retention and increased output of lactate and acid metabolites (18). By totally preventing any ischemic insult during crossclamping, the technique is also aimed at preventing any reperfusion injury (8). These hypotheses were investigated in the present study by coronary blood gas analysis and lactate assay at the end of aortic occlusion and then during the immediate reperfusion phase.

The hearts treated by warm blood cardioplegia in the present study, were maintained in a totally aerobic environment up to the end of the cross clamp period. Just before aortic declamping, after a mean cross clamp time of 81 ± 7 minutes, mean coronary venous pH was 7.41, mean coronary venous PCO2 was 39.3 mmHg, myocardial lactate production (0.1mmol/L) and acid metabolite production (0.18 mmol/L) were both negligible. Furthermore, all of these parameters were unchanged relative to the baseline state before the application of the crossclamp.

Myocardial metabolism during reperfusion: Following a period of ischemia, re-establishment of coronary blood flow is associated with both resucitation of myocytes and the induction of a reperfusion injury. Reperfusion injury is defined as a pathology that is extended, accelerated or expressed de novo from the profile observed during ischemia (10). It is characterized by coronary venous acidosis, CO2 and lactate washout and impaired myocardial oxygen extraction (34).

Impaired oxygen use during reperfusion has been previously identified as a marker of poor myocardial protection. A depression of oxygen consumption results from paralysis of the enzymes of respiratory chain, especially the cytochrome oxidase system and coenzyme Q, making the mitochondria unable to utilize the available oxygen (29). Such mitochondrial dysfunction was evident in the cold group of the present study. In this group, during the reperfusion stage myocardial oxygen extraction was significantly depreesed. This was also coupled with a significantly lower coronary venous pH than in the warm patients and significantly more CO2 accumulation. There was also more lactate production compared to lactate extraction in the warm group and furthermore, significantly more production of acid metabolites, compared to their extraction in the warm group.

Conclusion

The improvement in cardiac performance parameters expressed in the

warm cardioplegia group relative to the cold cardioplegia group, namely the higher rate of spontaneous resumption of normal sinus rhythm, the shorter reperfusion interval, the lower left atrial pressure, the less frequent use of inotropes and the lower incidence of atrioventricular block, indicate better myocardial recovery after the warm cardioplegia regimen. Furthermore, the lower incidence of conduction defects and the depressed release of CK-MB delineate the reduction of overall myocardial damage in hearts managed by continuous retrograde warm blood cardioplegia.

The theoretic principle of warm heart surgery is aimed at maintaining cardiac aerobic metabolism at all times and eliminating any ischemia or reperfusion injury.

The comparable incidence of systemic complications in the two groups suggests tha normothermic cardiopulmonary bypass is at least as safe as hypothermic cardiopulmonary bypass.

Therefore, it is concluded that, in a setting of predominantly valvular surgery, continuous retrograde warm blood cardioplegia at systemic normothermia is superior to intermittent cold antegrade crystalloid cardioplegia at systemic hypothermia.

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LEFT VENTRICULAR PERFORMANCE FOLLOWING DOUBLE VALVE REPLACEMENT FOR COMBINED AORTIC AND MITRAL REGURGITATION IN RHEUMATIC PATIENTS ROLE OF TOTAL CHORDAL PRESERVATION

ABSTRACT

Background: The changes in left ventricular performance after double valve replacement for combined mitral and aortic regurgitation have not well studied, also the importance of total chordal preservation in this group of patients is unknown.

Patients & Methods: For 43 patients undergoing double valve replacement for combined rheumatic mitral and aortic regurgitation, left ventricular function was echocardiographically assessed preopeiatively, 3 and 12 months after surgery. The echo data at 12 months after surgery were compared to the echo findings of 40 normal subjects of matched age and sex. The mean age was 26.9 ±11.9 years. Total chordal preservation were performed for 14 (32.6%) patients and only posterior chordal preservation were performed for 29 (67.4%) patients.

Results: Left ventricular end-diastolic (LVEDD) and end systolic (LVESD) dimensions significantly decreased (P < 0.0001, P = 0.005, respectively), at 3 months after surgery, but the percent decrease in LVEDD was more marked (18 ± 9 % Vs 9 ± 8 %) resulting in significant decline in left ventricular fractional shortening (FS) and ejection fraction (EF) form 33.1 ± 6.0 % and 60.3 ± 8.8% to 26.0 ± 6.2% and 50.4 ± 9.2%, respectively, (P< 0.0001 , P< 0.0001). At 12 months after surgery, significant reduction in LVESD and LVEDD were observed, (P< 0.0001 , P= 0.001, respectively), but the percent reduction in LVESD was more marked (19 ± 6 % Vs 12 ± 7%) resulting in nearly normalization of FS and EF (32.4 ± 5.5 % , 61.0 ± 7.6% respectively.). Comparing the echo data of the patients at 12 months with that of the control subjects showed that the ventricular dimensions still significantly higher than that of the control subjects, but no statistically significant difference in FS and EF was observed between both groups (P = 0.069, P = 0.146. respectively). Multivariate analysis identiried the preoperative LVESD and EF as predictors of ejection fraction at 12 mouths after surgery. Patients undergoing total chordal preservation had significantly higher FS and EF at 3 (P = 0.041, P= 0.024, respectively) and 12 (P=0.039, P=0.019, respectively) months after surgery compared to patients undergoing only posterior chordal preservation.

Conclusion: After initial postoperative decline in ejection fraction, normalization of ejection fraction, may be expected 1 year after double valve replacement for combined

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rheumatic mitral and Aortic regurgitation. Preoperative LVESD and EF are the only predictors of postoperative left ventricular performance. Total chordal preservation for this category of patients is associated with better preservation of left ventricular systolic function when compared to only posterior chordal preservation.

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INTRODUCTION

Simultaneously developing aortic and mitral regurgitation usually results from a severe and prolonged attack of rheumatic fever or from recurrent attacks (l). Also, myxomatous degeneration with leaflet prolapse of both valves accounts for some cases (2). The hemodynamics and loading conditions for isolated mitral or aortic regurgitation have been documented and their effect on postoperative left ventricular function has been established (3-6). Most of the published studies on double valve replacement for combined mitral and aortic regurgitation have stressed on the clinical outcome after surgery (7,8) and few data are available regarding postoperative left ventricular performance in this group of patients (9, 10). Several studies have shown that mitral valve replacement with total chordal preservation compared to posterior chordal preservation or total chordal resection for isolated mitral valve disease to be bentifical for preservation of the left ventricular function (11-13). But, the role of total chordal preservation in patients undergoing surgery for concomitant mitral and aortic regurgitation has not well studied.

In this prospective study, we sought to analyse the left ventricular performance following double valve replacement for combined aortic and mitral regurgitation and to determine preoperative predictors of postoperative ejection performance

Patients and Methods

In the period between January 1998 and June 2000, 47 patients underwent simultaneous aortic and mitral valve replacement for combined rheumatic severe pure aortic insufficiency and pure or predominant mitral regurgitation (mitral valve area > 1.8 CM^2). Two patients died within 30 days of surgery and 2 patients were lost to follow-up. The four patients were not included in the present study. The origin of the valve lesions was considered to be rheumatic in all cases, on the basis of clinical and echocardiographic criteria and as confirmed by surgical evaluation. None of the patients had history or ECG changes suggesting ischemic heart disease.

The preoperative patient characteristics are described in table 1.

Surgical technique:

For all patients, the operation was performed through a median stemotomy, carcliopulmonary bypass was carried out through an aortic and bicaval emulation. Myocardial protection was achieved through

moderate generalized hypothermia (28°c) surface cooling with ice slush and cold crystalloid cardioplegia. Chordae to the posterior mitral valve were preserved for 29 patients. Total chordal preservation was done for 14 patients using the technique described by David et al, (14) with certain modifications, bilateral commissurotomy (15) and splitting of the posterior leaflet in between chordal attachments (16) in order to implant a larger prosthesis. A modified De Vega tricuspid annuloplasty was performed for 8 (18.6%) patients. Bileaflet mechanical valves (Sorin Bicorbon and St.Jude Medical) were implanted in all cases.

Follow-up:

After surgery, all patients were followed up at our hospital. Two patients were lost to follow-up and they were excluded from the study. Patients were seen at 2 weeks, 1,2,3 months after surgery and thereafter every 3 months or more frequently if clinically indicated. At each visit, a clinical examination plus anticoagulation level determination were performed. Echocarchiographic studies were performed preoperatively and at 3 and 12 months after surgery and at a more frequent intervals when a complication was suspected using a Hewlett-Packard series 77025 A echocarchiography with a 2.5 to 3.5 MHz transducer. Left ventricular end-diastohic and end-systoic dimensions were measured just above the papillary muscles in the parasternal long-axis view. Average end-systolic and end-diastolic dimension. measurements were obtained from. 3 consecutive beats for patients in sinus rhythm and 5 consecutive beats for patients in atrial fibrillation. Using the average left ventricular end-systolic dimension (LVESD), and left ventricular end-diastolic dimension (LVEDD), fractional shortening (FS) and ejection fraction (EF) were calculated.

$$FS = [(LVEDD-LVESD)/LVEDD] \times 100$$

$$EF= [(EDV-ESV)/EDVJ \times 100$$

Left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV) were computed using the Teichholz method (17).

$$LVEDV = (7/[2.4+LVEDDI) \times LVEDD^3$$

$$LVESV = (7/[2.4+LVESD]) \times LVESD^3$$

Dujardin, et al (18) study showed that using left ventricular dimensions measured by echocardiography for assessing left ventricular remodeling after valvular surgery, allow acceptable estimation of left ventricular ejection fraction and correlate significantly with left ventricular volume.

The echo data of the patients at 12 months after surgery were compared to the echo findings of 40 normal subjects of matched age and sex as a control group.

Statistics:

Data are presented as the mean and standard deviation. Difference in discrete parameters were investigated using the chi-square test. With numeric parameters, an unpaired student t-test for differences between groups and a paired student t-test for differences within a group, were performed. All clinical and echocardiographic variables listed in table 1 were entered into a forward and backward stepwise multivariate regression analysis to

Table (1): Patient Characteristics (n=43).

Age, y	26.9 ± 11.9
Male / female, n	19 / 24
NYHA functional class	3.2 ± 0.5
Echocardiographic criteria	
LVEDD, mm	67.7 ± 6.8
LVESD, mm	45.3 ± 5.0
Fractional shortening, %	33.1 ± 6.0
Ejection fraction, %	60.3 ± 8.8
Intraoperative	
Aortic cross-clamp time, min	97.6 ± 19.6
Bypass time, min	125.0 ± 28.8
Total chordal preservation, n (%)	14 (32.6%)
Posterior chordal preservation, n (%)	29 (67.4 %)
Tricuspid annuloplasty, n (%)	8 (18.6 %)
Aortic valve size	22.2 ± 2.1
Mitral valve size	27.8 ± 2.3

NYHA = New York Heart Association, LVEDD= left ventricular end diastolic dimension, LVESD = left ventricular end systolic dimension

identify independent predictors of postoperative left ventricular ejection fraction at 12 months after surgery. P-value was considered significant at $P<0.05$. statistical analysis were performed using Stat Most for windows version 3.

Results

Forty three patients entered this prospective study. Follow-up was ranged between 12 to 42 months with a mean 25.4 ± 9.5 months. Two patients died of heart failure due to severe left ventricular dysfunction at 14 and 19 months after surgery.

Clinical data:

There were significant improvement of exertional dyspnea, as the mean NYHA functional class were 3.2 ± 0.5 preoperatively dropped to 1.6 ± 0.4 ($P <$ 0.0001) and 1.3 ± 0.4 ($p< 0.0001$) at 3 and 12 months after surgery respectively.

Echocardiographic data (table 2):

At 3 months after surgery, LVEDD and LVESD decreased significantly ($P<0.0001$, $P= 0.005$, respectively) compared to the preoperative dimensions. The percent decrease in LVEDD was more marked than that in LVESD (18 ± 9% Vs 9 ± 8%), resulting in a significant decrease in FS% and EF% from 33.1 ± 6.0 and 60.3 ± 8.8 to 26.0 ± 6.2 and 50.4 ± 9.2, respectively (P0.0001, P0.0001).

At 12 months after surgery, compared to that at 3 months, there were significant reduction in LVESD and LVEDD ($P <$ 0.0001 and $P = 0.001$, respectively), but the percent decrease in LVESD was more marked than in LVEDD (19 ± 6% VS 12 ± 7%) resulting in nearly normalization of left

Table (2) : Echocardiographic data of the patients (n-43) before, 3 and 12 months after double valve replacement and that of control subjects (n=40).

	preoperative	p-value	at 3 months	p-value	at 12 months	p-value	control subjects
LVEDD, mm	67.7 ± 6.8	<0.0001	55.7 ± 7.7	0.0011	49.2 ± 5.1	<0.001	42.3 ± 3.0
LVESD, mm	45.3 ± 5.0	0.0052	41.2 ± 4.9	<0.0001	33.3 ± 4.8	<0.0001	27.6 ± 2.5
Fractional shortening, %	33.1 ± 6.0	<0.0001	26.0 ± 6.2	<0.0001	32.4 ± 5.5	0.069	35.0 ± 7.2
Ejection fraction, %	60.3 ± 8.8	<0.0001	50.4 ± 9.2	<0.0001	61.0 ± 7.6	0.146	63.5 ± 7.6

Abbreviations as in table 1

Table (3): Preoperative characteristics of patients with posterior chordal preservation only (Group A) and with total chordal preservation (Group B).

	Group A (n=29)	Group B (n=14)	P-value
Age, Y	27.3 ± 12.5	26.1 ± 11.1	0.737
Sex, female, n(%)	14 (48%)	10 (71%)	0.015
NYHA functional class	3.3 ± 0.8	3.1 ± 0.7	0.560
LVEDD, mm	67.4 ± 6.6	68.3 ± 7.4	0.699
LVESD, mm	45.0 ± 4.7	46.1 ± 5.8	0.552
Fractional shortening, %	33.2 ± 6.1	32.5 ± 6.0	0.709
Ejection fraction, %	60.7 ± 9.0	59.3 ± 8.7	0.620
Aortic cross-clamp time, min	96.8 ± 18.2	99.0 ± 23.1	0.764
Bypass time, min	123.1 ± 28.4	128.9 ± 30.4	0.558

Abbreviations As In Table (1)

Table (4): Echocardiographic data at 3 and 12 months after surgery for patients with posterior chordal preservation (Group A, n=29), and patients with total chordal preservation (Group B, n=14).

	at 3 months			at 12 months		
	Group A (n=29)	Group B (n=14)	P-value	Group A (n=29)	Group B (n=14)	P-value
LVEDD, mm	57.1 ± 7.3	52.6 ± 8.0	0.091	49.4 ± 5.2	48.8 ± 5.2	0.697
LVESD, mm	43.0 ± 4.5	37.4 ± 3.3	<0.001	34.0 ± 4.0	31.8 ± 6.2	0.244
Fractional shortening, %	24.7 ± 5.8	28.9 ± 6.2	0.041	31.2 ± 5.5	34.8 ± 4.9	0.039
Ejection fraction, %	48.1 ± 8.3	55.2 ± 9.4	0.024	59.1 ± 7.2	64.9 ± 7.1	0.019

Abbreviations as in table 1

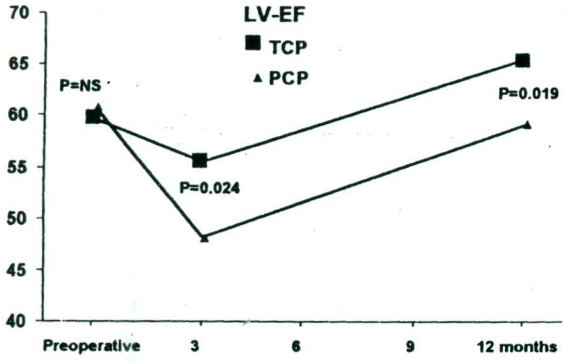

Fig. (1): Changes in left.ventricular ejection fraction (LV-EF)'for patients with total chordal preservation (TCP), and those with Posterior chordal preservation (PCP).

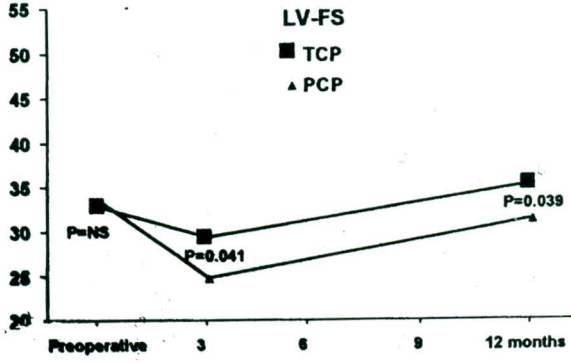

Fig. (2): Changes in left ventricular fractional shortening (LV-FS) for patients with total chordal preservation (TCP), and those with posterior chordal preservation (PCP).

ventricular fractional shortening and ejection fraction.

Comparing the echocardiographic data at 12 months after surgery with that of the control normal subject, showed that LVEDD and LVESD of the patients still significantly higher than that of the normal subjects (P 0.0001, P0.0001). Although, FS% and EF% of the patients tended to be lower than of normal subjects, these differences were not statistically significant (P=0.069 and P=0.146, respectively).

Multivariate analysis showed that preoperative LVESD (P=0.005) and EF% (P0.007) to be predictive of left ventricular ejection fraction at 12 months after surgery. Age, sex preoperative NYHA functional class, preoperative LVEDD, cardiopulmonary bypass time and aortic cross- clamp time were not found to correlate with ejection fraction at 12 months after surgery.

Role of total chordal preservation:

Total chordal preservation of the submitral apparatus was performed for l4(32.6%) patients and only posterior chordal preservation was performed for 29 (67.4%) patients. The decision regarding preservation of the submitral apparatus (total or posterior chordal preservation) was left to the operating surgeon.

Table (4), shows the serial echocardiographic changes of both groups. The left ventricular dimensions of the total preservation group tended to be smaller at 3 months after surgery and also at 12 months after surgery but to a less extent. The ejection fraction and fractional shortening significantly decreased at 3 months after surgery in both groups, but patients of the

total preservation group had significantly higher EF% (P=0.024) and FS% (P=0.041). Nearly parallel increase in EF% and FS% were seen at 12 months after surgery for both groups, that were also, significantly higher in patients of total preservation group (P=0.019 and P=0.039, respectively) (Fig 1, 2).

Discussion

In 1963, soon after introduction of durable prosthetic valves, Cartwright and colleagues were the first to report simultaneous aortic and mitral valve replacement (19).

Most of the published studies on double valve replacement for combined mitral and aortic regurgitation have stressed mainly on the clinical outcome after surgery (1,7,20,31). Few data are available regarding postoperative left ventricular performance in this group of patients after relieving the volume loading of mitral and aortic regurge (9,10,21). In common with our study, Skudicky et al (10) reported a significant reduction in ejection fraction 3 months after double valve replacement for combined rheumatic aortic and mitral regurgitation and late postoperative analysis showed normalization of the ejection fraction. Left ventricular diastolic dimensions respond earlier for relieving the volume overload while the recovery of contractile function (left ventricular fractional shortening and ejection fraction. Although the ejection fraction and fractional shortening nearly normalized at 12 months after surgery in our study, left ventricular dimensions remained higher than the control normal subjects. In contrast with our results Essop, et al (21) found relatively well preserved fractional shortening 3 months after surgery. This difference may be due to the fact that patients in our study were older (26.9 ±11.9 Vs 13 ± 0.8 years, $P < 0.001$), with more long-standing valvular regurgitation and therefore less contractile reserve. The study of Kontozis et al (22) showed that younger age patients (less than 18 years) were associated with better postoperative left ventricular function and had earlier restoration of left ventricular ejection fraction following mitral valve replacement for pure rheumatic mitral regurgitation, due to lesser degree of myocardial damage.

The predictive value of the preoperative left ventricular end-systolic dimension and ejection fraction after valve replacement for isolated aortic or mitral insufficiency are well established (3-6,23,24).

This study showed that left ventricular end-systolic and ejection fraction, also, had predictive value for left ventricular performance after double valve replacement for combined aortic and mitral regurgitation. According to these data, surgery should be considered early before deterioration of the ejection fraction or much increasing of the end-systolic dimension.

Compared with posterior chordal preservation or chordal resection, total chordal preservation of the mitral valve during mitral valve replacement for isolated mitral valve disease has proved beneficial, both experimentally and clinical for preservation of the left ventricular function (11-16, 26-30) but, there is a lack of data concerning its effect on left ventricular performance after double valve replacement for combined mitral and aortic regurgitation. This is may be due to the fact that simultaneous developing aortic and mitral valve disease mainly results form rheumatic fever, which is uncommon in western countries.

Skudicky et al (10) failed to predict any significance for posterior chordal preservation compared with chordal resection regarding postoperative left ventricular function in their series on rheumatic patients undergoing double valve replacement. In our study, we either did preserve the posterior chordae only (29 patients) or both anterior and posterior chordae (14 patients). Similar baseline characteristics of both groups (except for sex) in the present analysis suggest that a comparison between them would be valid. The heart size tended to be smaller in total preservation group at 3 and 12 months after surgery but without statistically significant difference expect for the LVESD at 3 months ($P < 0.001$) and the total preservation group had significantly better fractional shortening and ejection fraction at 3 and 12 months after surgery.

These data demonstrate that left ventricular function are better in patients who undergo double valve replacement with total chordal preservation than in patients in whom only posterior chordae are preserved.

In conclusion, after an initial postoperative decline in ejection fraction, normalization of the left ventricular function may be expected 1 year after double valve replacement for combined rheumatic mitral and aortic regurgitation. Preoperative left ventricular end-systolic dimension, and preoperative ejection fraction are the only predictors of postoperative left ventricular performance. These data suggests that early surgical intervention, should be considered for patients had combined moderate to severe mitral and aortic regurgitation. Also, total chordal preservation of the mitral valve must be considered for this group of patients especially for whom had low ejection fraction.

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IMMEDIATE AND MIDTERM OUTCOME OF MITRAL VALVE SURGERY IN MITRAL VALVE DISEASE WITH SEVERE PULMONARY HYPERTENSION

ABSTRACT

The aim of this study was to evaluate the initial and midterm outcome of patients with rheumatic mitral valve disease and severe pulmonary hypertension undergoing mitral valve surgery. Mitral valve surgery was performed in 89 patients with severe pulmonary hypertension (average systolic pulmonary artery pressure, 98 ± 19 mmHg: range, 60-130 mmHg). They were 43 males and 46 females with their ages ranging from 18 to 47 years (mean = 26 ± 13 year). 81 patients (91%) were in New York Heart Association functional class III or IV. There were 78 valve replacements and 11 open mitral commissurotomies. Operative mortality was 9% (8 patients) and pulmonary artery systolic pressure decreased to 53 ± 17 mmHg (P<0.01). follow-up was obtained for a period ranging from 4 to 32 months (mean = 13 ± 3 months). 10 late cardiac deaths (12%) occurred, 9 in patients with valve replacement and one in a patient who underwent commissurotomy. Of 27 patients who still have tricuspid regurgitation during follow up the pulmonary artery systolic pressure can be obtained in only 23 patients using echo-Doppler study. It has decreased from a mean preoperative value of 103 ± 23 to 37 ± 12 mmHg. With 71 of the survivors (89%) become in New York Heart Association class 1 or 11. The clinical and hemodynamic findings of this study suggest that severe pulmonary hypertension is not a contraindication to mitral valve surgery and pulmonary hypertension decreases significantly after operation.

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INTRODCUTION

Pulmonary hypertension is frequently associated with mitral valve disease. The relation between the degree of pulmonary arterial and pulmonary venous of hypertension in mitral valve disease varies greatly and significantly influences the clinical findings and prognosis (1). Surgical decompression of left atrium by mitral commisurotomy or by mitral valve replacement has often resulted in regress pulmonary hypertension (2,3). Previous studies have focused on patients with a wide range of pulmonary pressures and specific studies concerning patients with severe pulmonary pressures hypertension are scarce including only a relatively small number of patients (4). The purpose of the present study is to assess both immediate and midterm clinical outcome of mitral valve surgery in patients with mitral valve disease and severe pulmonary hypertension.

Patients and Methods

The study population consisted of 89 patients with mitral valve disease who underwent mitral valve surgery at National

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Heart Institute and Zagazig University Hospitals. There were 43 males and 46 females with their ages ranging from 18 to 47 years (mean 26.3 ± 13). Eighty one patients were in functional class III or IV according to New York Heart Association (NYHA) functional classification. The mitral valve was replaced in 78 patients; in 21 patients (23%) due to mitral regurgitation defined as Doppler echocardiographic evidence of moderate or severe mitral regurgitation; in 13 patients (14%) due to predominant mitral stenosis defined as any diastolic mitral valve gradient in the absence of mitral regurgitation or if mild mitral regurgitation was present with a mean mitral gradient equal to or more than 10 mmHg; and in 44 patients (50%) due to combined mitral steilosis and regurgitation. The remaining 11 patients underwent open mitral commissurotomy. Mitral valve disease was a sequelae of rheuinatic heart disease. All patients had severe pulmonary hypertension ranging from 60 to 130 mmHg with a mean of 98 ± 19 mmHg.

Echocardiographic studies:

All patients underwent a complete echocardiographic study before mid after mitral valve surgery. Measurements were performed following the recommendations of the American Society of Echocardiography raphy Mitral regurgitation (MR) was assessed by either pulsed wave Doppler or by color flow, real-time Doppler imaging. Grading of MR was determined semiquantitatively by the extent and width of the regurgitant jet within the left atrium during systole (6). Grades included trivial (regurgitation jet at the valve plane), mild (1+), mild to moderate (2+), moderate (3+), and severe (4+) regurgitation. Care was taken to analyze the presence of tricuspid regurgitation by color Doppler. Systolic pulmonary pressure was calculated with the modified Bernolli equation [systolic pulmonary artery pressure (mmHg) = 4x maximal systolic tricuspid velocity (m/s) 2+141 (7).

Mitral valve surgery:

All patients were monitored intraoperatively for right atrial, left atrial, pulmonary artery and systemic blood pressures. All the surgical procedures were carried out by standard cardiopulmonary bypass. Myocardial protection was achieved with moderate hypothermia, topical ice cooling and hyperkalemic cold cardioplepgla. Tilting disc prosthesis was used for mitral valve replacement and De Vega annuloplasty for repairing tricuspid valve regurgitation (8).

For all patients Isoprel was injected as a continuous infusion at a dose of 1.5 ug/kg after removal of the aortic cross clamp (9).

Statistical analysis:

Results were reported as mean values ± SD. Variables Measured before and after mitral valve surgery and follow-up were compared using the paired t-test. A P-values less than 0.05 was considered significant.

Results

Baseline characteristics: Of 89 patients included in this study, 43 were males (48%) and 46 were females (52%) with their ages ranging from 18 to 47 years (mean = 26.3 ± 13). Eighty-one patients (91%) were in New York Heart Association (NYHA) class III or

Table (l): Pafients characteristics.

* No of patients	89
* Age	26±13 years (18-47)
* Men	43 (48%)
* NYHA class III	81 (91%)
* Atrial fibrillation	38 (41%)
* Mitral valve disease:	
- Mitral regurg.	21 (23%)
- Mitral stenosis.	24 (27%)
- Combined	44 (50%)
* Treatment	
- Digoxine	74 (82%)
- Diuretics	89 (100%)
- ACE inhibitors	24 (27%)
- Anticoagulant	41 (47%)

NYHA: New York Heart association ACE: angiotension-converting enzyme.

Table (2): Clinical and hemodynamic data before and after surgery.

Before	
- No of patients	89
- NYHA class I, II	8 (9%)
- PASP	98±19 mmHg
- Death	-
Postoperative	
- No of patients	81
- NYHA class I, II	-
- PASP	53±17 mmHg
- Deaths	8 (9%)
Follow-up	
- No of patients	81
- NYHA class I, II	71 (89%)
- PASP	37±12 mmHg
- Deaths	10 (12%)

NYHA: New York Heart Association PASP= Pulmonary artery systolic pressure.

IV and eight patients (9%) were in NYHA class II. All had pulmonary artery systolic pressure more than 60 mmHg (average 98 ± 19 mmHg, range 60-130 mmHg). There was 45 (50.6%) patients had severe tricuspid regurgitation and 44 (49.4%) had moderate tricuspid regurgitation.

Seventy eight patients underwent mitral valve replacement (21 had mitral regurgitation, 44 had combined mitral stenosis and regurgitation and 13 patients had mitral stenosis) and the remaining 11 patients underwent open mitral commissurotomies. Mitral valve repair was

not done for any case because the valve apparatus were not suitable due to the severe rheumatic affection. De Vega annuloplasty for repairing tricuspid regurgitation was done for 46 (51.7%) patients. These patients were followed clinically and with echo. Doppler examinations for a mean period of 13 ± 3 months (range 4-32) (Table 1).

Immediate results: After mitral valve surgery, during the hospital course there were 8 deaths. These 8 deaths were related to the severity of pulmonary hypertension (PASP more than 100 mmHg). Intraoperative measurements of pulmonary artery systolic pressure showed statistically significant drop from 98 ± 19 mmHg preoperatively), to 53 ± 17 mmHg postoperatively (P<0.01).

Follow-up:

During follow-up period (mean 13 ± 3 months) there are another 10 (12%) cardiac deaths; 6 of cardiac failure, 3 due o valve malfunction and the remainder died of infective endocarditis. Functional status improved markedly from 71 survivors, 89% were in New York Heart Association class I or II compared to 9% preoperatively. Of 27 patients having tricuspid regurgitation during follow-up, pulmonary artery systolic pressure can be obtained in only 23 patients. In these 23 patients, pulmonary artery systolic pressure had decreased from a mean preoperative value of 103±23 to 37±12 mmHg (P<0.001) (Table 2).

Discussion

Rheumatic heart disease is quite prevalent in Egypt and rheumatic mitral valve disease is considered the commonest lesion. Patients are presenting for surgical correction in far advanced stage of the disease after development of pulmonary hypertension (10). The development of pulmonary hypertension frequently complicates mitral valve disease and it is often out of proportion to the degree of left atrial hypertension and is due to increased pulmonary vascular resistance. The latter condition has been attributed to a combination of active pulmonary vasoconstriction and morphologic changes in the pulmonary vasculature (10). Pulmonary hypertension poses a threat to the outcome of mitral valve surgery (3).

Previous hemodynamic studies in-patients who underwent operation for mitral valve disease, have demonstrated some reversibility of pulmonary hypertension immediately after cardiac surgery. However anatomic changes may supervene in the wall of pulmonary arterioles precluding the normalization of pulmonary pressures and vascular resistance after surgery (11 & 12).

The results of this study confirm previous reports that a decrease does occur in pulmonary atrial pressure immediately after mitral valve surgery (98 ± 19 to 53 ± 17 mmHg (P<0.01). Also we have demonstrated that further decrease occurs in the pulmonary artery pressure when measured in 23 patients at follow-up (103 ± 23 to 37 ± 12 mmHg; P<0.001). Many investigators reported comparable findings as regard the decline of pulmonary artery systolic pressure after mitral valve surgery and after a longer period of follow-up (13, 14, 15 & 16).

Classic surgical series have demonstrated a higher immediate ortality in patients with mitral alve disease and severe ulmonary hypertension than in atients with

lower pulmonary artery hypertension (17 & 18). Despite advances in surgical ecliniques and the use of cold ardioplegia, the morbidity and mortality of mitral valve surgery in patients with mitral valve disease and severe pulmonary hypertension has remained relatively high and recent surgical series have reported a mortality rate higher than 5-10% (14 & 16). The results of the present study go on hand with previous reports and owed 9% hospital mortality after mitral valve surgery in patients with mitral valve disease and severe pulmonary hypertension.

Data concerning the midterm clinical and Doppler follow-up after mitral valve surgery were not provided in previous studies. The present study demonstrated after follow up period for a mean of 13 months that there were further improvement in pulmonary artery systolic pressure (103 ± 23) to 37 ± 12 mmHg; ($P<0.001$), occurrence of further 10 (12%) late deaths and marked improvement of functional status of patients, as 89% of survivors became in NYHA class I or II. Jegaden et al. (13) after longer period of follow-up (96 months) reported that 86% of the survivors were asymptomatic. Pasaoglu et al. (14) found that 90% of the survivors were in NYHA class I or II compared to 23% preoperatively after follow-up for 36 months while Aris and Camara (16) reported that 93% of their patients became in NYHA class I or II after 44 months of follow-up ill patients with mitral valve disease and severe pulmonary hypertension who underwent mitral valve surgery.

The results of the present study showed that there were reasonable operative mortality, initial decline of pulmonary artery systolic pressure after surgery with further drop at follow-up and improved functional status in patients included in the study after a mean 13 months follow-up. So the clinical and hemadynamic findings in this work suggest that severe pulmonary hypertension is not a contraindication to mitral valve surgery. These results indicate that, in patients with mitral valve disease and severe pulmonary hypertension, surgical procedures can be performed with an acceptable operative mortality; excellent midterm survival and improved functional status can be obtained and pulmonary hypertension decreases after operation. In conclusion, patients with mitral valve disease may benefit from surgical treatment regardless of the degree of pulmonary hypertension.

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Moataz Abdelkhalik

AORTIC ROOT REPLACEMENT BY SCALLOPING OF THE AORTA TO PRESERVE THE CORONARY ORIFICES & COMPARING IT WITH THE CONVENTINAL TECHNIQUE OF CORONARY ARTERIES REIMPLANTATION

ABSTRACT

Forty patients with ascending aortic aneurysm who underwent aortic root replacement & coronary arteries re-implantation in the NATIONAL HEART INSTITUTE between January 1991 & December 2001 Have been studied. The patients have been classified into two groups.

Group 1 (20 patients) coronary arteries re-implantation have been made by excising a button of aortic- coronary tissue& suturing this button to the composite graft used for replacement of the aortic valve & ascending aorta.

Group 2 (20 patients). The scalloping technique (which entails insertion of the aortic valve prosthesis & the tubular synthetic graft separately leaving two scallops for the two coronary ostia).

The two groups were compared as regard the incidence of recurrence of the aneurysm, the incidence of ischemic events & the amount of blood loss. In group 1 three patients died, two patients had myocardial infarctions, blood loss was 1800 ml ± 500 ml& no recurrenc e of the aneurysm reporter]. In group 2 no mortalities reported, nay ischemic events, blood loss was 1000 ml ± 200 ml & two patients had recurrence of the aneurysm of the sinuses of valsalva.

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INTRODUCTION

Ascending aortic root replacement is indicated in aortic aneurysm caused by annuloaortic (1,2&3,4,5,6) ectasia, atherosclerosis, infection, trauma or dissection or in acute dissection of the ascending aorta.

Aortic root replacement can restricted to the suprabulbar part without coronary arteries re-implantation if the sinuses of valsalva are not dilated or can involve the whole aortic root with coronary arteries re-implantation.

Different techniques have been described for aortic root replacement & coronary arteries re-implantation e.g. Bentall, (8) a button of aortic & coronary tissue re-implanted in the graft Cabrol's technique (10) & others.

All these techniques utilize a composite graft (a valved tube).

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We have utilized a technique originally described by Miller & colleagues (1984) (11) by careful scalloping of the Aorta, leaving two scallops containing the right & left coronary orifices & meticulous suturing of the conduit around the coronary orifices.

The surgical technique:

Preparation for surgery as usual with a triple-lumen catheter in the RA & a Swan-Ganz catheter is inserted to measure the pulmonary wedge pressure or after the sternotomy a polyvinyl catheter is inserted in the LA. The femoral artery is exposed.

After giving the Heparine a single venous cannula is inserted in the RA & the femoral artery is cannulated for arterial perfusion.

The aneurysm is dissected all around, a standard CPB with cold potassium cardio-plegia given directly in the coronary ostia is instituted.

The aneurysm is opened longitudinally. The aortic valve is excised & AVR with a prosthetic valve is inserted usually with a continuous suture technique to save as much time as possible (Three mattress sutures with Teflon Pledges are made at the 3 comissures & attached to the valve high up & with each limb of the three sutures we make two or three stitches low down in the annulus & high up in the valve until the opposite limbs meet each others & then tied together).

The aneurysm is excised all around, leaving two scallops for the left & right coronary ostia & few millimeters above the prosthetic valve if possible, taking care not to injure the left coronary artery as it passes behind the ascending aorta & the pulmonary artery. The conduit is sutured to the remaining part of the aortic root with a teflon stripe on the intimal surface of the aorta & another one on the outer part of the conduit (Teflon sandwich).

Leaving few millimeters of the aortic wall to be attached to the conduit help to prevent bleeding around the valve sutures (as in classic AVR), however if the dissection is extending to the Aortic valve then the conduit is sutured to the aortic valve directly. As the anterior part of the proximal anastomosis is made care is taken to ensure that the right coronary artery (lying in the proximal atrioventricular groove, not at the ostium is not inadvertently compromised).

The distal anastomosis is done as usual between two Teflon strips.

Patients and Methods

Twenty patients with ascending aortic aneurysm who underwent aortic root replacement & coronary arteries re-implantation in the NATIONAL HEART INSTITUTE between January 1991 & December 2001 have been studied.

The patients have been classified into two groups:

Group 1 (20 patients) coronary arteries re-implantation have been made by excising a button of aortic- coronary tissue & suturing this button to the composite graft used for replacement of the aortic valve & ascending aorta.

Group 2 (20 patients) The scalloping technique (which entails insertion of the aortic valve prosthesis & the tubular synthetic graft separately leaving two scallops for the two coronary ostia).

Table 1

Age	Group 1	Group 2
20-30	6	4
30-40	2	4
40-50	4	6
50-65	8	6
Mean 40.5		

Table 2

Sex	Group 1	Group 2
Male	14	16
Female	6	4

Table 3

Pathological Etiology	Group 1	Group 2
Cystic medio necrosis	6	6
Atherosclerosis	6	5
Dissecting aortic aneurysm	5	4
Acute dissection	3	5

Table 4

Size of the aorta	Group 1	Group 2
3-5 cm	3	5
5.5 cm	5	5
6 cm	8	6
> 6cm	4	4
Mean 5.5 cm		

The two groups were compared as regard the incidence of recurrence of the aneurysm, the incidence of ischemic events & the amount of blood loss

Tables 1,2,3,4&5 show the age, the sex distribution, the pathology, the size of the aorta & the ischemic time.

Results

Mortality

Group 1

Three patients died.

Patient No 1, had dissecting aortic aneurysm, with severe AI, the patient died

Table 5

Ischemic time(min)	Group 1	Group 2
100-120	2	10
130-150	6	7
160-180	8	2
>180	4	1
Mean 152.5		

Table 6

Blood loss(ml/24 hrs)	Group 1	Group 2
700-1000	2	10
1100-1300	4	8
1400- 1800	10	2
> 1800	4	-
Mean 1412.5		

Table 7

ECG changes	Group 1	Group 2
Normal ECG	12	18
Flat T wave(? ischemia)	4	2
S-T depression(ischemia)	2	-
Frank MI.	2	-

from bleeding (both medical & surgical) & re-opened on the second day & confirmatory sutures are made on the proximal anastomosis & on the coronary anastomosis & excessive amount of blood clots are removed, but the patient suffered from DIC & failure of clotting& developed chest complications (ARDS) & died 24 hours after surgery.

Patient No 2, had Acute dissection, the patient came off by-pass uneventful, but in the immediate post-operative S-T elevation was apparent with dramatic deterioration & the patient developed cardiogenic shock & died from pump failure.

Patient No 3, had Acute dissection the, patient came off by-pass uneventful, but in the immediate post-operative S-T elevation was apparent with mild hypotension. Cardiac enzymes were elevated (CPKmb & CPK) the patient died on the day from arrhysmia.

Group 2, no single mortality.

Morbidity.

Group 1, Blood loss was (-----) mean value as in table 6.

Myocardial infarction, was evident in two patients of the mortalities. Ischemic changes (S-T depression) were evident in two patients & Flat T wave (? ischemia) in four patients (table 7), no recurrence of the aneurysm was reported.

Group 2, Blood loss was (-----) mean value as in table 6.

Flat T wave (? ischemia) in two patients, (table 7) & two patients had recurrence of the aneurysm of the sinuses of valsalva (the size of the aorta was > 6 cm with marked dilatation of the sinuses of Valsalva), no MI.

Discussion

Twenty patients with ascending aortic aneurysm who underwent aortic root replacement & coronary arteries re-implantation in the NATIONAL HEART INSTITUTE. Have been studied.

The patients have been classified into two groups.

Group 1 (20 patients) coronary arteries re-implantation have been made by excising a button of aortic- coronary tissue& suturing this button to the composite graft used for replacement of the aortic valve & ascending aorta.

Group 2 (20 patients). The scalloping technique (which entails insertion of the aortic valve prosthesis & the tubular synthetic graft separately leaving two scallops for the two coronary ostia).

The two groups were compared as regard the incidence of recurrence of the aneurysm, the incidence of ischemic events & the amount of blood loss.

Re-implantation of the coronary arteries is the, most critical step in the operation for aortic root replacement as it carries the risk of occlusion of the coronary artery by kinking or the risk of bleeding.

So the scalloping technique has been adopted by us to avoid touching the coronary ostia, to guard against any ischemic event.

From tables 1,2,3&4 we can see that there are no significant differences between the two groups as regard the age& the sex distribution, the etiology & the size of the aorta.

Table 5 shows that the ischemic time is longer with group 1 which need re-implantation of the coronary arteries.

Table 6 shows that the blood loss is more with group 1 because bleeding around the valved conduit is usually excessive but in the scalloping technique the conduit is usually sutured few mm above the prosthetic valve which is fixed separately, so the situation is as in isolated aortic valve replacement.

Table 7 shows that the incidence of ischemic complications is more with group 1 as torsion, kinking or stretching of the coronary arteries are known possibilities with this technique but not with the scalloping technique.

Group 2 shows recurrence of the aneurysm in two patients in whom the size of the aorta was > 6 cm with marked dilatation of the sinuses of Valsalva (the distance between the coronary ostia & the aortic annulus is > 2cm.) as with marked dilatation of the aorta the wall of the aorta is very diseased & with the scalloping technique more tissues of the sinuses are left - T incidence of recurrence.

In group 1, 3 patients died, one patient died from bleeding & two patients died from MI. In group 2, no mortalities reported.

It seems that the technique of Scalloping the aorta markedly simplifies the technique of aortic root replacement, it shortens the ischemic time, it decreases the amount of blood loss, it avoids the occurrence of any ischemic events & it has much less mortalities. The incidence of recurrence of the aneurysm of the sinus of Valsalva is more with this technique when these sinuses are much dilated (the distance between the coronary ostia & the aortic annulus is > 2cm).

Conclusion

The technique of scalloping the aorta markedly simplifies the technique of aortic root replacement, it shortens the ischemic time, it decreases the amount of blood loss, it avoids the occurrence of any ischemic events & it has much less mortalities.

The incidence of recurrence of the aneurysm of the sinus of Valsalva is more with this technique when these sinuses are much dilated (the distance between the coronary ostia & the aortic annulus is > 2cm).

So this technique is better avoided when the aorta is much dilated (the distance between the coronary ostia & the aortic annulus is > 2cm).

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RESULTS OF VALVE REPLACEMENT FOR REGURGITANT LEFT SIDED CARDIAC VALVES

ABSTRACT

This study was done to evaluate the effect of severe regurgitant left sided cardiac valves on preoperative left ventricular (LV) performance and to evaluate the results of their replacement on postoperative LV performance, morbidity, and mortality. It is a prospective randomzied study done in the Cardiothoracic Surgery Department, Mansoura University, between October 1997 and September 2001. It included 60 patients; 35 males and 25 females with mean age of 27.68 ± 10.17 years. The patients were divided into 3 groups, group A included 20 patients with severe mitral regurgitation (MR), group B included 20 patients with severe aortic regurgitation (AR), and group C included 20 patients with combined severe mitral and aortic regurgitation.

Careful clinical examination, ECG, chest X-rays, hematologic investigations, and echocardiography were done for all patients. Preoperative echocardiography confirmed that the highest impairment of LV performance was in group B and C with no statistical difference between both groups (P>0.05). This reflected the effect of severe AR in both groups on LV performance.

This was also confirmed by the P values of significance between group A and B regarding LVESD (0.001034), LVEDD (3.55438 E-05), EF (0.001228), FS (0.049267), SWT (0.010608), and LV muscle mass (0.0027220).

The highest values of LAD were in groups A and C with no significant difference between them (P = 0.492119437) and highly significant difference between groups A and B (P = 2.6791 E-05) and groups B and C (P = 7.4768E-05). The highest values of RVD were also in groups A and C with non significant difference between both groups (P = 0.932544). The changes in LAD and RVD reflected the effect of severe MR on these parameters. Valve replacement was done in all patients. The longest ischaemic time was in group C (88.8 ± 20.24 min.) with highly significant difference between it and group A (7.14258E-07) and group B (3.88377E-05). Also the longest pump time was in group C (128.30 + 17.97 min.) with highly significant difference between it and group A (7.03847E-07) and group B (9.138748E-05).

Postoperative echocardiography confirmed nonsignificant differences between the three groups (P<0.05) regarding LVEDD, LVEDD, EF, FS, SWT, PWT and LV muscle mass and conversion of the preoperative values to normal postoperative values. These findings indicate success of valve replacement to get normal LV performance. These findings were also supported by the pre and postoperative echocardiographic statistical analysis. There was highly significant (P = 0.00665) regression in LAD after mitral value repalcement but these values did not reach normal values. There was nonsignificant pre and postoperative changes (P>0.05) in RVD in all groups. Postoperative complications were adequately managed in all groups. There was one intraoperative mortality in

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group C and one postoperative mortality in groups B and C. The total mortality was 5%.

We conclude that replacement for severe regurgitant left sided cardiac valves are successful operations to restore the severely impaired LV performance to normal values with accepted morbidity and mortality.

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INTRODUCTION

Although isolated mitral or aortic regurgitation remains prevelant among young people, aortic and mitral regurgitation frequently occur in combination (1).

Rheumatic heart disease is the most common cause of left sided valve regurgitation in the developing countries inspite of nearly eradication of rheumatic fever from the developed countries (2).

The hemodynamics and loading conditions for isolated or combined mitral and aortic regurgitation have been well documented and their effect on left ventricular function has been established(3).

The principles of management of left side valvular regurgitation, which weight watchful against surgery, have crystallized over the past 20 years. While the timing of surgery once was enigmatic, it is now clear that surgery must be done prior to the development of prolonged left ventricular dysfunction (4).

Single or combined mitral and aortic valve replacement has become quiet common surgical procedure for management of single or combined left sided valve regurgitation (5).

Now, satisfactory indices have been developed that allow the clinician to detect and avoid prolonged left ventricular dysfunction. Therefore, patients now undergo surgery sooner, resulting in reduced operative mortality and better long-term survival with good left ventricular performance (6).

The aim of this study is:

1- To evaluate the effect of severe mitral regurgitation, severe aortic regurgitation, and combined severe mitral and aortic regurgitation on the preoperative left ventricular (LV) performance.

2- To evaluate the effect of mitral valve replacement, aortic valve replacement, and combined mitral and aortic valve replacement for regurgitant lesions on postoperative left ventricular performance and its relation to preoperative LV performance.

3- To evaluate the results of mitral valve replacement, aortic valve replacement and combined mitral and aortic valve replacement for regurgitant lesions.

Patients and Methods

This randomised prospectvie study included sixty patients submitted for single or double valve replacement of left sided cardiac valves due to regurgitant lesions done in the Cardiothoracic Surgery Department, Mansoura University, between October 1997 and September 2001.

The patients were divided into 3 groups.

Group A: Included 20 consecutive patients with severe mitral regurgitation (MR) for whom mitral valve replacement (MVR) was done. It included 16 females and 4 males. The age range was 21-51 years with a mean age of 30.25 $\pm$ 9.82 years.

Group B: Included 20 consecutive patients with severe aortic regurgitation (AR) for whom aortic valve replacement (AVR) was done. It included 18 males and 2 females. The age range was 15-55 years with a mean age of 24.75 $\pm$ 0.92 years.

Group C: Included 20 consecutive patients with combined severe mitral and aortic regurgitation (MR and AR) for whom double valve replacement (DVR) was done. It included 13 males and 7 females. The age range was 12-49 years with a mean age of 26.6 $\pm$ 8.31 years.

The demographic data of all groups are shown in table (1).

Inclusion and exclusion criteria:

Group A: Included 20 patients with severe mitral regurgitation grade III/IV or IV/IV. Trivial grades of aortic stenosis or regurgitation was accepted in this group. Moderate or severe aortic incompetence was excluded in this group.

Group B: Included 20 patients with severe aortic regurgitation grade III/IV or IV/IV. Trivial mitral stenosis or regurgitation was accepted in this group. Moderate or severe mitral regurgitation was excluded in this group.

Group C: Included 20 patients with combined severe mitral and aortic regurgitation grade III/IV or IV/IV. Trivial mitral stenois or aortic stenosis was accepted in this group. Moderate mitral or aortic stenosis or regurgitation was excluded in this group.

Table (2) shows the preoperative diagnosis in all groups. Careful history taking and clinical examination were done for all patients. Preoperative routine laboratory and hematologic investigations were done for all patients. Preoperative chest X-rays, ECG and echocardiography were done for all patients.

All patients had a preoperative and early postoperative (10-20 days) complete echo Doppler study of their cardiac valves and chamber dimensions. The same was repeated on the follow up visits at an average of 6-48 months. Echocardiogrpahic examination was done using Acuson 128 x L/S with a 3.5 MHz transducer for the examination performed using the standard technique with patient in left lateral decubitus position according to the recommendations of the American Echocardiographic Association (Henery et al., 1980).

All patients were operated upon using standard cardiopulmonary bypass with nonpulsatile perfusion. Cold blood cardioplegia with local cooling with ice

slush was used for myocardial protection. Systemic hypothermia was routinely used with a degree of 28°C-30°C. Mitral valve replacement, aortic valve replacement, and double valve replacement were done for patients in groups A, B, and C respectively. Ischaemic time and perfusion time were recorded for all patients. The patients were referred to ICU and extubated after all criteria for weaning were fulfilled. Postoperative echocardiography was done for all patients. All patients were followed up for 6-48 months (14.28 ± 8.77).

Statistical analysis:

All values were presented as means ± standard deviation (SD), the student t-test was used to compare parametric data. Statistical significance was assumed if P value was <0.05, highly significant if P value was <0.01 and nonsignificant if P value was >0.05.

Results

The preoperative and postoperative echocardigoraphic data are shown in tables (3) and (4) respectively. The longest ischaemic time was in group C with DVR (88.8 ± 20.24 minutes) with highly significant difference between this group and the other two groups. Also the longest pump time was found in group C with DVR (128.30 ± 17.97 minutes) with highly significant difference between this group and the other two groups. Table (5) shows the ischaemic and pump times in all groups. Table (6) shows the types of valves used in all groups.

Table (7) shows the preoperative echocardiographic statistical differences between all groups.

The highest preoperative values of LVESD, LVEDD, ARD, SWT and PWT, together with the lowest values of EF and FS were in groups B and C reflecting the effect of severe AR in both groups on preoperative impairment of LV performance. On the other hand, the highest values of LAD and RVD were found in groups A and C reflecting the effect of severe MR in both groups on these parameters.

Table (8) shows the postoperative echocardiographic findings. It clearly shows non significant differences between all groups regarding LVESD, LVEDD, EF, FS, SWT, PWT, and LV muscle mass and this reflects the effectiveness of valve replacement whether one or two valves on restoration of normal left ventricular performance. There was significant difference in LAD between group A and B, also between groups B and C which indicates that the LAD does not reach to preoperative values after mitral valve replacement. There was significant difference in ARD between groups A and B and also A and C which also indicates persistence of aortic root dilatation after AVR. There was no significant difference in RVD between group A and B and A and C which indicates regression of RVD after MVR. These postoperative echocardiographic data indicate marked improvement of LV performance after all types of valve replacement for left sided regurgitant cardiac lesions.

Table (1): Demographic data.

	Group A (MVR)	Group B (AVR)	Group C (DVR)
Sex	M4 (20%) F16 (80%)	M18 (90%) F2 (10%)	M13 (65%) F7 (35%)
Age:			
Minimal	21	15	12
Maximal	51	55	49
Mean	30.25	24.75	26.60
SD	9.82	10.92	8.31

Table (2): Preoperative diagnosis.

Preoperative diagnosis	No. of patients	%
Group A (MVR)		
MR III/IV and trivial MS	10	50
MR III/IV	5	25
MR IV/IV	3	15
MR IV/IV and MV endocarditis	1	5
MR IV/IV and LA thrombus	1	5
Total	20	100
Group B (AVR):		
AR III/IV with mild MR	8	40
AR IV/IV with trivial MR	5	25
AR IV/IV	2	10
AR III/IV	1	5
AR IV/IV with uncontrolled CHF	1	5
AR IV/IV with severely impaired systolic function	1	5
AR III/IV with trivial AS	1	5
AR IV/IV with trivial AS	1	5
Total	20	100
Group C (DVR)		
MR IV/IV with AR IV/IV	7	35
MR III/IV with AR III/IV	6	30
MR IV/IV with AR IV/IV and trivial MS	5	25
MR III/IV with AR III/IV with trivial MS and AS	1	5
MR IV/IV with AR IV/IV and trivial AS	1	5
Total	20	100

MR : Mitral regurgitation. MS : Mitral stenosis. MV : Mitral valve. LA : Left atrial. AR :Aortic regurgitation. CHF: Congestive heart failure. AS : Aortic stenosis.

Table (3): Preoperative echocardiographic data.

	Group A (MVR)	Group B (AVR)	Group C (DVR)
LVESD	4.02 ± 0.86	5.07 ± 0.89	5.03 ± 0.91
LVEDD	6.19 ± 0.84	7.51 ± 0.83	7.50 ± 1.08
LAD	6.24 ± 1.67	4.34 ± 0.76	6.06 ± 1.62
RVD	1.93 ± 0.42	1.75 ± 0.55	1.93 ± 0.31
ARD	3.38 ± 0.52	3.81 ± 0.66	3.44 ± 0.42
EF	67.42 ± 5.13	60.68 ± 6.60	59.42 ± 9.27
FS	36.26 ± 4.63	33.00 ± 5.25	32.47 ± 4.49
SWT	1.05 ± 0.5	1.16 ± 0.18	1.14 ± 0.15
PWT	1.05 ± 0.05	1.15 ± 0.17	1.12 ± 0.12
LV muscle mass	293.75 ± 107.83	479.51 ± 235.54	569.42 ± 298.74

Table (4): Postoperative echocardiographic data.

	Group A (MVR)	Group B (AVR)	Group C (DVR)
LVESD	3.72 ± 0.78	3.75 ± 0.89	4.01 ± 0.73
LVEDD	5.34 ± 0.90	5.41 ± 0.84	5.67 ± 0.94
LAD	5.17 ± 0.77	4.41 ± 0.63	5.19 ± 1.28
RVD	1.85 ± 0.49	1.60 ± 0.49	1.96 ± 0.24
ARD	2.97 ± 0.50	3.38 ± 0.52	3.54 ± 0.87
EF	56.58 ± 10.20	59.68 ± 7.20	59.42 ± 10.94
FS	35.11 ± 12.24	32.42 ± 5.49	35.16 ± 10.91
SWT	1.15 ± 0.5	1.09 ± 0.20	1.18 ± 0.25
PWT	1.15 ± 0.05	1.18 ± 0.26	1.05 ± 0.19
LV muscle mass	310.37 ± 98.36	264.80 ± 94.45	317.26 ± 162.81

Where: LVESD = Left ventricular end-systolic diameter. LVEDD = Left ventricular end-diastolic diameter. LAD = Left atrial diameter. RVD = Right ventricular diameter. ARD = Aortic root diameter. EF = Ejection fraction. FS = Fiber shortening. SWT = Septal wall thickness. PWT = Posterior wall thickness. LV muscle mass = Left ventricular muscle mass (gms).

Table (5): Ischaemic time and perfusion time.

	Group A (MVR)	Group B (AVR)	Group C (DVR)
Ischaemic time (min.)	54.95	56.15	88.80
SD	12.84	15.47	20.24
Pump time (min.)	92.85	85.40	128.30
SD	18.88	35.93	17.97
Statistical difference	Between A & B	Between A & C	Between B & C
P value (ischaemic time)	0.428661184	7.14358E-07	3.88377E-05
P value (pump time)	0.855463769	7.03847E-07	9.13848E-05

Table (6): Types of valves used.

	Group A (MVR)	Group B (AVR)	Group C (DVR)
St. jude valve:			
No. of patients	11	11	18
%	55%	55%	45%
Carbomedics valve			
No. of patients	9	9	22
%	45%	45%	55%

Table (7): Preoperative echocardiographic statistical differences.

	Groups A & B (MVR & AVR)		Groups B & C (MVR & DVR)		Groups B & C (AVR & DVR)	
LVESD	0.001034	HS	1	NS	1	NS
LVEDD	3.55438E-05	HS	0.000220962	HS	1	NS
LAD	2.6791E-05	HS	0.492119437	NS	7.4768E-05	HS
RVD	0.214512	NS	0.932544	NS	0.198031	NS
ARD	0.031331	S	0.667796	NS	0.04855	S
EF	0.001228	HS	0.009598	HS	0.883428	NS
FS	0.049267	S	0.012372	S	0.70155	NS
SWT	0.010608	S	0.009498	HS	0.706375	NS
PWT	0.112007	NS	0.207469	NS	0.597615	NS
LV muscle mass	0.002722	S	0.000401	HS	0.29722	NS

Table (8): Postoperative echocardiographic statistical differences.

	Groups A & B (MVR & AVR)		Groups B & C (MVR & DVR)		Groups B & C (AVR & DVR)	
LVESD	0.796504	NS	0.189343	NS	0.328685	NS
LVEDD	0.836462	NS	0.509544	NS	0.652438	NS
LAD	0.002247	S	0.747351	NS	0.012093	S
RVD	0.137469	NS	0.313364	NS	0.006041	S
ARD	0.026338	S	0.0224183	S	0.512442	NS
EF	0.36348	NS	0.665863	NS	0.744737	NS
FS	0.48179	NS	0.635399	NS	0.201743	NS
SWT	0.13727	NS	0.485944	NS	0.126198	NS
PWT	0.6166	NS	0.056881	NS	0.169721	NS
LV muscle mass	0.143328	NS	0.872083	NS	0.220195	NS

Where: NS = Non-significant (P>0.05). S = Significant (P<0.05). HS = Highly significant (P<0.01).

Table (9): Statistical differences between preoperative and postoperative echocardiographic parameters in each group.

	Group A		Group B		Group C	
LVESD	0.192749	NS	6.9351E-05	HS	0.000342	HS
LVEDD	0.006197	NS	1.04288 E-08	HS	8.12544E-07	HS
LAD	0.006654	HS	0.720915	NS	0.109287702	NS
RVD	0.026338	S	0.031331	S	0.695665	NS
ARD	0.581109	NS	0.082962	NS	0.544211	NS
EF	0.000173	HS	0.504771	NS	0.548807	NS
FS	0.590092	NS	0.750161	NS	0.1843	NS
SWT	3.38733 E-07	HS	0.162392	NS	0.490527	NS
PWT	3.38733 E-07	HS	0.458521	NS	0.536694	NS
LV muscle mass	0.613535	NS	0.000533	HS	0.002026	HS

Where: NS = Non-significant (P>0.05). S = Significant (P<0.05). HS = Highly significant (P<0.01).

Table (10): Postoperative complications.

Complication	Group A	Group B	Group C
Pericardial effusion	-	2 (10%)	1 (5%)
ICU syndrome	1 (5%)	1 (5%)	1 (5%)
Mediastinitis	2 (10%)	-	-
Paravalvular leak	-	2 (10%)	-
Superficial wound infection	1 (5%)	-	-
Pyopericardium	-	1 (5%)	-
Postoeprative bleeding	-	1 (5%)	-
Postoperative hematuria	-	-	1 (5%)

NB: More than one complication may be present in the same patient.

Table (11): Mortality.

Complication	Group A	Group B	Group C
Intraoperative mortality	-	-	1 (5%)
Perioperative mortality	-	1 (5%)	1 (5%)
Total mortality (5%)	0 (0%)	1 (5%)	2 (10%)
Preoperative risk factors	-	CHF, and low COP	CHF, low COP and endocarditis
Cause of death	-	-	Low COP

Where:. CHF : Congestive heart failure. COP : Cardiac output.

Table (9) shows the statistical differences betwen preoperative and postoperative echocardiographic values in each group. There were highly significant differences in groups B and C regarding LVESD, LVEDD, and LV muscle mass with non significant difference in group A and this reflects the marked effect of severe AVR on these parameters and the opposite is true with severe MR. There were highly significant differences as regards LAD, EF, SWT, PWT in group A and the reverse was true in groups B and C.

The commonest postoperative complication was pericardial effusion (hemopericardium) which was present in 3 patients, all of which were adequately drained. Table (10) shows the postoperative complications in all groups. There was one intraoperative mortality in our study in group C and this patient was operated upon in low cardiac output and infective endocarditis. The total mortality in our study was 5%.

Table (11) shows distribution of mortality in all groups.

Discussion

Although previous studies have looked at the clinical outcome of patients undergoing single or combined left sided valve replacement for regurgitant lesions, low data are available on postoperative left venricular function in these patients (8). In this study, we analyze the changes in left ventricular function after single or double valve replacement for regurgitant lesions and determine the preoperative predictors of the postoperative LV performance.

Previously reported studies indicated that rheumatic heart disease is the most common cause of single or combined mitral and aortic valve regurgitation (9). In our country, rheumatic valvular heart disease form more than 80% of patients seen in cardiac medical or surgical clinics and they usually presented late with bad ventricular function (10). In our study nealry all patients have history of rheumatic fever (93%) and all of them with rheumatic heart diseases. The mean age of our patients was 27.68 ± 10.17 years.

Our demographic data were matched with other studies from developing countries (10,11) where their patients have rheumatic heart disease and their age was around 30 years. This differs from patients from westren countries (12,13,14), where the mean age was around 50 years and other causes of aortic and mitral valve lesion as degenerative and myxomatous diseases were found in addition to the rheumatic disease.

In our country, rheumatic cardiac patients usually presented late with bad ventricular functions, severe pulmonary hypertension, liver failure or bad nutritional and general condition (15). The symptomatology in our study showed that our patients were in advanced disease stage with late NYHA functional class (Grade III or IV).

Also the preoperative echocardiographic data revealed markedly enlarged left ventricular dimensions with low ejection fraction and fractional shortening of most of our patients and the same was reported by others studies (11,13,15). Also in our study the impairment of left ventricular function was marked with combined MR and AR, followed by AR and least with MR.

The longest pump time was found in group C with DVR which also has the longest ischemic time rather than the other 2

groups with highly significant difference between them. The pump and ischemic times are considered as risk factor in the outcome of patients with double valve replacement rather than single valve replacement (16).

Boucher et al. (17) reported a significant reduction in ejection fraction 2 to 4 weeks after isolated aortic or mitral valve replacement for aortic or mitral regurgitation because of decrease in end-diastolic volume. However, late postoperative analysis (1-2 years) after surgery showed normalization of the ejection fraction in the aortic insufficiency group owing to a reduction in end-systolic volume, whereas in the mitral regurgitation group, ejection fraction remained subnormal. There is a paucity of data examining the effect of double valve replacement on left ventriculuar ejection performance in patients with combined mitral and aortic regurgitation.

Essop et al. (18) found relatively well preserved fractional shortening 3 months, after surgery in a short term evaluation of 13 young pateints with active rheumatic carditis in whom mitral valve replacement was done. Daniel et al. (19) also demonstrated subnormal left ventricular systolic function 3 months after surgery owing to a reduction in the end- diastolic diameter with no change in the end-systolic diameter while normalization of the ejection fraction was only observed at 1 year.

In our study, we showed a significant improvement of left ventricular echocardiagraphic data in all groups regarding LVESD, LVEDD, EF, FS, SWT, PWT and LV muscle mass without significant difference between all groups and this reflects the effectiveness of valve replacement whetehr one or two valves on restoration of normal or near normal left ventricular performance. We showed also persistant dilatation of LAD and ARD which do not reach normal values after valve replacement of left sided valves. These echocardiographic data indicate marked improvement of LV performance after all types of valve replacement for left sided regurgitant cardiac lesions and are similar to that reported for patients with isolated aortic regurgitation or mitral regurgitation (20,21,22,23,24,25).

They also found that left ventricular end-systolic diameter and ejection fraction were signfiicant independent predictors of postoperative ejection performance. Some discrepancy may be found between their results and our resutls which may be due to the fact that patients in the current study were older with more long standing valvular regurgitation and therefore with less contractile reserve. It would appear, therefore, that the hemodynamics of combined valve regurgitation more closely approximate those of isolated aortic regurgitation than isolated mitral regurgitation (19).

These data are similar to our results and although the postoperative increase in ejection fraction most likely due to a substantial reduction in afterload, a concomitant improvement in contractility can not be excluded. These resutls would also suggest that detrimental loading conditions created by mitral valve replacement are more than offset by the favorable hemodynamics of aortic valve replacement (26).

It would appear from these data that to optimize postoperative left ventricular

function in patients undergoing isolated MVR or AVR or combined mitral and aortic valve replacement for regurgitant lesions, surgery should be considered before the ejection fraction drops or the end-systolic diameter increases.

Chronic aortic valve regurgitation has deleterious effects on left ventricualr functions because it causes progressive volume overload of the left ventricle which causes progressive dilatation of the left ventricular cavity and hypertrophy of the ventricualr walls (27). This continues to certain limits then failure occurs when dilatation causes stretching beyond the limits of Frank Starling low, with poor effects on prognosis, survival and outcome of the patient with severe AR (28).

In our study, the highest impairment of left ventricular performance preoperatively was seen in groups B and C with no statistical difference between them and highly significant difference between group A and B and this reflects the effect of severe AR on left ventricular performance. The highest preoperative values of LAD and RVD were found in group A and C and this reflects the effect of MR in both groups.

Aortic valve replacement and mitral valve replacement result in abolishment of the volume overload and pressure overload and lead to regression of left ventricular dilatation and hypertrophy (28). This improve the symptoms, survival and markedly decreases the complications (28). The rate of regression of ventricular hypertrophy and dilatation and improvement of left ventricular performance varies according to the preoperative data (30).

In our study, the valve replacement for severe regurgitant left sided cardiac valves were successful operations that restore the severely impaired left ventricular performance to normal values with accepted morbidity and mortality. The statistical difference in our study between the preoperatvie and the postoperative echocardiographic data in each group confirmed the marked improvement in left ventricular performance in group B and C which had marked preoperative impairment due to severe AR.

There were highly significant differences in groups B and C regarding LVESD, LVEDD and LV muscle mass with non significant difference in group A and this reflects the marked effect of severe AR on these data and the opposite is true in severe MR. Also there were highly significant differences as regards LAD, EF, SWT and PWST in group A and the reverse was true in group B and C.

The commonest postoperative complications were mediastinal collection and ICU syndrome (5%) which were present in 3 patients for each out of 60 patients. All collections were adequately drained. Other complication as mediastinitis, ICU syndrome and paravalvular leak were (3.3%) 2 patients out of 60 patients. The least incidence of complciation was (1.6%) one patient out of 60 patients and these complications include postoperative bleeding, superficial wound infection, and postoperative hematuria. Many authors (3,11,15,22,29) reported all of these complications and they mentioned that presence of many preoeprative risk factors with prolonged operative time might be responsible for the increased incidence of complications.

The reported incidence of hospital mortality after valve surgery shows a

considerable variability between 0-8% in single valve replacement and may reach 15% in double valve replacement (8,11,13,15). In our study, the incidence of mortality was 0% in MVR, 5% in AVR and 10% in DVR. This low incidence of mortality was due to good selection of cases and the cause of death was low cardiac output syndrome due to marked impairment of left ventricular functions preoperatively. This factor was suggested by many authers (11,13) as a predictar for operative mortality and this was in our case of AVR who died postoperatively, but in one case of mortality after DVR, another risk factor was reported which was infective endocarditis. High risk factors by other authors (6,9) who also studied that DVR itself appears to be an incremental risk factor for death compared to isolated MVR or AVR.

Conclusion

1- The highest preoperative impairment of LV performance was seen in groups B and C with no statistical difference between them and highly significant difference between groups A and B and this reflects the effect of severe AR in groups B and C on LV performance.

2- The highest preoperative values of LAD and RVD were in groups A and C and these reflected the effect of severe MR in both groups. These values did not reach to normal values postoperatively.

3- Valve replacement was successful in conversion of preoperative echocardiographic values into normal postoperative echocardio-graphic values as regards LVESD, LVEDD, EF, FS, SWT, PWT and LV muscle mass with nonsignificant difference between all groups.

4- Statistical differences between preoperative and postoperative echocardiographic data in each group confirmed that the marked improvement in LV performance was in groups B and C which had marked preoperative impairment due to severe AR.

5- Valve replacement for severe regurgitant left sided cardiac valves are successful operations that restore the severely impaired LV performance to normal with accepted morbidity and mortality.

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MINIMALLY INVASIVE SURGICAL CLOSURE OF SECUNDUM ATRIAL SEPTAL DEFECTS: SAFETY AND EFFICACY?

ABSTRACT

Objective: Surgical closure of secundum atrial septal defects (ASD) via median sternotomy (MS) is a low-risk procedure with mortality rates approaching zero. Minimally invasive right thoracotomy (MIRT) is an alternative approach. We compared MIRT versus MS in relation to safety and efficacy.

Patients and Methods: Between July 1997 and October 2000, 83 patients underwent surgical closure of secundum ASD. Twenty-nine (34.9%) were closed via MIRT [groupI], 54 (65.1%) were closed through MS [groupII]. Continuous variables were compared using unpaired t-test or Mann-Whitney U test as appropriate. Fisher's exact test was used to compare categorical variables. Follow up was complete.

Results: Preoperative variables in groupI and groupII were; mean age (13.7±2.2) years versus (18.7±2.5), p=not significant (NS); mean weight (38.7±4.7) kg versus (39.1±3.8), [p=NS]; atrial fibrillation 0(0%) versus 2(5.6%), [p=NS]; while atrial flutter 2(6.9%) versus 1(1.9%), [p=NS]. Operative variables were; mean ventricular fibrillation time (15.3±1.7) min. versus mean cross clamp time (20.7±1.6) min., [p=0.03] and total cardiopulmonary bypass time was (29.0±1.9) min. versus (34.1±1.9), [p=NS]. Postoperative variables were; ventilation time (176.5±15.3) min. versus (192.6±18.2), [p=NS]; residual shunt in 2(6.9%) versus 1(1.9%), [p=NS]; pericardial effusion 0(0%) versus 8(14.8%), [p=0.04]; atrial fibrillation 0(0%) versus 4(7.4%), [p=NS]; atrial flutter 0(0%) versus 2(3.7%), [p=NS]; phrenic nerve palsy was (0%) in both groups, while postoperative hospital stay was (5.7±0.4) days versus (7.0±0.5), [p=0.006]. Follow up was (12.9±1.5) and (15.9±1.7) months, respectively.

Conclusion: Minimally invasive right thoracotomy is a safe and effective alternative approach to median sternotomy for secundum ASD closure with less postoperative morbidity.

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INTRODUCTION

One of the most common congenital cardiac anomalies is isolated atrial septal defect (ASD). Untreated, it usually follows a benign course throughout the first 2 decades of life. Most cases of isolated ASD are surgically treated between 3 and 8 years of age (1). Conventional surgical closure through midline sternotomy is considered the gold standard in the treatment of these defects due to very low morbidity and mortality rates and the availability of long-term follow up data available for this

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procedure. Recent advances in the use of minimally invasive surgical techniques (characterised by very small incisions with minimal exposure of the operative field) are now challenging the role of the conventional approach, especially in the cases of small to medium sized defects. Supposed advantages of the new approaches include a more cosmetic skin incision, less postoperative pain, shorter hospital stay and earlier return to physical activity (2-9). However, minimally invasive surgery appears more technically demanding than conventional surgery (10). Therefore, the issue of abandoning the well-established median sternotomy approach in favour of the newer techniques remains highly controversial (2). In this series, we compared minimally invasive right thoracotomy (MIRT) versus median sternotomy (MS) in relation to safety and efficacy.

Patients and Methods

2.1. Patients:

Between July 1997 and October 2000, 83 patients underwent surgical closure of secundum ASD. Twenty-nine (34.9%) were closed via MIRT [group I], 54 (65.1%) were closed through MS [group II].

2.2. Inclusion criteria:

All patients, including children and adults, who underwent surgical repair of isolated secundum ASD. Patients with previous attempt of catheter closure were also included.

2.3. Exclusion criteria:

All patients with primum ASDs, sinus venosus ASDs or concomitant cardiac lesions (e.g., VSD, anomalous venous drainage…) were excluded from the study.

2.4. Data collection:

The data of the patients included the patients demographic and clinical data Operative data included the surgical technique, total cardiopulmonary bypass time, aortic cross clamp time and ventricular fibrillation time. All postoperative complications, residual ASD, heart block, arrhythmias, pericardial effusion, postoperative ventilation and hospital stay, were noted.

2.5. Echocardiography:

Preoperative and early postoperative studies were performed while the patient was in the hospital. Follow up was obtained during the regular follow up of the patient by the cardiologist in the outpatient clinic. All patients were examined by two-dimensional and Doppler echocardiography to detect any residual shunt.

2.6. Patients groups:

For the purpose of the study, the patients were divided into two groups. Group I consisted of 29 patients (34.9%) who underwent ASD closure via minimally invasive right anterior thoracotomy (MIRT). Group II included 54 patients (65.1%) who had ASD closure through conventional median sternotomy (MS) approach.

2.7. Surgical techniques:

Minimally invasive right thoracotomy (Group I) A sub-mammary small (6- to 8-cm) anterior right thoracotomy incision was performed after positioning the patient with the right side elevated by 30 degrees. The incision started about 2 cm anterior to the nipple and extended about 6-to 8-cm posteriorly. The breast tissue, pectoral muscles, serratus anterior and latissimus

dorsi were not divided. The chest was entered through the fourth intercostal space. The pericardium was opened about 2 cm anterior and parallel to the phrenic nerve, and a piece of it was harvested for later use as a patch. After heparin administration, aorta and bicaval cannulation was performed. In all cases the complete connection to the heart-lung machine was carried out via limited anterior thoracotomy. For cannulation of the ascending aorta, an elongated one-piece arterial trochar cannula (Medtronic DLP, Grand Rapids, Michigan) was used, and both caval veins were cannulated by angled plastic tip cannulae. The view to the aortic cannulation site could be improved when fixation of the upper venous cannula is accomplished first and the right auricle is elevated from the ascending aorta by careful traction. Cardiopulmonary bypass under normothermic or mild hypothermia (32°C) was started and the caval tapes were snared. Ventricular fibrillation was induced and the defect was closed either directly with a continuous 5/0 polypropylene sutures or using a patch of pericardium through an oblique right atrial incision. During defect closure, avoidance of emptying the left atrium of blood was carefully done. The atriotomy was then closed, after careful deairing, the caval snares were released, ventilation was resumed, and the heart was defibrillated. After discontinuation of the cardiopulmonary bypass, the thoracotomy was closed in a routine fashion after placement of ventricular pacing electrodes and pericardial and pleural drains. To decrease postoperative pain, we routinely placed a subcostal epidural catheter for injection of local anaesthetic (Marcaine 0.5%). All the patients were followed up clinically and with transthoracic echocardiography in the immediate postoperative period as well as 3, 6 and 12 months after surgical closure.

Median sternotomy (Group II) The classic midline sternotomy approach was utilized. Mild hypothermic (32°C) cardiopulmonary bypass was instituted with the use of aortic and bicaval cannulations. During a short period of aortic cross clamp time, the defect was closed through transatrial approach. The rest of the procedure was done in the usual fashion. The follow up was done for all the patients in a similar way to that of minithoracotomy patients.

2.8. Follow up:

All patients were followed up in the immediate postoperative period, to detect any residual left to right shunt and any accumulation of pericardial effusion, and also for a variable period in the outpatient clinic. Follow up was (12.9±1.5) months for group I and (15.9±1.7) months for group II.

2.9. Definitions:

Early mortality or morbidity was defined as any death or morbidity before hospital discharge or within 30 days of surgical interference.

2.10. Statistical analysis:

Continuous variables are presented as means ± standard error of mean (SEM) and range. Categorical variables are presented as percentages. Levene's test was used to test for equality of the variances. Continuous variables were compared with unpaired t-test or Mann-Whitney U test as appropriate. Categorical variables were compared with Pearson Chi-Square or Fisher's exact test as appropriate. The level of statistical significance was set at a p value of 0.05 or less. Analysis was done using the statistical

Table (1):

Preoperative clinical data:	Minimally invasive right thoracotomy Group I (n=29)	Median sternotomy Group II (n=54)	P value
1. Effort intolerance	6 (20.7%)	27 (50%)	p=0.009*
2. Failure to thrive	1 (3.4%)	6 (11.1%)	p=0.41
3. Palpitations	3 (10.3%)	9 (16.7%)	p=0.52
4. Atrial fibrillation	0 (0%)	3 (5.6%)	p=0.54
5. Atrial flutter	2 (6.9%)	1 (1.9%)	p=0.27
6. Congestive failure	0 (0%)	3 (5.6%)	p=0.54
7. Preoperative medications :			
a. Ace inhibitors	0 (0%)	1 (1.9%)	p=1.0
b. Diuretics	0 (0%)	7 (13.0%)	p=0.09

*** p= statistically significant.**

package SPSS PC (version 10.0) (SPSS INC., 444 N. Michigan Avenue, Chicago, IL 60611, USA).

Results

3.1. Preoperative patient demographics:

- Age: Group I (n=29), the mean age was 13.7 ± 2.2 years (range, 3 – 42 years). While group II (n=54), the mean age was 18.7 ± 2.5 years (range, 0.8 – 63 years). There was no statistical difference (p=0.15), between the mean ages of both groups.

- Weight at operation: Group I, the mean weight was 38.7 ± 4.7 Kg (range, 13.5 – 100 Kg). While group II, the mean weight was 39.1 ± 3.8 Kg (range, 5.1 – 86 Kg). No significant difference between the weights of both groups (p=0.94).

- Sex: The male/female ratio was 9/20 (31%/69%) in group I. While in group II it was 21/33 (38.9%/61.1%).

3.2. Preoperative clinical data (Table I):

3.3. Operative data (Table II):

3.3. Postoperative mortality:

- No mortality occurred in both groups.

3.4. Postoperative course and morbidity (Table III):

- Two patients in group I had residual shunt, one of them needed interference during the same hospital admission to close the residual ASD with the use of percutaneous device closure (interventional catheter closure). The other one developed dehiscence of the suture line 6 months post-surgery (the ASD was directly closed) and needed redo surgery to close the residual ASD with bovine pericardial patch through the same minithoracotomy approach. While one patient of group II needed redo surgery to

Table (2):

Operative data:	**Minimally invasive right thoracotomy Group I (n= 29)**	**Median sternotomy Group II (n=54)**	**P value**
1.Cross clamp time (min.)	Not used	20.7 ± 1.6	
2. Ventricular fibrillation time (min)	15.3 ± 1.7	Not used	}p=0.03
3. Total Cardiopulmonary Bypass time (min.)	29.0 ± 1.9	34.1 ± 1.9	*
4. ASD closure			p=0.10
a. Direct suture	23 (79.3%)	23 (42.6%)	p=0.001
b. Patch closure	6 (20.7%)	31 (57.4%)	*

*** p= statistically significant.**

Table (3):

Post-operative data and morbidity:	**Minimally invasive right thoracotomy Group I (n= 29)**	**Median sternotomy Group II (n=54)**	**P value**
1.Ventilatory support (min)	176.5 ± 15.3	192.6 ± 18.2	p=0.55
2.Morbidity:			
a. Post-operative bleeding	0 (0%)	1 (1.9%)	p=1.0
b. Residual shunt	2 (6.9%)	1 (1.9%)	p=0.27
c. Pericardial effusion:	0 (0%)	8 (14.8%)	p=0.04*
Surgically drained	0 (0%)	3 (5.6%)	
Spont. Resolution	0 (0%)	5 (9.2%)	
d. Arrhythmias:			
Atrial fibrillation	0 (0%)	4 (7.4%)	p=0.29
Atrial flutter	0 (0%)	2 (3.7%)	p=0.54
e. Phrenic nerve palsy	0 (0%)	0 (0%)	-
f. Wound infection	0 (0%)	2 (3.7%)	p=0.54
3.Post-operative hospital stay (days)	5.7 ± 0.4	7.0 ± 0.5	p=0.006*

*** p= statistically significant.**

close significant residual ASD during the same hospital admission (p=0.27).

- Postoperative pericardial effusion was statistically higher in group II patients (p=0.04). Eight patients in group II developed postoperative pericardial effusion and 3 of them needed surgical drainage. While no patient in group I developed postoperative pericardial effusion.

3.6. Follow up (outpatient clinic):

- Follow up was (12.9±1.5) months for group I, and (15.9±1.7) months for group II.

- No late mortalities or morbidities related to ASD closure occurred in both groups except the late occurrence of residual ASD which occurred in one patient of group I (6 months postoperatively).

- Patients of group I (MIRT) were examined in the follow up and there was no difference between the two sides of the chest; the breast volume and symmetry (in female patients) were considered unchanged after the operation. All of the patients were satisfied with the cosmetic result of minimally invasive right anterior thoracotomy.

- All patients of group I were in sinus rhythm during the follow up period. Four patients of group II were in atrial fibrillation and another 2 patients in atrial flutter and were under medical therapy.

- All patients of both groups were free of symptoms and in New York Heart Association Functional Class I.

Discussion

The first successful ASD repair was performed by Gross in 1953 using the atrial well technique (11). Gibbons introduced the heart-lung machine the following year. This major milestone opened the door to much technical advancement in cardiac surgery by permitting safe access to the intracardiac anatomy. As experience progressed, the operative mortality for ASD closure fell dramatically and is now below 0.5% in most centres (12, 13).

The median sternotomy incision has become the universal method of exposure for most cardiac procedures. Milton originally described Sternotomy in 1897 (14), but it was Julian who resurrected and popularised this incision (15). Practicing surgeons quickly learned that median sternotomy provided ideal exposure to every region of the heart, great vessels, and mediastinum. As a result of frequent usage, surgeons are universally comfortable with the angle of view and exposure to cardiac structures obtained via sternotomy. Furthermore, concerns about wound trauma and the final appearance of the surgical scar were a low priority for the pioneering surgeons facing congenital lesions for the first time. However, now that the technical challenges of repairing less complicated congenital lesions have been met, other considerations are surfacing.

For young women with simple congenital defects, a prominent midline scar remains an unsightly and lifelong reminder of an otherwise low-risk and successful procedure. Now that such defects can be safely closed, the challenge remains to reduce the impact of the cosmetic blemish characteristic of median sternotomy. For that reason, most of our patients of group I (69%), were female patients who were willing to have a more cosmetic incision. The cosmetically acceptable approach is the

right anterior thoracotomy (8). The exposure of the right heart is adequate for bicaval as well as aortic cannulation. In women, the unilateral submammary incision used in this approach remains cosmetically hidden. However, the breast tissue must be partially mobilised and this is associated with physical size defects in the ipsilateral breast in 7.4% and periareolar numbness or hypoesthesia in 38.8% of patients (16). Mobilisation of the pectoral muscles and breast tissue en block with a muscle sparing thoracotomy can reduce the incidence of nipple hypoesthesia to 12.5%, but does not eliminate this complaint altogether. However, in our patients of group I, during the follow up period (mean of 12.9 months), we examined all of them and there was no difference between the two sides of the chest; the breast volume and symmetry (in female patients) were considered unchanged after the operation. All of our patients were satisfied with the cosmetic result of minimally invasive right anterior thoracotomy. In our series, the right anterior thoracotomy consists of a submammary incision without division of the breast tissue and pectoral muscles, as recommended by Cherup and colleagues (17). We chose a limited anterior thoracotomy because skin incision in the submammarian crease results in an excellent cosmetic outcome, and the operation can be performed under direct vision with standard instruments. Moreover, due to our protocol, the complete cannulation to the heart-lung machine was performed exclusively through the limited anterior thoracotomy as also described by others (18). Other authors indicated that the length of the skin incision in an anterior thoracotomy could be reduced significantly when using cannulation of femoral vessels and clamping of the ascending aorta via additional incisions (19). However, in our patients we avoided these approaches, as they require additional incisions or puncturing the groin area for cannulation of the femoral vessels, which might result in vascular complications, especially in children, or wound healing problems. Moreover, due to the limited space provided by a smaller incision, special surgical instruments are necessary to perform the cardiac procedure, which demands a prolonged learning curve.

An essential part of our protocol is the cannulation of the ascending aorta, which is performed with an elongated, one-piece arterial trochar cannula. The use of this device enables us to cannulate safely the ascending aorta by distance as also performed by others (4). Cardioplegic arrest with aortic clamping is possible through this approach; however, ventricular fibrillation remains our preferred choice in MIRT. Experience has proved that ventricular fibrillation, especially in non-hypertrophied hearts, under certain conditions (mild hypothermia during a half hour and maintained with acceptable perfusion pressure) results in no demonstrable decline in myocardial function or myocardial damage (20). It is to be noted that the mean ventricular fibrillation time of our patients of group I (MIRT) was 15.3 ± 1.7 min., which was statistically significant less than the cross clamp time used in group II (MS) which was a mean of 20.7 ± 1.6 min. ($p=0.03$).

The limited surgical access can be a cause of a major surgical problem of minimally invasive open-heart surgery. This problem is air embolism, which can occur because manual heart massage is not possible (4). To avoid this problem in our patients of group I, in whom we used ventricular fibrillation, avoidance of emptying the left atrium of blood was carefully done during defect closure.

The intraoperative complication rate was zero in our patients. Also the postoperative complications in MIRT do occur in sternotomy as well. The reported incidence of significant complications such as postoperative bleeding, pericardial effusion, infection, and atrial arrhythmias varies from 2.5% to 13% (12, 13). We found that the incidence of postoperative morbidity was less in our patients especially those of group I (MIRT). No statistically significant differences, in terms of postoperative morbidity, were found between groups. However, there was less incidence of pericardial effusion in group I (0%) while it was (14.8%) in group II and the difference was statistically significant (p=0.4). This higher incidence (14.8%) of postoperative pericardial effusion in group II was less than that reported in other series (20% to 30%) (21, 22). But the incidence of pericardial effusion in patients of group II was near to the incidence of 16%, which was reported by LeBlanc and colleagues (23). Postoperative pericardial effusion is one of the most common complications and may be accompanied by significant morbidity and rarely mortality (21, 22). The fact that no patient in group I developed postoperative pericardial effusion may be attributed to the approach itself. This can be explained because the approach is through the right side of chest, so that any effusion will be drained to and absorbed by the right pleura and will not accumulate inside the pericardium. Residual shunts at follow-up are usually uncommon but an incidence as high as 16.7% has been noted (24-26). We had an incidence of residual shunt in 2 patients (6.9%) of group I and one patient (1.9%) of group II, with no statistically significant difference between groups (p=0.27). In fact, the late suture dehiscence in one case of the minithoracotomy group should be regarded by far as the most important of all post-surgical problems, and necessitated re-do ASD closure. Although this case was operated on early in our experience, we acknowledge that limited surgical field, typical of a limited minithoracotomy, may have had an impact on the determination of a fractured suture line, ultimately resulting in significant recurrent shunt. This complication was also reported in the series of Formigari and colleagues (2). Phrenic nerve damage, which is especially attributed to right anterior thoracotomy (27), was not seen in our patients. Since the nerve is always easily visible, there should not be incidental damage.

As regards postoperative hospital stay, the mean time was 5.7 days in group I, which was statistically significant (p=0.006) less than that of group II (7.0 days). This is another favourable postoperative outcome in minimally invasive right thoracotomy approach, pointing not only to the safety and efficacy of the approach, but also to superior results in some occasions.

Currently, cosmetic aspects are more and more emphasised and cannot be neglected in cardiac surgery. This applies especially to congenital lesions, which are completely healed. Thus, the scar is the only residue for a lifetime. We therefore consider minimally invasive right anterior thoracotomy as the standard approach for closure of secundum ASD in females and are currently expanding it to male patients, too.

Conclusions

Minimally invasive right anterior thoracotomy for closure of secundum ASD, although a technically demanding

procedure, has proven to be safe and effective. Poor ventricular exposure requires special strategies regarding de-airing, pacing wire insertion and defibrillation. Cosmetic and functional results are good, but can be improved by subtle techniques. Further follow-up is recommended to ensure normal breast development in the pre-adolescent patients.

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THE MANAGEMENT OF LEFT ATRIOVENTRICULAR VALVE REGURGITATION FOLLOWING REPAIR OF COMPLETE ATRIOVENTRICULAR SEPTAL DEFECTS: EARLY VALVE REPLACEMENT MAY BE PREFERABLE

ABSTRACT

Objective: Conventional wisdom suggests left atrioventricular valve replacement early after complete atrioventricular septal defect (cAVSD) repair is a disaster. This study evaluates the efficacy of two surgical strategies for severe left sided atrioventricular valve regurgitation (LAVVr) following repair of cAVSD.

Patients and methods: Thirty-seven children who underwent two-patch repair of an isolated cAVSD between March 1995 and September 2001were studied. Until August 1997, repeat repair was the first line surgical treatment of severe post-operative LAVVr. Fifteen children were operated during this period (group I, median age 3.4 months, range=2.6-19.7). After August 1997, early valve replacement became the preferred surgical option. Twenty-two children underwent repair of cAVSD over this period (group II, median age 3.8 months, range=0.3-48.3). Demographic and clinical characteristics were similar in both groups. Follow up was complete.

Results: In group I, 3 children died early (20%) and 1 died late but never left the hospital. Two developed severe LAVVr, one had valve repair (11 days) and one had valve repair followed by valve replacement (28 and 40 days). In group II, there were no early or late deaths. Four children had severe LAVVr, (3) underwent an early atrioventricular valve replacement (1,9 and 10 days) and (1) early repair (14 days). Kaplan-Meier survival at 60 months for group I Vs II was 73.3±11.4% Vs 100% (p=0.01).

Conclusion: These data suggest that early primary atrioventricular valve replacement may be more effective than valve repair in treating sever LAVVr following cAVSD repair. The adoption of this surgical strategy in our unit from August 1997 has been associated with a significantly better survival.

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INTRODUCTION

Surgical management of patients with complete atrioventricular septal defect (cAVSD) has advanced over the last 20 years from a two-staged approach with pulmonary artery banding and high-risk definitive repair, to successful complete primary correction in early infancy. Improved accuracy of preoperative diagnosis, better understanding of the surgical anatomy, progress of the surgical technique, myocardial protection, and individualised postoperative care, including management of pulmonary hypertensive events, have contributed to increased survival and reduced rates of reoperation. The crucial task of the surgeon is to

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reconstruct the left atrioventricular valve (LAVV) (1). Failure of repair of the LAVV is still an important factor in early morbidity and mortality (2-6). Significant early LAVV regurgitation is an indication for early reoperation, especially because remarkably often the valve can be additionally repaired (2-8). The incidence of early reoperation for regurgitant LAVV is being reported as 2-12% (2, 5, 6, 8, 9). The risk of early reoperation for regurgitant LAVV is also reported to be increased in the presence of additional valvular anomalies (5, 6, 8). At reoperation, the regurgitant LAVV, most often, can be repaired. However, every now and then, the implantation of a prosthetic valve is necessary (3, 6, 10). This study evaluates the efficacy of two surgical strategies for severe left sided atrioventricular valve regurgitation (LAVVr) following repair of cAVSD.

2. Patients and methods:

2.1. Patients:

Thirty-seven infants and children who underwent two-patch repair of an isolated cAVSD between March 1995 and September 2001 were studied. Until August 1997, repeat repair was the first line surgical treatment of severe post-operative LAVVr. Fifteen children were operated during this period (group I, median age 3.4 months, range = 2.6-19.7). After August 1997, early valve replacement became the preferred surgical option. Twenty-two children underwent repair of cAVSD over this period (group II, median age 3.8 months, range = 0.3-48.3).

2.2. Inclusion criteria:

All infants and children who underwent two-patch repair of cAVSD. Patients who had palliative procedures, with subsequent repair, were included. Also patients with associated simple congenital anomalies e.g. ASD, PDA, and Patent foramen ovale, were included.

2.3. Exclusion criteria:

All patients with partial (ostium primum) or transitional defects were excluded. Patients with associated major congenital anomalies, e.g. Fallot's tetralogy, double outlet right ventricle. Also, patients with severely unbalanced defects who underwent single-ventricle repair were excluded.

2.4. Data collection:

The data of the patients included the patients' age, sex, Down' syndrome, coexisting cardiac anomalies and any previous palliative procedures. Operative data included the surgical technique, total cardiopulmonary bypass time, aortic cross clamp time and circulatory arrest time. All postoperative complications, recurrence of LAVV incompetence, residual VSD, heart block and deaths were noted.

2.5. Echocardiography:

Preoperative and early postoperative studies were performed while the patient was in the hospital. Follow up was obtained during the regular follow up of the patient by the cardiologist in the outpatient clinic. All patients were examined by two-dimensional and Doppler echocardiography. LAVV regurge was categorized into a scale of 0 to 4, where 0 = none, 1 = trivial, 2 = mild, 3 = moderate, and 4 = severe.

2.6. Patients groups:

For the purpose of the study, the patients were divided into two groups. Group I consisted of the first 15 patients to whom repair of the cAVSD with two-patch

technique and closure of the cleft. Group II comprised the last 22 patients who underwent repair of the cAVSD like group I in addition to LAVV annuloplasty when needed. In Addition to maximum trial of repair in the first operation, aggressive management of early LAVV regurge with reoperation to replace the LAVV if there was severe regurge due to dysplastic valve morphology.

2.7. Surgical techniques:

The operative procedures were always conducted with moderate (28-32 °C) hypothermic continuous cardiopulmonary bypass. Total circulatory arrest was used in only 4 patients of group I but in no patient in group II. After cardioplegic arrest, with cold blood cardioplegic solution administered antegradely, supplemented by cold topical saline, the right atrial approach was used to repair the cAVSD in all patients with two-patch technique. Bovine pericardial patch for the ventricular component and autologous pericardial patch for the atrial component. In addition to cleft closure in patients of group I, a more aggressive approach to correct any regurge of the LAVV was done to patients of group II. Other techniques for repair of LAVV in group II patients included annuloplasty or chordal shortening when needed. Competency of the LAVV was assessed after repair by irrigating the left ventricle with sterile saline solution. In the latter part of the study, either epicardial echocardiography or trans-oesophageal echocardiography was used to assess the adequacy of repair after weaning off bypass. Concomitant pulsed and colour Doppler interrogation were used to assess the presence and severity of valvar regurgitation or stenosis along with residual shunting at the atrial or ventricular level. In patients who needed reoperation, all reoperations were performed using conventional cardiopulmonary bypass, moderate hypothermia, and antegrade cold blood cardioplegia. The LAVV was approached through the right atrium with an atrial septal patch incision, or in cases involving isolated LAVV incompetence and a large atrium, through the left atrial wall. At the time of reoperation for severe postoperative LAVV regurge, mitral valve replacement was undertaken (group II) to early correct severe LAVV regurge, which was not amenable for repair, before further deterioration of the patient's clinical condition.

2.8. Postoperative management:

The postoperative management was centred on careful follow up of the LAVV function as well as avoiding pulmonary hypertensive crises and optimising cardiac output. Any factors that trigger pulmonary hypertension such as hypoxia, hypercapnia, acidosis, pain, and hypothermia were avoided. Cardiac output was optimised by the routine use of dopamine and dobutamine. Recently, afterload reduction was obtained with the use of phosphodiesterase inhibitor (Milrinone), which had the advantage of inotropic support as well as afterload reduction. Nitric oxide (NO) inhalation was used to prevent postoperative reactive pulmonary hypertension as well as pulmonary hypertensive crisis.

2.9. Follow up:

All patients were followed up for a variable period in the outpatient clinic. Physical examination as well as Two-dimensional and Doppler echocardiography were done to detect any residual lesion, or any progression of LAVV incompetence.

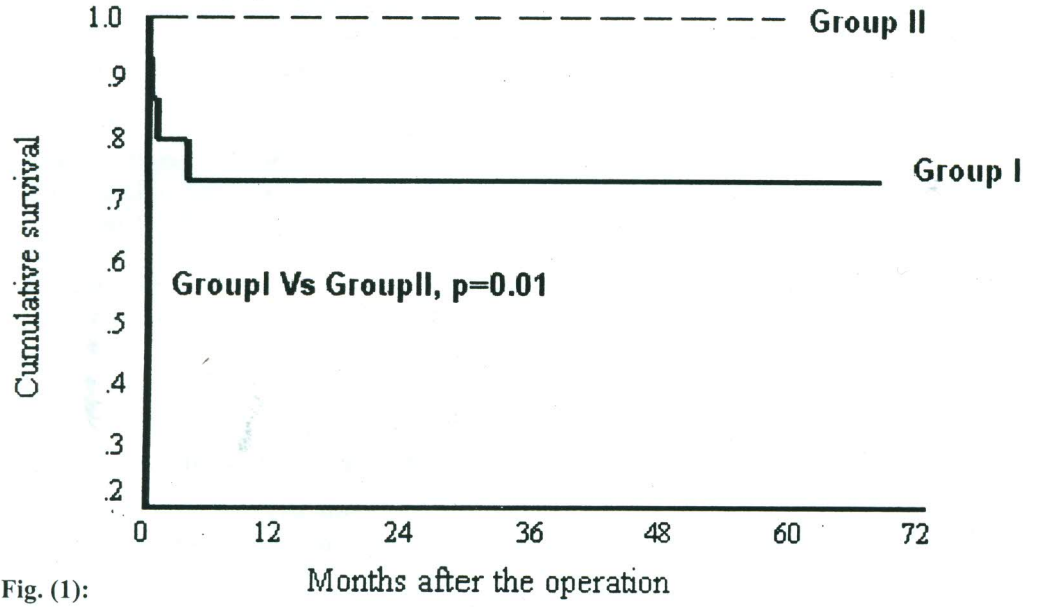

Fig. (1):

2.10. Definitions:

Complete atrioventricular canal was defined as absence of the atrioventricular septum with a single common atrioventricular valve.

Double-orifice LAVV was defined when there were two separate valve orifices in the LAVV, and a distinct subvalvular apparatus supported each orifice.

Early mortality or morbidity was defined as any death or morbidity before hospital discharge or within 30 days of surgical interference.

2.11. Statistical analysis:

Continuous variables are presented as means ± standard error of mean (SEM) and range except age is represented as median and range. Categorical variables are presented as percentages. Levene's test was used to test for equality of the variances, the unequal variance being selected if the F statistic for the equality of the variances was associated with a p value of 0.05 or less. Means were compared with independent sample t-test. Proportions were compared with Fisher's exact test. The actuarial % survival was estimated with the Kaplan-

Meier product limit method and the results were compared with the long-rank method. The level of statistical significance was set at a p value of 0.05 or less. Analysis was done using the statistical package SPSS PC (version 10.0) (SPSS INC., 444 N. Michigan Avenue, Chicago, IL 60611, USA).

Results

3.1. Preoperative data and status of the patients:

- **Age:**

The median age of all of the patients (n=37) was 3.7 months (range, 0.3 – 48.3 months). Thirty patients (81.08%) were

below 6 months of age at time of repair. Group I (n=15), the median age was 3.4 months (range, 2.6 – 19.7 months). Thirteen patients of group I (86.6%) were below 6 months of age at repair. While group II (n=22), the median age was 3.8 months (range, 0.3 – 48.3 months). Seventeen patients (77.27%) were below 6 months of age at the time of definitive repair. There was no statistical difference (p=0.58), between the median ages of both groups.

- **Sex:**

The male/female ratio was 17/20 (45.9% / 54.1%) for all patients (n= 37).

- **Down's syndrome:**

19/37 patients were Down's syndrome (51.4%), 8/15 of them in group I (53.3%) and 11/22 in group II (50.0%).

- **Palliative procedures:**

Palliative operations prior to definitive repair were undertaken in 6 patients (16.2%). Two of them in group I, one pulmonary artery banding and the other coarctation repair. While in group II, 4 palliative operations were done. Two underwent pulmonary artery banding and the other 2 patients had coarctation repair and pulmonary artery banding. All of the patients who underwent palliative procedures were below 6 months of age with associated cardiac lesions. Three of them had associated coarctation and the remaining 3 patients had associated multiple muscular VSDs.

3.2. Operative data:

- The surgical technique that was used for all patients was that of two-patch technique with closure of the cleft between the left superior and left inferior bridging leaflets. Bovine pericardial patch was used for closure of the ventricular component, and autologous pericardial patch for the atrial component. Annuloplasty of the LAVV was undertaken in 8 patients of group II and chordal shortening in 2 patients of group II.

- The total cardiopulmonary bypass (CPB) time was a mean ± SEM of 90.14 ± 6.48 min. (range, 38 – 268 min.) for all patients. In patients of group I, the total CPB time was a mean ± SEM of 109.13 ± 13.56 min. (range, 50 – 268 min.); while it was 77.18 ± 4.23 min. (range, 38 – 123 min.), for group II. There was statistically significant difference between the mean of total CPB time between groups I and II (p=0.01).

- The aortic cross clamp time was a mean ± SEM of 60.62 ± 3.12 min. (range, 24 – 102 min.) for all of our patients. In group I, it was 68.20 ± 5.18 min. (range, 43 – 102 min.); and 55.45 ± 3.56 min. (range, 24 – 90 min.) for group II. Again there was statistically significant difference between the aortic cross clamp times in both groups (p=0.04).

- Circulatory arrest technique was used only in 4 patients in group I, with a mean ± SEM time of 54.00 ± 8.13 min. (range, 43 – 78 min.).

3.3. Mortality:

- Overall mortality was 4 patients (10.8%) out of 37.

- **Group I:** Four patients out of 15 died in-hospital (26.6%). 3 patients died early and 1 patient died late but never left the hospital. Two of them died 1 and 5 days following surgery due to acute myocardial failure. They were operated at the age of 2.6 and 3 months respectively. LAVV regurge was noted in both patients before death. The third patient, who was operated at the age of 3.5 months, died after 14 days of redo repair

of the LAVV due to intractable congestive heart failure. He had redo repair of the LAVV after 11 days of his first operation. The fourth patient, who was operated at the age of 3.2 months, died 2 months after the third redo operation (the second was a trial of repair and the third was mitral valve replacement).

- **Group II:** No patient died either early or late with (0%) mortality in group II patients who were operated during the second period of study.

3.4. Reoperation due to early severe LAVV regurge:

- Six patients out of 37 (16.2%) needed reoperation for severe LAVV regurge.

- **Group I:** 2 patients (13.3%) had reoperation for management of severe LAVV regurge early after total correction. The first one was operated on at the age of 3.5 months. Redo surgery for severe LAVV regurge was done 11 days after his first operation. LAVV redo repair (more cleft closure and annuloplasty) was done with resuturing of ASD patch. Unfortunately, the patient died 14 days after redo repair due to intractable congestive heart failure. The second patient was operated at the age of 3.2 months. Before hospital discharge, he suffered severe LAVV regurge and a second trial of repair (annuloplasty) was done 28 days after his first operation. Unfortunately, he had persistent severe LAVV regurge and a third operation, 40 days after the first operation, was undertaken to replace the mitral valve with Carbomedics 16 mm mitral prosthesis. The patient died 2 months after mitral valve replacement due to complications of repeat surgery.

- **Group II:** 4 patients (18.1%) needed early reoperation for severe LAVV regurge. Three of them underwent early mitral valve replacement 1, 9 and 10 days, respectively, following their initial total atrioventricular canal repair. They had Carbomedics 16 mm mitral prosthesis; Top Hat 19 mm inverted aortic prosthesis and On-X 19 mm mitral prosthesis. In all of the 3 patients it was found that, at the second operation, the mural leaflet was dysplastic and deficient. In addition, one of them had double-orifice LAVV. Any trial of repair either with more cleft closure and /or annuloplasty could not yield competent valve. It was, therefore, decided to replace the valve to avoid subsequent LAVV regurge after reoperation. The fourth patient had redo repair of the LAVV, after 14 days of his first operation, due to severe LAVV regurge that was found to be due to recurrent cleft due to dehiscence of the sutures. Reclosure of the cleft was done with resultant competent valve.

3.5. Reoperation due to causes other than severe LAVV regurge:

- **Group I:** No patient needed reoperation.

- **Group II:** 2 patients needed reoperation. One of them needed permanent pacemaker implantation, 8 months after complete atrioventricular canal repair, due to development of complete heart block. The other patient needed reoperation in second postoperative day to repair partial dehiscence of atrial and ventricular patches with resultant left to right shunt. This is the only patient in both groups who needed reoperation for residual shunting (1/37, 2.7%).

3.6. Follow up (intermediate results):

- **Group I:** 3 early and 1 late deaths. Four patients have no mitral regurge and on no therapy. Five patients have trivial or mild mitral regurge. Two patients have moderate mitral regurge and on Captopril (NYHA II).

- **Group II:** No early or late deaths. Three children with mitral valve replacement are well and on warfarin therapy with normal cardiac status at follow up. Six patients have no mitral regurge and on no therapy. Ten patients have trivial or mild mitral regurge. Three patients have moderate mitral regurge and on Captopril (NYHA II).

- Kaplan-Meier survival at 60 months follow up for group I versus II was 73.3 ± 11.4% versus 100% (p=0.01) (Fig. 1). Statistically significant better survival in group II other than group I patients.

Discussion

The operative repair of complete atrioventricular canal defect in infants and children has undergone major advances during the past 20 years. Improvements in cardiopulmonary bypass and myocardial protection have essentially eliminated low cardiac output as a cause of postoperative mortality. Attention has now been directed toward the establishment of a competent left atrioventricular valve (LAVV) and the elimination of residual intracardiac shunting (2). Our results demonstrated that the two-patch repair using a Bovine pericardial patch for the ventricular component and autologous pericardial patch for the atrial component with closure of the mitral cleft results in a low incidence (2.7%) of residual shunting and competent left atrioventricular valves. The only patient who needed reoperation, in the second postoperative day, to resuture partial dehiscence of atrial and ventricular patches (with residual shunting) was of 5.4 months of age with friable tissues.

The use of single-patch technique involves dividing the common valve leaflets and suspending them from a single patch used to close the atrial and ventricular defects. We think, like others (2) that the use of separate atrial and ventricular patches creates less distortion of the valve tissue, thereby allowing a more accurate reconstruction of the mitral and tricuspid valves. In particular, when common leaflets are divided and then sewn back into a single patch, 3 to 4 mm of leaflet tissue is used up (11). This situation is avoided in the two-patch technique and may be important in smaller infants in whom the sacrificed valve tissue comprises a greater proportion of the whole. Several other surgeons (12) have reported similarly excellent results with the two-patch technique.

Most recent studies support definitive repair of AV canal in infants, rather than a palliative procedure such as pulmonary artery banding aimed at preventing the development of irreversible pulmonary hypertension or controlling congestive heart failure (13). We currently recommend complete repair before 6 months of age. We repaired thirty patients (81.08%) below 6 months of age. Early repair avoids the potential complications of pulmonary artery bands, because they often migrate out of position and cause deformity, stenosis, or erosion of the branch pulmonary arteries if they are too distal or distortion of the pulmonary valve if they are too proximal (14). Delay of definitive repair may also allow progression of adverse structural changes in the AV valve apparatus, such as annular dilatation (13). Increasing experience with complete repair of AV canal defects led us to abandon pulmonary artery

banding in almost all instances. Notable exceptions include patients with other associated cardiac anomalies e.g. coarctation of aorta, or with multiple VSD_s. Palliative operations prior to definitive repair were undertaken in 6 patients (16.2%). Two of them in group I, one pulmonary artery banding and the other coarctation repair. While in group II, 4 palliative operations were done. Two underwent pulmonary artery banding and the other 2 patients had coarctation repair and pulmonary artery banding. All of the patients who underwent palliative procedures were below 6 months of age with associated cardiac lesions. Three of them had associated coarctation and the remaining 3 patients had associated multiple muscular VSDs.

Failure of repair of the LAVV is still an important factor in early morbidity and mortality (2-6). Significant early LAVV regurgitation is an indication for early reoperation, especially because remarkably often the valve can be additionally repaired (2-8). The incidence of early reoperation for regurgitant LAVV is being reported as 2-12% (2, 5, 6, 8, 9). Six of our patients out of 37 (16.2%) needed reoperation for severe LAVV regurge. The risk of early reoperation for regurgitant LAVV is also reported to be increased in the presence of additional valvular anomalies (5, 6, 8). At reoperation, the regurgitant LAVV, most often, can be repaired. However, every now and then, the implantation of a prosthetic valve is necessary (3, 6, 10). This is true in our series where in group I, 2 patients needed early reoperation for severe LAVV regurge and reoperations were delayed until 11 and 28 days postoperatively. Both LAVV repeat repair failed and both of the patients died in the postoperative period. We think that it was better at that time to early replace the valves to preserve the myocardial functions and to avoid the need for subsequent surgery after failure of repeat repair. In group II patients, more aggressive surgical strategy was undertaken. Early assessment of the repair was done intraoperatively and in the paediatric intensive care. If there was evidence of early postoperative severe LAVV regurge, mitral valve replacement was our preferred surgical option especially if there was additional valve abnormalities or deficiency of leaflet tissue. This was our surgical strategy in patients of group II. We encountered 4 patients (18.1%) needed early reoperation for severe LAVV regurge. Three of them underwent early mitral valve replacement 1, 9 and 10 days, respectively, following their initial total atrioventricular canal repair. In all of the 3 patients it was found that, at the second operation, the mural leaflet was dysplastic and deficient and a trial of repair either with more cleft closure and /or annuloplasty, could not yield competent valve. In addition, one of them had double-orifice LAVV. It was, therefore, decided to replace their left AV valves to avoid subsequent LAVV regurge after reoperation. While the fourth patient who had redo repair of the LAVV, after 14 days of his first operation due to severe LAVV regurge, that was found to be due to recurrent cleft due to dehiscence of the sutures. Reclosure of the cleft was done with resultant competent valve.

We make every effort to repair native valves with a view to avoid, or at least, delay the need for replacement but in some infants the left AV valve may be grossly

abnormal and valve replacement becomes the only surgical option. In the intermediate term follow up, of our patients of group II who needed early valve replacement after repair of complete AV canal, we still have good results in terms of morbidity or mortality. All of the 3 children are well, on warfarin therapy and with normal cardiac status. None of them required permanent pacemaker implantation for complete heart block. The only patient, who needed permanent pacemaker implantation, was a patient of group II who did not have any reoperation or replacement of the LAVV after repair except 8 months post-repair for implantation of the pacemaker. That patient developed early postoperative partial heart block, which progressed to complete heart block in the late postoperative period. Our surgical strategy in patients of group II was associated with statistically significant better survival than group I patients. Kaplan-Meier survival at 60 months follow up for group I versus II was 73.3±11.4% versus 100% (p=0.01) (Fig. 1).

Our data suggest that early primary atrioventricular valve replacement may be more effective than valve repair in treating sever LAVV regurge following complete atrioventricular septal defect repair. We agree with others (15) that severe valve deformity and anomalies of the left AV valve preclude adequate valve reconstruction in some patients, thus leaving valve replacement, with its well known drawbacks, especially for small children, as the only alternative.

Conclusions

Mitral valve replacement early after correction of complete atrioventricular septal defects may be a preferable option than repeat repair for treating severe LAVV regurge especially in patients with deficient leaflet tissue and / or dysplastic valves. The adoption of this surgical strategy in our unit from August 1997 has been associated with a significantly better survival.

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MANAGEMENT OF POSTOPERATIVE CHYLOTHORAX AFTER PEDIATRIC CARDIAC SURGERY

ABSTRACT

Background: We reviewed the management of 27 cases of chylothorax (14 females, 13 males; 1 and 10 years-old) following 2400 cardiothoracic procedures between January 1995 and December 2001 at pediatric cardiac surgery unit- cardiothoracic surgery department at Ain Shams University.

Results: The surgical procedures preceding the occurrence of lymph leak included bi-directional Glenn shunt in 12 cases (44.4%), total correction of tetralogy of Fallot in 5 cases (18.5%), modified Blalock-Taussig shunt in 3 cases (11.1%), ligation of patent ductus arteriosus in 4 patients (14.8%), repair of aortic coarctation in 3 patient (11.1%). A protocol for management of postoperative chylothorax was applied for all patients. In this protocol, non-surgical management was always the first line of treatment for patients with postoperative chylothorax in the form of intercostal tube for drainage and diet modification using either medium chain triglycerides (MCT) diet or total parentral nutrition (TPN) with complete bowl rest. Twenty-one of our patients (77.8%) responded to conservative therapy. Of those, 17 patients (63%) cured with MCT diet alone. For the other 4 patients, TPN was instituted after failure of MCT diet to control lymph leakage. Six patients (22.2%) underwent surgical exploration to ligate the lymph fistula in order to control the lymph leakage after failure of conservative management (both MCT diet then TPN) to stop lymph leakage.

Conclusion: Conservative management of postoperative chylothorax should be the first line of treatment in postoperative chylothorax either by MCT diet alone or (in case of failure) to be followed by TPN and complete bowl rest. Most of cases of chylothorax respond to diet modification together with intercostal tube drainage. Surgical intervention should be reserved as a last option in resistant cases with either large amount, and/or prolonged duration of lymphatic leakage.

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INTRODUCTION

Postoperative chylothorax is an uncommon complication which may occur after virtually any intrathoracic procedure. The reported incidence of chylothorax following cardiothoracic procedure for congenital cardiac anomalies ranges from 0.5% to 2% (1). The chylous leak may lead to high morbidity and may even compromise survival because of large amount of losses, that is, deficit in lymphocytes, proteins and immunoglobulin. Its occurrence also delays the recovery or further complicates the already complex postoperative course of pediatric cardiac patients.

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Postoperative chylothorax is caused by traumatic laceration of the thoracic ducts, as it seems to occur more frequently after procedures performed in the vicinity of thoracic duct (2). However, it has been reported, yet less frequently following median sternotomy. The magnitude and duration of lymph leak can be potentiated by central vein thrombosis or other clinical conditions associated with high-central venous pressure such as following a Fontan operation, Bi-directional Glenn shunt or total correction of Fallot tetralogy (3).

Chylothorax used to carry a high mortality. Even though the management of chylothorax has significantly evolved in the last two decades, it is still subjected to a great deal of debate. Different therapeutic approaches: purely conservative, with elemental diet or total parentral nutrition, or surgical (early or late) with ligation of thoracic duct, pleurodesis, and/or placement of pleuroperitoneal shunts (4).

We retrospectively reviewed the management of postoperative chylothorax in pediatric cardiac surgical patients at our institution in the last 7 years. The primary goal of this study is to assess the efficacy of our therapeutic management approach.

Patient and Methods

Medical records of all children having postoperative chylothorax following surgical procedures for cardiothoracic lesion between 1995 and 2001 were reviewed.

The following clinical data were collected: age; sex; weight at the onset and during the treatment for chylothorax or chylopericardium; the preoperative diagnosis of congenital lesion; the surgical procedure preceding the onset of lymph leak; central venous pressure; the duration between the diagnosis of chylothorax and chylopericardium and the cessation of drainage; the daily volume of chylous drainage; associated metabolic and hematologic abnormalities (hyponatraemia, hypoalbuminemia and lymphopenia); and the surgical procedure(s) performed to treat the chylothorax.

The diagnosis of chylothorax or chylopericardium was made on the basis of the milky appearance of the fluid, cell count (more than 4000 mononuclear cells/mm3 and more than 80% lymphocytes), and triglycerides content more than 500 mg% of the pleural aspirates.

All cases of chylothorax and chylopericardium were initially treated conservatively in the form of tube thoracostomy for drainage, and immediate institution of medium chain triglycerides (MCT) diet for one week. The amount of chyle drained through the intercostals tube was then evaluated. If the amount was <10ml/kg/day, this was a parameter for successful conservative treatment and the MCT diet was continued for another 3 weeks before return to normal diet. If after the first week the drainage was >10 ml/kg/day, this was considered failure of conservative treatment and institution of total parental nutrition (TPN) and complete bowl rest was started for 3 weeks to control lymph leakage. Surgical intervention to ligate the thoracic duct or closure of the lymph fistula is considered if the TPN failed to control the chyle leak to <10 ml/kg/day.

The decision to abandon nonoperative therapy was made at any time when the amount of drainage exceeds 100 ml/kg/day. Our protocol for management of postoperative chylothorax follows that

Table (1): Patients' demographics, preoperative diagnoses and operative procedures.

Pt. Number	Age (Years)	B.W. (Kgs)	Gender	preoperative diagnosis	Operation
1	2	7.5	Male	Coarctation of aorta	Subclavian Flap
2	4	11	Female	Single Ventricle	Bidirctional Glenn Shunt
3	3	9.5	Male	Single Ventricle	Bidirctional Glenn Shunt
4	10	33	Male	Fallot tetrallogy	Total correction of Fallot
5	6	23.5	Female	Fallot tetrallogy	Total correction of Fallot
6	6	19.5	Male	Single Ventricle	Bidirctional Glenn Shunt
7	4	11.5	Female	Single Ventricle	Bidirctional Glenn Shunt
8	1	6.5	Female	PDA	PDA ligation
9	1	7	Female	PDA	PDA ligation
10	1	6.5	Male	Fallot tetrallogy	Modfied Blalock - Taussig Shunt
11	2	8.3	Male	Coarctation of aorta	Patch aortoplasty
12	7	27.5	Female	Single Ventricle	Bidirctional Glenn Shunt
13	5	16	Male	Single Ventricle	Bidirctional Glenn Shunt
14	2	8.6	Female	Single Ventricle	Bidirctional Glenn Shunt
15	3	9.5	Male	PDA	PDA ligation
16	2	9	Male	Fallot tetrallogy	Total correction of Fallot
17	5	20	Female	Fallot tetrallogy	Total correction of Fallot
18	2	8	Male	Single Ventricle	Bidirctional Glenn Shunt
19	1	7.5	Female	Fallot tetrallogy	Modfied Blalock - Taussig Shunt
20	3	11	Male	Coarctation of aorta	Subclavian Flap
21	5	22.5	Female	Single Ventricle	Bidirctional Glenn Shunt
22	2	7	Female	Fallot tetrallogy	Modfied Blalock - Taussig Shunt
23	1	7	Female	PDA	PDA ligation
24	5	19	Male	Single Ventricle	Bidirctional Glenn Shunt
25	6	26	Male	Single Ventricle	Bidirctional Glenn Shunt
26	3	14	Female	Fallot tetrallogy	Total correction of Fallot
27	2	7.9	Male	Single Ventricle	Bidirctional Glenn Shunt

suggested by Beghetti and his colleagues for management of chylothorax (figure 1).

Results

There were 27 cases of postoperative lymph fistula at pediatric cardiac surgery unit, cardiothoracic surgery department in Ain Shams university hospitals. Their ages ranged from 1 to 10 years old (mean 3.84 years), and their body weight ranged from 6.5 to 33 kilograms (mean 13.49 Kg).

The preoperative diagnoses of our chylothorax group of patient were as follow (table 1); coarctation of the aorta in 3 cases (11.1%), single ventricle in 12 cases (44.4%), tetralogy of Fallot 8 cases (29.6%), and patent ductus arteriosus in 4 cases (14.8%).

The operative procedures were (table 1); repair of aortic coarctation 3 cases (11.1%), bi-directional Glenn shunt in 12 cases (44.4%), total repair of Fallot tetralogy in 5

Table (2): Time elapsed till diagnosis of postoperative chylothorax, MCT diet duration and TPN duration (in days).

Pt. Number	Time till diagnosis of CT	MCT diet duration	TPN duration	outcome
1	1	7	7	F
2	7	28	0	S
3	15	7	21	S
4	8	28	0	S
5	7	7	21	S
6	3	7	21	F
7	8	7	14	S
8	1	28	0	S
9	1	28	0	S
10	1	28	0	S
11	1	28	0	S
12	10	28	0	S
13	5	7	21	F
14	5	28	0	S
15	1	28	0	S
16	7	7	21	S
17	9	28	0	S
18	13	7	21	F
19	2	28	0	S
20	1	28	0	S
21	2	28	0	S
22	1	28	0	S
23	1	28	0	S
24	5	7	21	F
25	7	7	7	F
26	3	28	0	S
27	6	28	0	S

cases (18.5%), modified Blalock-Taussig shunt in 3 cases (11.1%), and ligation of patent ductus arteriosus in 4 cases (14.8%)

The average duration between the surgical procedure and the onset of chylothorax was 6 days (range from 5 hours to 15 days) (Figure 2). In 2 patients (7.4%) (Patient 3 and 18), both came back 5 and 3 days respectively after their discharge from the hospital with respiratory distress and massive chylothorax with complete opacity of the hemithorax in their chest x-ray. The rest of patients (25 patients, 92.6%), the diagnosis of chylothorax was made during their hospital stay.

Conservative management was started for all the 27 patients as per protocol (figure 1). In 10 patients (37%), TPN and complete

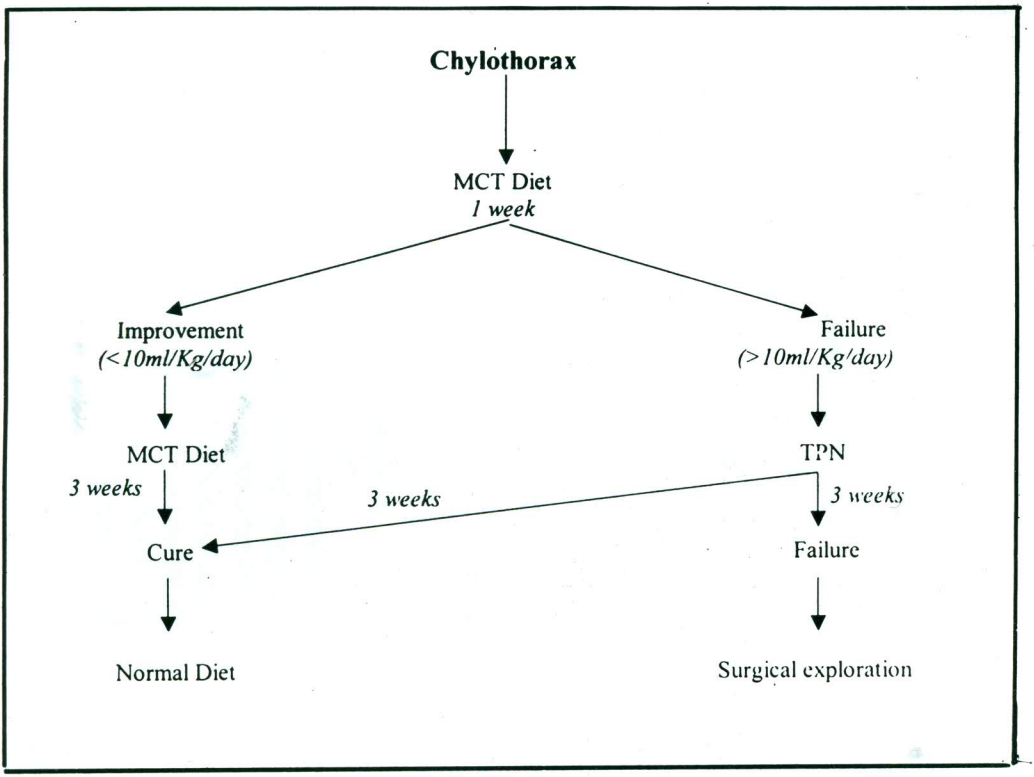

Figure (1): Therapeutic approach to chylothorax.

bowel rest was started after one week after failure of MCT diet. In the other 17 patients (63%), MCT diet was instituted for 4 weeks without the need for TPN.

In TPN group of patients, the diagnosis of chylothorax was made from 6 hours to 15 days postoperatively (average 7 days). Oral intake was totally stopped after one week of MCT diet, and TPN was instituted. In 3 patients drainage was <10 ml/kg/day after one week from the start of TPN, and chyle leakage completely stopped after 2 weeks from the start of TPN. TPN regimen stopped after 3 weeks from its institution (total 4 weeks from the diagnosis of chylothorax) (Table 2).

In 6 patients of the TPN group, the decision was made to abandon conservative management and proceed for surgical exploration to either ligate the thoracic duct or control the lymph fistula. This decision was made because we had reached the definition of failure of conservative management for those 6 patients i.e. chyle drainage was more than 100 ml/kg/day (patients number 1 and 25) or the chyle leakage continued to be more than 10 ml/kg /day for three weeks despite of TPN and complete bowel rest (patients number 6, 13, 18, and 24).

In our medically treated patients, one patient died 3 weeks after the diagnosis of

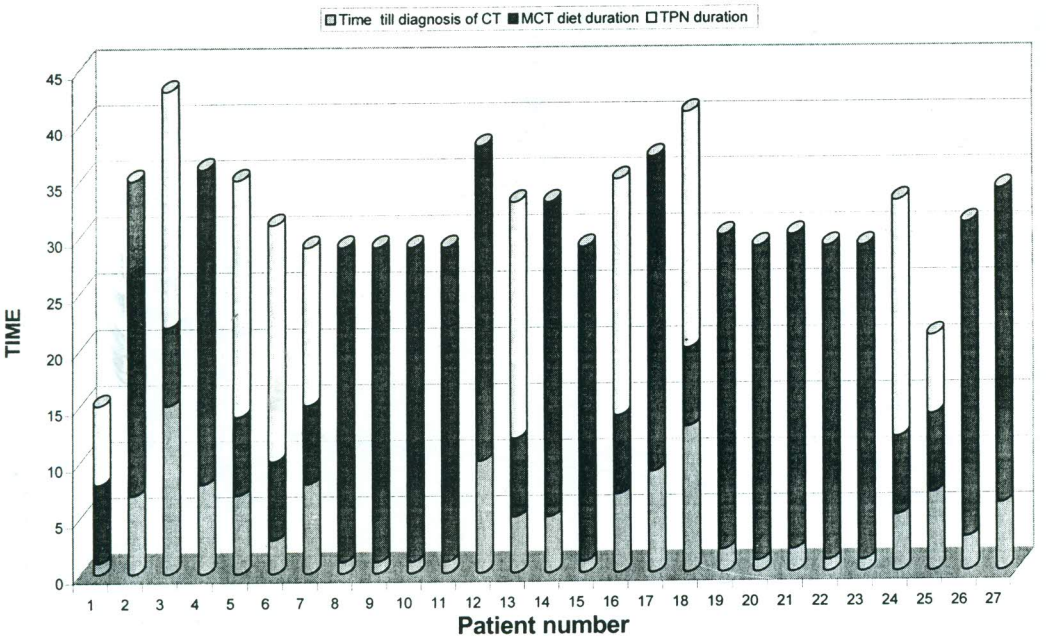

Figure (2): Time elapsed till the diagnosis of postoperative chylothorax, duration of both MCT and TPN regimen.
CT= Chylothorax, MCT= Medium chain triglycerides, TPN= Total parentral nutrition.

chylothorax due to uncontrolled generalized sepsis. This was a 4 years-old male patient who had had bi-directional Glenn shunt for single ventricle pathology. Right-sided massive pleural effusion was discovered 8 days postoperatively. Pleural effusion analyzed biochemically and discovered to be chyle (triglycerides >500mg %). Intercostal tube drainage and institution of MCT diet was started and continued for one week, but failed to control the chylous leak. TPN was the second line of treatment. The chylous drainage after two weeks from the start of TPN was less than 10 ml/kg/day, but did not stop completely. By the end of the first week of TPN, patient had high fever and leukocytosis. Antibiotics according to culture and sensitivity from sputum, urine and central line samples were administered. Patient died 14 days after the start of TPN due to uncontrolled sepsis.

In the group of patients in whom conservative management was successful, the average duration of chyle leak was 16.1 days (range from 5 days to 28 days). The maximum daily drainage of chyle drained per day was 36.4 (range from to 8.5 to 130 ml/kg/day).

A total of 6 patients in our series (22.2%) required surgical intervention for closure of the lymph fistula after failure of

conservative management. The first patient was 2 years-old male patient who had had repair of aortic coarctation using subclavian flap. Chyle leakage was discovered 6 hours after the operation. There was large amount of milky fluid drained through the intercostal tube that was confirmed to be chyle by measuring its triglycerides contents. Conservative management was started immediately by institution of MCT diet for one week. TPN was started thereafter due to failure of MCT diet to control the chylous leak. Three days later, TPN was abandoned and the decision was made to interfere surgically to close the fistula due to high amount of chyle leakage (more than 100 ml/kg/day) Through previous left posterolateral thoracotomy, the leaking point from injured thoracic duct at the aortic arch was identified and ligated. Immediate and complete cessation of lymph leakage was achieved postoperatively and patient was discharged from the hospital one week later.

The other 5 patients treated surgically all had had bi-directional Glenn shunts. Postoperatively, they had high central venous pressure. Chyle leakage started on the 3rd and 17th day postoperatively.

There were two mortalities in the surgically treated group of patients. The first one was 5 years-old patient (patient number 24) who had massive pericardial and right-sided pleural effusion. Conservative management was abandoned 21 days after the start of chyle leakage due to deterioration of patient's general condition. Through right thoracotomy, the lymph fistula was identified and ligated in addition to mass ligation of the area of the thoracic duct. In spite of the apparent stoppage of the lymph leak in the pleural space, patient died 5 hours postoperatively due to low cardiac output.

The 2nd mortality in the surgically treated group was a 2 years-old patient (patient number 18) who also had had bi-directional Glenn shunt for single ventricle pathology. Conservative management failed to control the lymph fistula for 28 days after its institution as the drainage through the intercostal tube continued to be more than 10ml/Kg/day. Surgical exploration was conducted through right thoracotomy with mass ligation of the vicinity of the thoracic duct at the aortic hiatus. Patient died 5 days later due to respiratory failure and generalized uncontrolled sepsis.

Discussion

Postoperative chylothorax is a serious complication that requires prolonged hospitalization and that may jeopardize the surgical outcome. It is associated with high percentage of mortality that may reach 50% in non-treated patients (5).

The incidence of chylothorax after surgical repair of congenital heart disease varies in the literature from 0.5% to 2% (6). This coincides with the incidence in our series that was 1.1% of postoperative patients (27/2400).

Laceration of the thoracic duct can occur during any surgical procedure in the chest or in the mediastinum, but appears to be more common when the procedure takes place in the vicinity of the thoracic duct as repair of aortic coarctation, ligation of patent ductus arteriosus or construction of Blalock-Taussig shunt (7).

In our series, 10 patients (37%) had postoperative chylothorax caused by direct injury of the thoracic duct. This had occurred either after patent ductus arteriosus

ligation (4 cases), modified Blalock-Taussig shunt (3 cases), aortic coarctation repair (3 cases). Postoperative chylothorax was presented by left sided massive effusion.

Postoperative chylothorax can also occur without direct injury of the thoracic duct. After bi-directional Glenn shunt or Fontan procedure lymph fistula may occur due to increase in systemic venous pressure that is transmitted to the lymphatic system (8). This type of fistula is also recorded after Senning or Mustard procedure in transposition of great arteries and after total correction of Fallot tetralogy (9,10).

Seventeen of our group of patients (63%) had such type of postoperative lymph fistula, either after bi-directional Glenn shunt or after total correction of Tetralogy of Fallot.

The treatment of patients with postoperative chylothorax is still open to debate, with different therapeutic approaches: purely conservative, with MCT diet or TPN or surgical (either early or late) with ligation of the thoracic duct, pleurodesis, and/or placement of pleuro-peritoneal shunt (11).

Our protocol in management of patients with postoperative chylothorax (figure 1) is similar to that reported in the literatures. There is an agreement that in postoperative chylothorax, conservative approach should be the first line of management (12,13). This conservative management consists of drainage of the pleural space using tube thoracostomy to alleviate respiratory embarrassment and to inflate the lung so as to decrease the dead space in the thoracic cavity and to promote adhesions between the parietal and visceral pleura (14). The diagnosis of chylothorax should be confirmed by biochemical and cytological analysis of the pleural effusion. In the literature there are different opinions regarding the appropriate initial nutritional modification protocol, the definition of medical treatment failure and the indication(s) for surgical intervention.

It is well known that fatty meals increase the lymph flow up to ten times the basal rate. A diet with medium chain triglycerides (MCT) results in significant decrease in the lymph flow through the thoracic duct and hence, through the lymph fistula. Knowing this, the use of MCT diet is crucial in the management of postoperative chylothorax and gives excellent results in controlling the lymph fistula (15).

This coincides with our results with the use of MCT diet in our group of patients. In 27 patients, 17 patients (63%) responded well to MCT diet alone with complete recovery after 4 weeks from the diagnosis of chylothorax.

In 10 patients (37%), MCT diet failed to reduce the chyle leakage through the intercostal tube to lass than 10ml/Kg/day. For those patients, TPN and complete bowel rest was the second line of treatment. TPN regimen was successful in 3 patients to control chyle leakage after one week from its institution to less than 10ml/Kg/day and to stop the leakage completely after 3 weeks.

As observed by other investigators (16), increase in the systemic venous pressure and/or systemic venous obstruction are usually associated with more prolonged, higher amounts of lymph leak and more frequent failure of conservative therapy. Beghetti et al (2) reported a series of 24 cases of postoperative chylothorax which show a major difference between two groups

of patients: those with direct trauma to the thoracic duct and those with chylothorax secondary to increased pressure in the superior vena cava. In the first group, chylothorax has a spontaneous rapid resolution and is easy to treat whereas in the second group chylothorax is of longer duration and being more resistant to treatment.

Our experience agreed with these findings that 16 patients in our series had had expectedly higher systemic venous pressure than normal either after bi-directional Glenn shunt or after total correction of Fallot tetralogy. Nine of those patients (9/16), MCT failed to control chyle leakage after one week. TPN also failed to control chyle leakage in 5 patients (5/16), and we were left with the option of surgical exploration and either closure of the lymph fistula or ligation of the thoracic duct.

Six patients (22.2%) had prolonged chyle leakage that failed to respond to MCT diet alone. TPN also failed to control the lymph flow through the fistula. High amounts of lymph drained through the intercostal tube with the resultant nutritional deficiency, and the expected hazards of the central line (infectious complications, volume overloading and superior vena cava thrombosis) all were the reasons to abandon the conservative therapy and interfere surgically to close the fistula.

In agreement with other results, surgical treatment of chylothorax generally involves ligation of the thoracic duct. The criteria for surgical intervention to control the lymph fistula in adults as described by Dugue and coworkers are most frequently used in clinical practice (17). They recommended reoperation to ligate the thoracic duct when chylous leakage persists for at least 5 days at a rate of 1500 ml/day or more in adults and when the drainage of chyle does not decrease within two weeks or the patient's nutritional status becomes measurably more impaired during the same period. In pediatric group, the criteria for surgical intervention are somewhat different. Surgery is usually indicated when drainage is greater than 100ml/Kg/year of age for more than 2-3 weeks. In all instances, exploration should be done without delay when the lung appears to be trapped or when the nutritional complications begin to manifest themselves (18).

Our protocol for management of chylothorax, surgical intervention was decided when the MCT diet and thereafter the TPN both failed to control the drainage through the intercostals tube and the amount of chyle drained continue to be more than 10 ml/Kg/day.

The mortality rate in our series was 11.1% (3/27). Two patients died in the surgically treated group (7.4%) and one patient died in the medically treated group (3.7%). This patient died from generalized sepsis 3 weeks after the start of conservative management of chylothorax. Patient had very bad general condition the does not permit surgical intervention.

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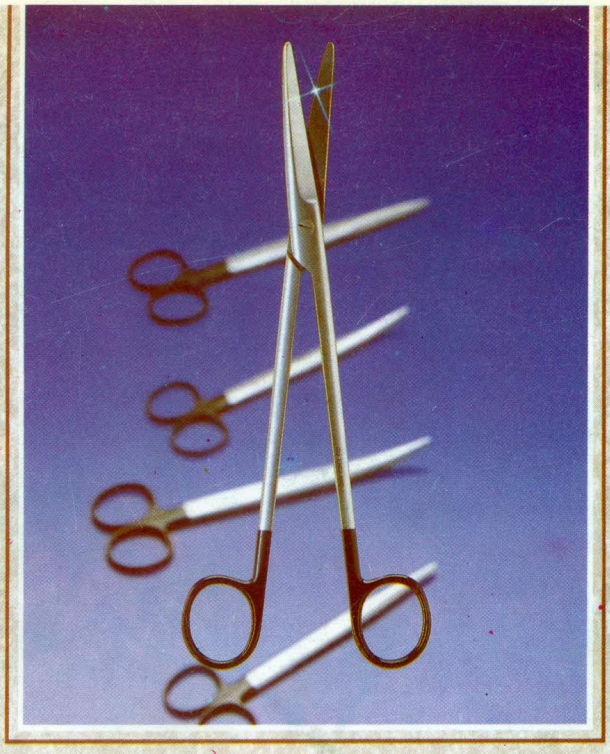

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