Early and Midterm Result of Mitral Valve Repair in Children

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Abstract: Background: Mitral valve repair is a better therapeutic alternative than valve replacement in children. Repair procedures are especially well suited to developing countries where heart prostheses and life-long anti-coagulation therapy are largely unaffordable. This study aimed to evaluate the early outcome and midterm results of mitral valve repair in children. **Patients and Methods**: From March 2010 to November 2013, 40 children with mitral valve disease underwent mitral valve repair. The mean age of patient at operation was 7.55 years. 82.5% of patients were rheumatic mitral regurgitation, 10% were degenerative mitral regurgitation, 5% were congenital mitral stenosis and one patient was congenital mitral regurgitation. Mitral valve repair was done by different methods, the most common one using rigid Carpentier ring to 35 patients. **Results:** Regarding NYHA class and degree of mitral regurge, there were a significant difference between pre-operative and post-operative (early and late). Comparison between pre- and post-operative echo data of the studied patients, there was a significant decrease in left ventricular end diastolic diameter (LVEDD), left atrial diameter (LAD) and pulmonary artery pressure (PAP) in early and late postopetive. There was no significant difference between pre-operative and early post-operative regarding left ventricular end systolic diameter (LVESD) and ejection fraction (EF) while there was a significant difference between pre-operative and 6 month post-operative regarding ESD and EF. **Conclusion:** Mitral valve repair was successful in stabilizing myocardial function and remodeling the left ventricle. Outcome is dependent on careful patient selection and evaluation of lesions. Middle-term outcome is encouraging.

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1. Introduction

Degenerative MV disease is a common disorder affecting around 2% of the population **(Enriquez-Sarano *et al.,* 1995).** The most common finding in patients with degenerative valve disease is leaflet prolapse due to elongation or rupture of the chordal apparatus, resulting in varying degrees of MV regurgitation due to leaflet malcoaptation during ventricular contraction **(Madesis *et al.,* 2014).**

Rheumatic heart valve disease (RHVD) is the result of rheumatic fever (RF) triggered by autoimmune humoral and cellular responses **(Guilherme *et al.,* 2007)** and remains the predominant heart valve disease in developing countries. It is seen in epidemic proportions in the preschool and school age groups but is also found in patients in their teens and early twenties **(Carapetis *et al.,* 2005; Marijon *et al.,* 2007).**

Mitral valve (MV) repair is the operation of choice for mitral regurgitation (MR). It reduces the risk of thromboembolic events and the need for long-term anticoagulation. MV repair results in less risk of endocarditis, excellent long-term durability, and improved survival **(Wong *et al.,* 2010)**.

In the developed countries, where mitral incompetence of degenerative and ischemic origin is the rule most cases of MV disease can be successfully approached by repair. Rheumatic valve disease still exists in areas with less developed health care systems. Repair in rheumatic valve disease has been advocated, but still, in this disease a certain proportion of chronic cases with calcification may require valve replacement **(Madesis *et al.,* 2014).**

The aim of this study was to evaluate the early outcome and midterm results of mitral valve repair in children.

2. Patients and Methods

This is a prospective study of mitral valve repair in 40 children with mitral valve disease either regurgitation or stenosis of different etiological causes as defined by history, clinical examination, and recent echocardiography study within three months before surgery. The study was carried out at Cardiothoracic Surgery Department of National Heart Institute, Egypt, in the period from March 2010 to November 2013.

Children with acquired rheumatic mitral valve disease either pure mitral regurge or stenosis, those

with degenerative or congenital mitral valve lesions were subjected to open mitral valve surgery. Children with history of previous mitral surgery or those complaining from mitral associated with aortic valve disease were excluded from this study.

Methods

I. Preoperative Assessment:

All patients were subjected to detailed history taking and complete clinical examination, routine laboratory investigations and markers of hepatitis and HIV were performed, resting 12 lead Electro-Cardiogram (ECG), plain chest X-ray P-A and echocardiography (All patients underwent echocardiographic studies using a Philips HD machine (Philips Medical Systems, Andover, MA). Standard 2D echocardiogram was done for all patients enrolled in the study using phased array transducers of different frequencies tailored according to each patient's age, body built and weight.

The study included 2D, M mode and color flow Doppler from all standard echocardiographic windows (i.e. subcostal, apical, parasternal and suprasternal), applying the sequential analysis to establish within three months before surgery)

II. Intra-operative data:

A. Anesthetic procedures:

All children were premedicated one hour before induction by morphine (0.1 mg/kg) I.M and diazepam (0.15 mg/kg) orally.

Induction of anesthesia was done by combination of fentanyl (20-30 µg/kg) and diazepam (0.1-0.2 mg/kg). Neuromuscular blockade was given with 0.1 mg/kg vecuronium bromide followed by ventilation for 4 minutes. Oro-tracheal intubation was then performed and anesthesia was maintained with nitrous oxide in oxygen and incremental doses of fentanyl as needed, additional doses of fentanyl and neuromuscular blockade was given as needed before and during cardiopulmonary bypass.

Anesthesia following cardiopulmonary bypass usually involved ventilation with oxygen alone and perhaps additional doses of morphine or fentanyl and neuromuscular blockade.

Systemic blood pressure was continuously monitored by invasive arterial cannula and body temperature also was monitored throughout the operation using a nasopharyngeal and rectal probe.

Central venous line for CVP measurements, and oxygen saturation probe.

Urine output was measured via an indwelling Foley's catheter.

Broad spectrum antibiotic was given routinely at time of skin incision and at cardiopulmonary bypass.

Coagulation status was managed according to ACT, so that heparin and protamine doses were individualized for each patient.

B. Surgical Technique:

The heart was approached in all patients through a standard median sternotomy incision. Cardiopulmonary bypass was established by ascending aortic, and bicaval cannulation, and membrane oxygenator. Moderate Systemic hypothermia between 28-32 C, antegrade cold blood cardioplegia with a ratio of 4:1 was used for induction of cardiac arrest and was repeated every 20 min and if there were any signs of cardiac activity on the ECG, in addition to topical ice slush were used for myocardial protection. A left atrial incision was used in all patients for direct access to the mitral valve.

C. Valve Analysis:

The final decision in all patients regarding the feasibility of valve reconstruction was made at the operation; so the cornerstone of mitral reconstruction is to visually examine all the components of the mitral valve apparatus.

This was accomplished by using a pair of hooks or by saline injection into the left ventricular cavity, to identify the mechanism of valve dysfunction, whether dilated annulus, prolapsed leaflet, restricted motion of the leaflet or defects in the leaflet's substance. The subvalvular apparatus was examined for elongated, ruptured or fused short chordae.

D. Reparative technique:

The anterior leaflet marginal chordae were never resected, secondary chordae were resected to increase leaflet mobility.

Papillary muscles were frequently divided to their bases to correct subvalvular narrowing and permit free chordal action. Also, adherent muscle to the left ventricular wall was sharply separated to allow free contraction along its whole length.

Elongated chordae of the anterior leaflet were treated by two techniques, shortening plasty was done in the first 6 cases, by invagination of the excess length of the chordae into a trench created in the papillary muscle by longitudinal split using 4/0 prolene suture, and in the remaining patients chordal transfer in case of anterior leaflet prolapse due to elongated or ruptured chordae was used, except in 4 cases of degenerative mitral regurgitation artificial chordae replacement with 5/0 PTFE suture was used.

Posterior leaflet prolapse due to excessive leaflet tissue or rupture of the posterior marginal chordae was treated by quadrangular resection of the affected segment and resutured by 5/0 prolene.

In case of no satisfactory results after assessment of the principle repair by ventricular saline injection, Alfieri stitch was used in some cases.

Annular dilatation and/or deformity was treated by prosthetic ring annuloplasty, it was applied either by rigid or flexible ring to remodel the annulus, and also to reinforce the reparative technique.

E. Mitral valve repair assessment:

This step is very important in process of surgical repair of the mitral valve, there were several methods used according to availability and surgeon preference:

- Through the valve orifice, cold saline was injected with a bulb syringe to fill the left ventricle. This method was used in all cases with other methods or alone.
- Through cardioplegia line in the aortic root, cardioplegia was injected, while inducing aortic regurgitation by finger pressure on the aortic annulus to fill the left ventricle. Before assessment, venting the aortic root through the cardioplegia line was essential to prevent coronary air embolism by declamping the aorta partially.

The repair was considered to be satisfactory if it fulfils two conditions:

- The first and most important, if the line of leaflet closure is parallel to the mural part of the ring (smiling valve), since this indicates good apposition of the leaflet, and a good surface of coaptation.
- Second, ballooning of the anterior leaflet indicates good holding of the leaflet, minimal degree of regurgitation was accepted provided that the previous two features are present.

Leakage was considered minimal when testing fluid was trickling on the posterior leaflet surface, as it will be abolished by heart contractions. If the repair was not satisfactory, additional reparative procedures were done followed by assessment of the repair.

Intra-operative trans-esophageal echocardiographic TEE was done post by-pass to all patients of mitral valve repair to assess the myocardial contractility, cardiac dimensions, mitral valve area, degree of valve incompetence, any residual lesions and PAP.

F. Weaning from cardiopulmonary bypass:

Rewarming of the patient started during closure of the left atriotomy using 3-0 prolene suture. Air was removed from the heart before tying left atriotomy suture by intermittent ventilation of the lungs, left atrial venting and venting of the ascending aorta from the cardioplegia line, then the aorta was declamped.

The D.C shock was applied when coarse fibrillation of the heart occurred. The heart was supported by partial bypass until resuming its effective contractions, then CPB is stopped and protamine started.

After securing hemostasis and confirming that the patient is hemodynamically stable with or without inotropics or vasodilators, the chest was closed in layers leaving two mediastinal drainage tubes and pleural tube if it opened during the operation.

III. Post-operative assessment:

Early postoperative:

After appropriate hemodynamic stabilization, patients were transferred to the intensive care unit to be ventilated and awakened from anesthesia without reversal neuromuscular blocker or narcotic. The patients had assisted ventilation with pressure controlled ventilator for at least three hours after the operation. The hemodynamic parameters (systemic blood pressure, central venous pressure, and heart rate), O_2 saturation, ECG, fluid balance and ventilation were continuously monitored.

Laboratory investigations as blood picture, coagulation profile, electrolytes and arterial blood gases were done routinely. Pharmacological agents such as inotropics, vasodilators, diuretics and antiarrhythmic drugs were used according to the situation and the patients need. After extubation and weaning of all inotropic drugs, all invasive cannulae were removed, and patients were discharged from the ICU for further one week follow up and recovery in the inpatients unit.

Patients with ring annuloplasty and patients with atrial fibrillation were given anticoagulants. The period of anticoagulant treatment was 3 months in cases of ring annuloplasty, with normal sinus rhythm and for life if the patient had atrial fibrillation, an INR of around 2 was our target. All patients were examined by echocardiography before discharge for repair assessment, left ventricular function and diameters.

Late postoperative assessment and follow up:

Mid-term patients were advised to attend the outpatient clinic every week during the first post-operative month, then every two weeks for 3 months, then every month for the first year. Patients were followed up by echocardiographic examination every six months.

Statistical Analysis

Descriptive statistics were assessed accordingly using the Statistical Package for the Social Sciences (SPSS) version 16.0 (IBM, Chicago, IL). The mean ± SD were used for quantitative variables while number and % were used for qualitative variables. Parametric data was compared using paired t-test for the detection of significance. Chi-square and Fisher's exact tests were used to compare non-parametric data. *P*-values of <0.05 were considered significant.

3. Results

I. Pre-operative data:

The mean age of patients at the time of surgery, symptoms, signs on clinical examination and

etiological classification of patients and NYHA functional classification were illustrated in table (1).

The grade of mitral and tricuspid regurge, the mean of ejection fraction, left ventricular end systolic diameter, left ventricular end diastolic diameter and pulmonary artery pressure were showed in table (2).

II. Operative data:

Annular lesions, anterior leaflet lesions, posterior leaflet lesions, commisural lesions, lesions of chordae and lesions of papillary muscle in studied patients were showed in table (3). Operative repair of mitral valve, size of annuloplasty rings, tricuspid repair with devaga, intraoperative trans-esophageal echo data (MR grades), ischemic and bypass time in the studied patients were showed in table (4).

Table (1): Pre-operative clinical presentation of the patients.

	Number (N=40)	Percentage
Age (years) Mean ±SD	7.55±3.2	
Sex (Males/females)	21/19	52.5/47.5
Symptoms		
Dyspnea	33	82.5%
Palpitation	18	45.0%
Fatigue	18	45.0%
Recurrent chest infection	8	20.0%
Lower limb edema	5	12.5%
Signs on clinical examination		
Sinus tachycardia	37	92.5%
Cardiac enlargement	11	27.5%
Lower limb edema	5	12.5%
Atrial fibrillation	3	7.5%
Etiology		
Rheumatic mitral regurgitation	33	82.5%
Degenerative mitral regurgitation	4	10.0%
Congenital mitral stenosis	2	5.0%
Congenital mitral regurgitation	1	2.5%
NYHA Class		
- I	0	0 %
- II	7	17.5 %
- III	25	62.5 %
- IV	8	20 %

NYHA: New York Heart Association

Regarding NYHA class, there was a significant difference between pre-operative and post-operative (early and late) NYHA functional classification (tables 5, 6).

Comparison between pre- and post-operative echo data of the studied patients, there was a significant decrease in EDD, LA and PAP early and late postoperatively. There was no significant difference between pre-operative and early post-operative regarding ESD and EF while there was a significant difference between pre-operative and 6 month post-operative regarding ESD and EF (tables 7, 8).

There was a significant difference between pre-operative and post-operative (early and late) mitral regurge degree (table 9, 10).

Table (2): Pre-operative ECHO data of the patients.

	Number (N=40)	Percentage
Mitral regurge grades		
- 0	0	0 %
- I	0	0 %
- II	0	0 %
- III	14	35 %
- IV	24	60 %
Tricuspid regurge grades		
- 0	1	2.5%
- Trivial	3	7.5%
- I	13	32.5%
- II	17	42.5%
- III	6	15%
- IV	0	0%
ECHO parameters (Mean ±SD)		
- EF %	62±6.1	
- LAD cm	4.11±0.58	
- LVESD cm	3.07±0.64	
- LVEDD cm	4.93±0.76	
- PAP mmHg	59.43±10.16	

EF: ejection fraction, LAD: left atrial diameter, LVESD: left ventricular end systolic diameter, LVEDD left ventricular end diastolic diameter, PAP: pulmonary artery pressure.

Table (3): Operative pathological data

	Number (N=40)	Percentage
Annular lesions in studied patients		
- Not dilated	9	22.5%
- Dilated	31	77.5%%
Anterior leaflet lesions		
- Thickened	12	30.0%
- Prolapse	4	10.0%
- Restricted	2	5.0%
- Pliable	35	87.5%
- Doming and not coapted	35	87.5%
- Clefted (incomplete)	1	2.5%
- Translucent	28	70.0%
Posterior leaflet lesions		
- Thickened	12	30.0%
- Restricted	2	5.0%
- Prolapsed	5	12.5%
- Pliable	35	87.5%
- Domed and not coapted	35	87.5%
- Translucent	28	70.0%
Commisural lesions		
- Fused	0	0.0 %
- Not fused	40	100.0%
Lesions of chordae		
- Normal	28	70.0%
- Parashote	2	5.0%
- Elongated	2	5.0%
- Thickend	8	20.0%
Lesions of papillary muscle		
- Normal	38	95.0%
- Single	2	5.0%

Table (4): Operative Procedures.

Procedures	Number (N=40)	Percentage
Operative repair of mitral valve		
Repair with ring annuloplasty	35	87.5%
Posterior annuloplasty with gortex tube	3	7.5%
quadrangular resection of PL	5	12.5%
Splitting of papillary muscle	2	5.0%
Closure of clefted AML	1	2.5%
Triangle resection	2	5.0%
Artificial chordate	2	5.0%
Size of annuloplasty rings		
- Size 26	10	28.57 %
- Size 28	19	54.29 %
- Size 30	6	17.14 %
Tricuspid repair with devaga		
- Repaired with devaga	6	15.0%
- Repaired without devaga	34	85.0%
Intraoperative trans-esophageal echo data (MR grades)		
- 0	13	40.6%
- Trivial	11	34.4%
- I	7	21.9%
- II	1	3.1%
- III	0	0.0%
Ischemic time(min): Mean ±SD	69.78±17.22	
Bypass time(min): Mean ±SD	87.43±15.82	

PL: posterior leaflet, AML: anterior mitral leaflet, MR: Mitral regurge.

Table (5): Comparison between pre- and early post-operative NYHA class.

NYHA class	Preoperative		Early Postoperative		*P*- value
	No.	%	No.	%	
I	0	0	31	77.5	< 0.001
II	7	17.5	8	20	
III	25	62.5	1	2.5	
IV	8	20	0	0	

Table (6): Comparison between early post-operative and 6 months post-operative NYHA class.

NYHA class	Preoperative		6 months Postoperative		*P*- value
	No.	%	No.	%	
I	0	0	29	72.5	< 0.001
II	7	17.5	9	22.5	
III	25	62.5	2	5	
IV	8	20	0	0	

Table (7): Comparison between pre- and early post-operative Echo data.

Echo data	Preoperative Mean ±SD	Early postoperative Mean ±SD	*P* –value
ESD	3.612±0.809	3.527 ±0.830	0.278
EDD	5.402 ±1.085	5.112±1.042	<0.001
EF	0.609±0.085	0.555±0.070	0.018
LA	4.765 ±1.173	4.105 ±0.866	<0.001
PAP	53.22±17.77	31.47±7.79	<0.001

Table (8): Comparison between pre- and 6 month postoperative Echo data.

Echo data	Preoperative Mean ±SD	6 months postoperative Mean ±SD	*P* –value
ESD	3.612 ±0.809	3.333 ±0.801	<0.001
EDD	5.402 ±1.085	4.930±0.942	<0.001
EF	0.609±0.085	0.582 ±0.065	0.074
LA	4.765 ±1.173	3.877 ±0.887	<0.001
PAP	53.22±17.77	31.17±8.27	<0.001

Table (9): Comparison between the degree of MR in the preoperative and early postoperative period.

Grade	Preoperative		Early Postoperative		*P*-value
	No	%	No	%	
0	2	5%	32	80 %	< 0.001
I	0	0%	7	17.5%	
II	4	10%	1	2.5%	
III	14	35%	0	0	
IV	24	60%	0	0	

Table (10): Comparison between the degree of MR in the preoperative and late postoperative period.

Grade	Preoperative		Late Postoperative		*P*-value
	No	%	No	%	
0	2	5%	29	72.5 %	< 0.001
I	0	0%	7	17.5%	
II	4	10%	3	7.5%	
III	14	35%	1	2.5%	
IV	24	60%	0	0 %	

4. Discussion

Repair of the mitral valve (MV) is reportedly superior to replacement since it is associated with better preservation of valve tissue, subvalvular apparatus and left ventricular function, as well as improved long-term survival. Furthermore, MV repair permits greater protection from endocarditis, thomboembolism and anticoagulation-related morbidity **(Riegel *et al.*, 2011).**

MV repair may be associated with an increased number of reoperations; it is associated with improved 5-year survival compared to MV repair in pediatric patients. At some point following multiple MV repairs, however, MV repair will prove to be preferred but further follow-up and analysis is necessary to better define that time point **(Baird *et al.*, 2012).**

This results showed that, pre-operative data demonstrated that, the mean of age of our patients at the time of surgery were 7.55±3.2 years. There were 21 boys (52.5%) and 19 girls (47.5 %). **Shawky *et al.*(2003),** reported 135 patients were operated upon. Their ages ranged from 16 months to 16 years (12.3 years). There were 50 boys (41%) and 73 girls (59%). **Andrea Rocha and his colleagues, (2009),** reported 40 patients were operated upon. Their ages ranged from 4 to 17 years (12 years). There were 19 boys (47.5%) and 21 girls (52.5%).

Regarding clinical assessment, the most common complaint of the patients at time of surgery was exertional dyspnea were 33 out of 40 cases (82.5%) and palpitations were 18 cases out of 40 (45%), fatigue was the representing symptom in18 patients (45%), recurrent chest infection 8 cases (20%), and lower limb edema 5cases (12.5%) and, while AF were found in 3 (7.5%) of the patients, sinus tachycardia were found in 37 (92%) and cardiac enlargement were found in 11 (22.5%) of the patients as obvious signs.

The present study revealed that, 7 patients were in NYHA class II (17.5%), 25 patients (62.5%) were in NYHA class III, and 8 patients (20%) were in NYHA class IV. **Shawky *et al.* (2003),** reported exertional dyspnea in 103 patients (82%) and palpitation in 87 patients (70%). 25 patients were in NYHA class II (20%), 72 patients were in NYHA class III (59%) and 26 patients were in NYHA class IV (21%). **Choudhary *et al.* (2001),** found that, dyspnea on exertion was the predominant symptom, and 527 patients (64%) were in New York Heart Association (NYHA) functional class III or IV. Controlled or frank congestive heart failure was present in 116 patients (14%).

In this study 33 of cases were rheumatic mitral regurgue (82.5%), 4 out of 40 were degenerative mitral regurge (10%), two patients were congenital mitral stenosis (5%) {Parachute mitral valve}, while one patient was suffering congenital mitral regurgue (2.5%). **Shawky *et al.* (2003),** reported isolated mitral regurgitation was present in 97 patients (78%), mixed lesions in 15 patients (13%), and 11patients (9%) with isolated mitral stenosis which is also a relatively small number, especially if we know that rheumatic mitral stenosis is common. This could be explained by the increasing tendency of the cardiologists to treat mitral valve stenosis with balloon dilatation. **Lee *et al.*(2010),** studied 138 children and reported that MR was predominant in 125 patients (90%), and mitral stenosis was predominant in 14 patients (10%). Severity of MR was grade IV in 47 patients, grade III in 44, grade II in 26 and grade I in eight. MS was severe (mean gradient >10 mmHg) in four patients, moderate (mean gradient 5-10 mmHg) in eight and mild (mean gradient ≤5 mmHg) in two.

Choudhary *et al.* (2001), found that pure MR was present in 433 patients (53%), and a combined stenotic and regurgitant lesion was present in 385 (47%) patients. In our study, 36 patients (90%) were suffering tricuspid regurgitation, 13 patients (32.5%) grade I, 17 patients (42.5%) grade II, and 6 patients (15%) grade III. **Kalangos *et al.*(2008),** reported 51patients (23%) had tricuspid valve insufficiency.

Regarding the techniques of mitral repair, the prosthetic annuloplasty using the Classical Carpentier ring was one of the major steps of valve reconstruction, and was mandatory 35 out of 40 (87.5%) mitral repair. **Andrea Rocha and his colleagues, (2009),** reported that they used Classical Carpentier ring annuloplasty for 28 patients out of 40 (70%), while they used quadrangular resection of PL in 17patients out of 40 (42.5%) children. **Kalangos *et al.*(2008),** reported that in 81% (173 of 213) of the patients, a rigid Carpentier-Edwards ring was used in which the ring size ranged from (26 to 34).

In this study ring size (26-30) was used in all cases which permit excellent hemodynamics in these age groups. At the same time it is much better to treat such valve disease with a prosthetic ring size (28-30), than to use a small mitral valve prosthesis size 25, **Shawky *et al.*, 2003** preferred ring size of (size 28-32), with low early mortality rate (3.3%).

There was statistical significant difference between pre-operative and post-operative (early and late) NYHA functional classification. These results were nearer to other literatures **(Kumar *et al.*, 1995; Shawky *et al.*, 2003; Talwar *et al.*, 2005).**

In this study, after six months of follow up, 72.5%, 22.5%, 5% and 0% of patients were in class I, II, III and IV NYHA functional classification respectively. These results were in concordance with **Shawky *et al.* (2003),** study that reported 63% of patients were in NYHA class I, 12% of patients were in NYHA class II and 7% of patients were in NYHA class III, and 18% of patients were in NYHA class IV. While **Kalil *et al.* (1993),** showed that the postoperative functional class was I or II in 84% and III or IV in 16% of patients with unsupported mitral valve repair.

In this study, there were 32/40 patients with mitral valve repair (80%) with trivial or grade 0 mitral regurgitation, and there were 7 patients (17.5%) in grade I and 1 patient (2.5%) grade II of MR were asymptomatic. **Talwar *et al.* (2005),** showed that 65% of rheumatic children patients underwent mitral valve repair, with no or trivial mitral regurgitation. **Choudhary *et al.* (2001),** 70% of survivors had trivial or mild MR after one year follow-up. An additional 16% of survivors had moderate MR, but most of these (118 of 125) were asymptomatic. Also, 30% of survivors developed moderate or severe MR. Younger age, mixed lesion, ventricular dysfunction, and cuspal thickening were the important predictors for development of MR. **Choudhary and his colleagues, (2001),** showed that in the majority of patients with moderate or severe MR, the valve failed within the first 2 years after surgery. The instantaneous hazard of developing moderate-to-severe MR was highest in the 1st postoperative year. There was another (but slowly rising) hazard phase after 5 postoperative years. The early peak in the instantaneous hazard may be attributed to suboptimal repair or to the inherent complexity of the disease process, which often results in gross deformity of the valve. Recurrence and progression of the rheumatic process may have contributed to both the early and late failures.

In the study of **Shawky *et al.* (2003),** five patients out of 102 with ring annuloplasty (3.9%) had residual MR (infective endocarditis was the cause of valve failure in one of them. These are actually a very low rates in comparison with other reports; **Skoularigis and his co-workers, (1994),** reported that (23/143) 16% of patients had residual severe MR **(Skoularigis *et al.*, 1994).**

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