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Mitral valve repair for mitral regurgitation in pediatrics and children: Initial experience

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Abstract

Introduction

Mitral valve repair in pediatrics has been slow because of the great variety in congenital mitral valve malformations and the still unknown growing effect over the mitral valve. The aim of this study is to evaluate the early and mid-term results in surgical repair of mitral valve regurgitation in pediatrics and children.

Patients and methods

A total of 16 patients had mitral valve repair for mitral regurgitation (MR) between November 2016 and December 2020 at the National Heart Institute. There were seven (43.75%) males and nine (56.25%) females. The mean age was 7.5 years (5 months and 14 years). The mean weight was 19.9 kg (5.5–40 kg). Concomitant procedures were done in 11 (68.75%) patients. The mean cardiopulmonary bypass time was 82 min (40–150 min), and the mean aortic cross-clamp time was 59 min (25–110 min).

Results

There was only one (6.25%) early mortality after 3 months. The number of patients who had posterior patch annuloplasty was six (37.5%), rigid rings was four (25%), whereas suture annuloplasty was five (31.25%). The mean postoperative mitral valve gradient was 5 mmHg (3.5–8 mmHg). More than 50% of patients with suture annuloplasty had moderate MR, whereas posterior patch annuloplasty had trivial to mild MR and rigid ring annuloplasty had trivial MR. Aortic valve surgery was done in two (12.5%) cases. The mean hospital stay was 7.2 days (4–14 days) and ICU mean stay was 2.9 days (1–7 days), with a mean mechanical ventilation time of 6 h (2–15 h). Reoperation was done in four (26.6%) patients, with 81.25% freedom from reoperation for mitral valve prosthetic replacement.

Conclusion

Mitral valve repair for mitral valve regurgitation in pediatrics and children improves symptoms, valve function, and myocardial performance and delays replacement. Posterior patch and ring annuloplasty have satisfactory early and mid-term results, low mortality, and a high freedom from reoperation.

Keywords: Mitral valve repair, posterior patch, ring, suture annuloplasty

Introduction

The mitral valve is a three-dimensional morphologic and functional apparatus formed by annulus, leaflets, chorda tendinea, papillary muscles, left ventricle, and atrium [1]. Affection of one or more of these components by a pathology will result in a valvular dysfunction in the form of regurgitation or stenosis or both [2].

The current interest in surgical repair techniques returned as the gold standard for treatment over prosthetic valve replacement owing to improved diagnosis of production mechanisms of the mitral lesions by echocardiography. Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) echocardiography give appropriate

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diagnosis of the mitral valve malformation and assessment of its severity [3].

It is widely accepted that mitral valve repair is superior over replacement in adults [4]. However, repair in pediatrics has a slow progress because of the great variety in the presentation of congenital mitral valve malformations and the unknown growth of repair over the mitral valve in the future [5,6].

Annulus stabilization and remodeling with a ring has been demonstrated to be a necessary step in mitral and tricuspid valve repair to maintain effective leaflet coaptation and improve long-term results [7]. Rigid and flexible rings meet the needs of adults, but they do not allow growth of the native annulus in children.

Growth potential must be considered to be preserved in children as much as possible, that is why the idea of biodegradable ring is to remodel the annulus, reinforce the repair, restore the function of the atrioventricular valve, and maintain the three-dimensional dynamic motion and geometry of the mitral valve annulus. The mid- and long-term results showed that degradation of the device occurred without negative observable consequences [8].

The biodegradable ring is inserted subendocardially directly into the mitral annulus, away from blood contact; it is replaced by a fibrous tissue, which stabilizes the annulus, while allowing for annular growth in children. Inflammation is triggered, inducing the formation of this fibrous tissue [9,10].

The use of biodegradable rings is a new concept in maintaining the three-dimensional dynamic geometry of the mitral and tricuspid valves. The mitral orifice undergoes striking changes in its size and shape during different parts of the cardiac cycle [11].

The annulus changes its shape both in the horizontal plane and in the vertical plane, where it changes from a saddle shape to a more flat structure [12], and preserving them can improve the result and durability of the repair [11].

Patients and methods

Sixteen patients had mitral valve repair for pediatric mitral valve regurgitation between November 2016 and December 2020 at the National Heart Institute.

Exclusion criteria

The following were the exclusion criteria:

(1) Cyanotic congenital heart disease.
(2) L-transposition of great arteries.
(3) Single ventricle (functional).
(4) Anomalous left coronary origin from pulmonary artery.
(5) Ischemic mitral regurgitation (MR).
(6) Functional MR.
(7) Idiopathic dilated cardiomyopathy.
(8) Left ventricle hypoplasia.
(9) Hypoplastic left heart syndrome.

Inclusion criteria

The following were the inclusion criteria:

(1) Cleft mitral valve.
(2) Congenital mitral valve dysplasia.
(3) Genetic, chromosomal, or systemic syndromes, including Marfan syndrome, Barlow's disease, and Down syndrome.

ECG showed sinus rhythm in all cases, except one case presented with atrial fibrillation which was on amiodarone and oral anticoagulant. All children had their mitral valve evaluated preoperatively by means of two-dimensional TTE and color flow Doppler to establish the type of mitral valve regurgitation according to Carpentier's classification [13].

Surgical techniques

All patients were done with median sternotomy. Cardiopulmonary bypass (CPB) was established after full heparinization by aortic and bicaval cannulation. After aortic cross-clamp, the heart stopped after infusion of cardioplegia with moderate hypothermia at 28°C. Left atriotomy was done in the interatrial groove, and several mitral surgical repair techniques were used for every patient.

In case of cleft mitral, it was assessed for the presence of sufficient tissue. A saline injection through the valve will bring the cleft into opposition. The cleft may be positioned centrally, asymmetrically, or at any point on the anterior or the posterior leaflet. The chordae are inspected. When sufficient leaflet tissue is present on both sides of a cleft, the cleft is repaired by suturing the edges of the leaflets together from where the cleft begins, up to the free margin of the leaflets, with interrupted polypropylene suture. The cleft should be completely closed, and the valve opening diameter should be at least 10% below the normal based Hegar dilator size on the BSA-dependent mitral valve diameter.

Annuloplasty is done for all patients except one, either by a suture annuloplasty, posterior patch annuloplasty, or ring annuloplasty.

A suture annuloplasty (biodegradable Kalangos ring like) was done in five (31.25%) patients with 2/0 Polyglatin 910 (Vicryl) suture. The subendocardial insertion started at the level of the posterior commissure from the trigone to the trigone, 2 mm away from the hinge point and 3 mm in depth, taking always the same exit point to move forward around the posterior annulus.

Posterior patch annuloplasty was done in six (37.5%) patients with interrupted ethibond 2/0 suture along the posterior annulus. The length of the patch is measured according to the hegar circumference, sparing the circumferential length of the anterior leaflet. The materials used in the patch included were PTFE (Gortex-0.6 mm patch) or Dacron tube patch.

Ring annuloplasty was used in four (25%) older children with no need to concern about annulus growth. Charpentier ring size 26° is used to reconstruct the annulus. Ring annuloplasty was done with interrupted ethibond 2/0 suture along the whole circumference of the mitral valve, according to the mitral valve sizer, which is estimated over the size of anterior mitral leaflet.

Saline infusion test was done (as a first initial step, if competent = good repair). After completion of repair, the left atrium was closed. Aortic cross-clamp was off, and when the heart beat was spontaneous, the weaning of CPB was initiated smoothly. After weaning of CPB was completed, and before the decannulation, intraoperative TEE was routinely performed to evaluate mitral valve repair and to assess the success of mitral valve repair (as a final step = good repair). If there was more than mild MR, CPB was resumed to correct the residual lesion.

Early and mid-term follow-ups were done clinically and by echocardiography. A clinical follow-up evaluation and functional class stratification using the New York Heart Association classification for children and young patients were done. Echocardiographic follow-up was obtained in all patients at the fifth day before hospital discharge and after 6 months. The degree of echocardiographic MR was estimated by a semiquantitative method based in the regurgitant jet maximum length and width in relation to the left atrium size as follows:

(1) 0 = none.
(2) 1 = mild (<1/3).
(3) 2 = moderate (1/3–1/2).
(4) 3 = moderate to severe (1/2–2/3).
(5) 4 = severe (>2/3).

The regurgitant jet direction was also evaluated for estimation of eccentric jet owing to leaflet prolapse or restriction [14].

Results are presented as a mean, variability ranges, and percentages in relation to the risk population. The overall survival rate and freedom from reoperation for mitral valve prosthetic replacement survival rate are estimated. Clinical follow-up was made at a mean time of 12 months in all survivors.

Ethical considerations

The study was approved by the institutional Ethics Committee of the National Heart Institute.

Results

A total of 16 pediatric patients and children with mitral valve regurgitation had mitral valve repair. There were seven (43.75%) males and nine (56.25%) females (Table 1). The mean age was 7.5 years, ranged between 5 months and 14 years. The mean weight was 19.9 kg and ranged from 5.5 to 40 kg.

All patients had sinus rhythm at the time of admission to the hospital except one (6.25%) patient who had atrial fibrillation as she was on oral anticoagulant and amiodarone as the left atrial size was 4.6 × 5.5 cm. The patient was on temporary pacemaker after operation for sinus bradycardia AND then returned to normal sinus rhythm after 24 h without medication, as her left atrial size returned to 3.5 cm postoperatively. All patients were on sinus rhythm after hospital discharge.

Concomitant procedures associated with mitral valve surgery were done in 11 (68.75%) patients (Table 2).

The surgical repair techniques used are described in Table 2.

Table 1: Preoperative data

Number of patients	16
Age (years) [mean (Range)]	7.5 (0.4-14)
Sex [*n* (%)]	
Male	7 (43.75)
Female	9 (56.25)
Weight (kg) [mean (range)]	19.9 (5.5-40)
Echocardiography (preoperative)	
EDD (mm) [mean (range)]	45 (26-69)
ESD (mm) [mean (range)]	28.6 (18-43)
EF% [mean (range)]	65 (45-80)
MR [*n* (%)]	
+2	1 (6.25)
+3	2 (12.5)
+3-4	2 (12.5)
+4	11 (68.75)
TR [*n* (%)]	
Trivial	3 (18.75)
+1	7 (43.75)
+1-2	2 (12.5)
+2	2 (12.5)
+4	2 (12.5)
PAP (mmHg) [mean (range)]	32.6 (15-60)
LA size (cm) [mean (range)]	3.5 (1.9-5.1)
RV (cm) [mean (range)]	1.4 (0.8-2.5)

EDD, end diastolic diameter; EF, ejection fraction; ESD, end systolic diameter; LA, left atrium; MR, mitral regurgitation; PAP, pulmonary artery pressure; RV, right ventricle; TR, tricuspid regurgitation.

Annuloplasty was done in all patients except one. Posterior patch mitral annuloplasty using either Dacron or Gortex patches was used for in six (37.5%) patients, rigid rings using Charpentier rings size 26° were done in four (25%) patients, whereas suture annuloplasty was done in five (31.25%) patients. One patient had cleft of anterior leaflet who had simple closure of the cleft with posterior patch annuloplasty.

The mean postoperative mitral valve gradient was 5 mmHg (3.5–8 mmHg). More than 50% of patients with suture annuloplasty had moderate MR, whereas posterior patch annuloplasty patients had trivial to mild MR, and rigid ring annuloplasty patients had trivial MR.

Aortic valve surgery was done in two (12.5%) cases: one had repair with sub-commissural annuloplasty in a 12-year-old patient (6.25%) who had a moderate aortic regurgitation in association with suture annuloplasty for severe mitral valve regurgitation, and the other was a 13-year-old patient (6.25%) with severe aortic regurgitation who had aortic valve replacement with St Jude 19° reagent along with mitral valve repair with rigid ring 26° and tricuspid valve repair (De Vega).

The mean postoperative hospital stay was 7.2 days and ranged from 4 to 14 days. The mean ICU stay was 2.9 days and ranged from 1 to 7 days. The mean mechanical ventilation time was 6 h and ranged from 2 to 15 h (Table 3).

There were no operative or hospital mortalities. There was only one early mortality (6.25%) after 3 months. The mitral

Table 2: Operative data

Mitral valve repair [*n* (%)]	
Etiology	
Congenital MR	11 (68.75)
Cleft AML	1 (6.25)
Supramitral ring, HOCM, SAM	1 (6.25)
Flail AML prolapse	2 (12.5)
Fused short chordae+dilated annulus	1 (6.25)
Ring annuloplasty 26	4 (25)
Posterior patch annuloplasty	6 (37.5)
Suture annuloplasty	5 (31.25)
Cleft closure	1 (6.25)
Quadrangular resection PML	2 (12.5)
Triangular resection AML	1 (6.25)
Plication AML	2 (12.5)
Chordal transfer	3 (18.75)
Chordal resection	1 (6.25)
Concomitant procedure	11 (68.75)
De Vega	5 (31.25)
Septal myomectomy	1 (6.25)
PDA ligation	4 (25)
VSD closure	1 (6.25)
ASD closure and PV dilatation	1 (6.25)
Aortic valve surgery	2 (12.5)
Repair (SCA)	1 (6.25)
Replacement	1 (6.25)
CPB time (range) (min)	82 (40-150)
ACC time (range) (min)	59 (25-110)

ACC, aortic cross-clamp; AML, anterior mitral leaflet; ASD, atrial septal defect; CPB, cardiopulmonary bypass; HOCM, hypertrophic obstructive cardiomyopathy; MR, mitral regurgitation; PDA, patent ductus arteriosus; SAM, systolic anterior motion; SCA, Sub-Commissural Annuloplasty; VSD, ventricular septal defect

Table 3: Postoperative data

Postoperative echocardiography	
EDD (cm) [mean (range)]	3.7 (2.3-5.6)
ESD (cm) [mean (range)]	2.4 (1.3-4)
EF% [mean (range)]	60.1 (39-76)
MV gradient (mmHg) [mean (range)]	5 (3.5-8)
MR [*n* (%)]	
Trivial	9 (56.25)
+1	2 (12.5)
+1-2	2 (12.5)
+2-3	1 (6.25)
+3	1 (6.25)
+4	1 (6.25)
TR [*n* (%)]	
Trivial	8 (50)
+1	6 (37.5)
+2	2 (12.5)
Mortality	1 (6.25)
Hemolysis	2 (12.5)
Redo	4 (25)
Re-repair	1 (6.25)
Replacement	3 (18.75)
Mechanical ventilation (h) [mean (range)]	6 (2-15)
ICU stay (day) [mean (range)]	2.9 (1-7)
Hospital stay (day) [mean (range)]	7.2 (4-14)

EDD, end diastolic diameter; EF%, ejection fraction; ESD, end systolic diameter; MR, mitral regurgitation; MV, mechanical ventilation; TR, tricuspid regurgitation.

valve showed shortened fused chordae with dilated annulus. She had suture annuloplasty with fenestration of fused chordae to correct the mitral valve. The patient had two regurgitant jets, i.e., one small central and another large eccentric (most probably due to tear in the anterior leaflet), and she died outside the hospital.

There was no bleeding, no infection, no thromboembolic manifestations, or neurological complications postoperatively during this study. There was hemolysis in two (12.5%) patients who needed reoperation.

There were four (26.6%) patients who needed reoperation to mitral valve during the early postoperative period. The one who had re-repair was a 6-month-old, 5-kg infant who had ventricular septal defect (VSD) closure and mitral valve repair with posterior patch annuloplasty. She needed another repair after 2 months because of hemolytic anemia. The other three patients had mitral valve replacement with mechanical valve prosthesis (St Jude 19, 25, 19). The first was a 6-year-old female patient who had hypertrophic obstructive cardiomyopathy (HOCM) with severe MR causing obstruction of the LVOT by systolic anterior motion associated with septal hypertrophy. After septal myomectomy, the mitral valve was inspected. There was a supramitral ring which was removed and there was an accessory papillary muscle giving attachement to the main chorda of the anterior mitral leaflet. The chorda was resected from the accessory muscle, and another secondary chorda was transferred to the anterior leaflet. Although TEE reported a mild residual mitral valve regurgitation, weaning of CPB was successful without hemodynamic deterioration. In the early postoperative period, she developed clinical and radiologic signs of severe congestion, and later, she was reoperated for mitral valve replacement with an inverted aortic St Jude 19 reagent mechanical prosthesis placed with preservation of the posterior leaflet, with a successful postoperative course. After 2 weeks from hospital discharge she developed severe pericardial effusion owing to high international normalized ratio from oral anticoagulant, which needed evacuation twice.

The second was a 13-year-old female patient who had a myxomatous mitral valve with prolapsed anterior and posterior leaflet and annular dilatation. She had triangular resection of the anterior leaflet and quadrangular resection of the posterior leaflet and suture annuloplasty. Mild to moderate regurgitation was reported by the transesophageal intraoperative echocardiography. Later on, we decided for reoperation of this patient for mitral valve replacement with a mechanical St Jude 25 mitral prosthetic valve in annular position with preservation of the posterior leaflet, with good postoperative results.

The third was a 5.5-year-old female patient who had a previous patent ductus arteriosus (PDA) ligation through left lateral thoracotomy 2 years ago. She had a mitral valve repair for severe MR with a posterior patch annuloplasty. After 2 months from repair, another mitral valve replacement was done because of hemolysis. During reoperation, there was papillary-commissural fusion with restricted posterior leaflet motion, and the posterior patch annuloplasty was completely covered with endothelium. The patch was removed for any suspicion, and mitral repair was tried but failed, so mitral valve replacement was performed with an inverted aortic St Jude 19° reagent mechanical valve prosthesis with preservation of the posterior leaflet with a successful postoperative course. Up to date, all the three patients who had valve replacement are asymptomatic and with appropriate prosthetic valve performance by echocardiography.

All of the patients had New York Heart Association classification functional class less than or equal to II. Additionally, a patient in our series developed mitral valve repair failure at the midterm (15 months), of no important clinical significance. In this case, optimum medical treatment allowed to delay the time of reoperation.

The overall survival rate after surgical mitral valve repair was 100% at 30 days and 93.75% after 30 days and at 1-year follow-up. It also showed 81.25% freedom from reoperation for mitral valve prosthetic replacement in early and mid-term follow-up.

Discussion

The best treatment options for congenital MR include mitral valve repair first and then replacement with mechanical valve prostheses; however, bioprostheses are contraindicated in children in the mitral position because of premature accelerated degeneration and calcification [15].

The good functioning of the native or repaired heart valve depends on the coaptation capacity of its leaflets. Annuloplasty rings are artificial prosthesis sutured to the native mitral or tricuspid valve annulus that have been used since 1968, to remodel the shape, correct the dilatation and consolidate the repair of the valve, and improve coaptation of the valves leaflets during systole [16].

Rigid rings do not allow for the further growth of the native annulus, which is an important issue for the long-term results if implanted in children. Indeed, their implantation in growing hearts could result in a stenotic effect, which could worsen with time [17]. In this study, four (25%) children with rigid ring annuloplasty had trivial MR after mitral valve repair.

The new concept is to use absorbable and biodegradable sutures or implants instead of rigid rings in growing pediatric patients and children who have the following characteristics:

(1) Promote/accelerate body self-repair.
(2) Provide a gradual transition to regain a normal organ function.
(3) Do not interfere with organ growth in children.
(4) No need for operations to remove them.
(5) Low risk of infection [17,18].

The advantages of biodegradable rings over rigid rings and posterior patch annuloplasty are as follows:

(1) Less gradient, measured at 3 months, 6 months, and 1 year. The gradient had a steady increase with a rigid ring by time while with the biodegradable ring, the increase was significantly lower.
(2) Better posterior leaflet mobility: it was significantly decreased in the rigid ring and posterior patch annuloplasty and only mildly reduced in the biodegradable.
(3) Faster recovery of the shortening fraction after surgery. It was initially reduced in all, but the recovery to preoperative values was 3 months for the rigid rings and 3 weeks for the biodegradable [17].

A study stated the experience of using biodegradable Kalangos ring in 22 patients with congenital MR, who were compared with 18 patients who had posterior biodegradable suture annuloplasty using 4-0 or 5-0 PDS and 17 controls with posterior pericardial band fixed onto the native annulus by interrupted mattress polypropylene stitches (control groups). Patients with a biodegradable ring showed homogeneous growth of the mitral anteroposterior and lateral annular diameters, similar to physiologic growth in 57 ± 12 months, with two patients developing moderate MR, whereas in the two control groups, half (50%) of the patients developed moderate MR [18].

The incidence of associated heart defects associated with congenital mitral valve malformations is high [19–21] and has an effect that may be significant on the outcome clinically. The associated lesions in this study were 11 (68.75%) patients, including PDA closure in four (25%) patients, VSD closure in one (6.25%) case, ASD closure with pulmonary valve dilatation in one (6.25%) case, septal myomectomy in one (6.25%) case, and tricuspid valve repair (De Vega) in five (31.25%) patients. The four reoperation procedures had three patients with associated lesions: one had HOCM with systolic anterior motion who had septal myomectomy, another had tricuspid valve repair, and one had VSD closure with previous PDA ligation.

Mechanical and bioprosthetic mitral valve replacements have significant short-term and long-term problems in children [22,23], which is why mitral valve repair techniques to remodel regurgitant valves have many advantages [20,21,24]. They lower the perioperative mortality from 21 to 43% for mitral valve replacement [5,25,26] to 0–5% for mitral valve repair [6,20,24,25]. The operative mortality of mitral valve repair in this study was early and only one (6.25%) patient died, and there was no mortality for the three patients who had mitral valve replacement after failed repair.

Annular dilatation causing MR in infants and young children requires remodeling of the native annulus with a ring or posterior patch annuloplasty. Although rigid ring is used in young children, infants and growing children have more problems in choosing a correct prosthesis size. Chauvaud *et al*. [20] have approached this problem by performing the posterior annular reduction without the use of a rigid prosthesis. They used Gortex or pericardial patch for the reduction of the posterior native mitral annulus, because the anterior aspect does not enlarge as much owing to its attachment to the fibrous skeleton.

In our series, we only used Charpentier rigid ring sized 26° in four (25%) children. Posterior suture annuloplasty (biodegradable) using 2/0 vicryl suture was done in five (31.25%) patients and posterior patch annuloplasty using Gortex or Dacron tube patch in six (37.5%) patients, which has the advantage of easy manipulation and stronger than the autologous pericardium.

There were four patients in this study who needed reoperation (one had repair and other three had replacement) because of failure of the original mitral valve surgical repair. Intraoperative TEE is a very useful tool to evaluate the immediate results of surgical mitral valve repair and identify early technical failure.

The early reoperation rate had favorable results compared with other reports [5,19,24,27] of mitral valve repair in children. In this study, the outcome of the four (25%) reoperated patients has a favorable outcome, where one patient had re-repair and three patients had mitral valve replacement.

Although intraoperative TEE is an important method that allows the surgeon to decide which is the best surgical mitral repair technique to use and to evaluate the early results, the decision of surgery depends on each type of patient. Most reports dealing with congenital anomalies recognize the importance of intraoperative TEE for functional evaluation giving the surgeon the option for reintervention as deemed necessary [5,20]. TEE was mandatory in operating room in all patients.

Preservation of the native mitral valve is the target in this study to preserve the mitral valve as long as possible, even if we know by echocardiography later on that it is not completely satisfactory. The time given by repair allows growth of the valve and gives a chance for another repair if possible, or replacement with a mechanical valve prosthesis in order to allow a larger size to be implanted, as the native annulus will not be allowed for the further growth, which is an important issue for the long-term results if implanted in children. Indeed, the implantation in growing hearts could result in a stenotic valve, which could worsen with time [17].

Hetzer *et al*. [28] reported that actuarial freedom from repeat mitral valve reconstruction is 91.1 ± 1.5%, and freedom from mitral valve replacement is 81.1 ± 7.5%. In this study, the actuarial freedom from repeat mitral valve reintervention was 75%, whereas freedom from mitral valve replacement was 81.25%.

Stellin *et al*. [29] stated that actuarial survival was 96.8%, freedom from reoperation rate was 85.9%, whereas freedom from mechanical ventilation prosthesis was 93%. In our study, actuarial survival was 93.75%, freedom from reoperation rate was 75%, whereas freedom from mechanical ventilation prosthesis was 81.25%.

The absence of thromboembolic episodes observed in our patients is also consistent with the findings of others [5,20,24,30] and contributes to the low postoperative morbidity. Aspirin is given for life in mitral valve repair, whereas anticoagulation therapy is needed except for only the first 3 months postoperatively when rigid ring is used. This is the time required to be covered with endothelium.

Recurrence is often the result of repair of mitral valve regurgitation without annuloplasty. The function of annuloplasty is to stabilize the repair and to match the area of the leaflet tissue to the cross-sectional area of the mitral orifice in systole. It should be considered mandatory in all repairs for mitral valve regurgitation, except in lesions with no annular dilation, such as cleft mitral valve unless associated with annular or ventricular dilatation [31]. In this study, all patients had annular stabilization with ring or posterior annuloplasty or posterior suture annuloplasty even in the only case with cleft mitral that had left ventricular dilatation, except the patient with HOCM with anterior systolic motion.

Postrepair results of intraoperative TEE are not a statistically significant predictor for future reintervention, as there are errors of underestimation during general anesthesia relative to postoperative TTE in awaken patients [15].

Mitral valve repair for acquired disease in adults is a well-established treatment and has long-term follow-up reliability [32,33]. Surgical results in children with congenitally malformed mitral valve are reported to be not as good, because of the complex wide spectrum of morphological abnormalities, the frequent association with other cardiac anomalies, lower incidence rate [31,34,35], and consequent lesser experience with surgical repair in such a group of patients [24].

Sousa *et al*. [24] in their 13-year experience with mitral valve repair in the first year of life reported excellent results in such a difficult selected population, with low operative mortality, and actuarial survival and actuarial rate of freedom from reoperation of 94 and 58%, respectively, at 7 years. In this study, actuarial survival and actuarial rate of freedom from reoperation was 93.75 and 75%, respectively.

The goal of surgical repair was to achieve a functional rather than an anatomical surgical reconstruction. Good functional results can be achieved with minimal surgical maneuvers [29].

Some patients presented with a residual degree of regurgitation after repair. However, an improvement in valve function can preserve myocardial performance, improve clinical symptoms, and delay replacement [29]. There was one patient with dilated left ventricle who improved clinically after repair with absorbable suture annuloplasty in spite of having moderately severe MR later after repair.

Chauvaud *et al*. [20,31] considered ring annuloplasty for MR is mandatory in children older than 2 years. This statement is supported by their experience of 25% incidence rate of residual significant MR after repair without ring insertion [31]. Other reports [24] stated that prosthetic rings are not necessary to achieve favorable results in infants [6]. In this study, ring annuloplasty has been employed only in four patients aged 9, 9.5, 11, and 13 years weighting 26, 29, 30, and 32 kg, as rigid ring annuloplasty patients had trivial MR after repair.

Stellin *et al*. [6] mentioned the high effectiveness of posterior patch annuloplasty, favoring any conservative procedure that does not require a prosthetic material. The same results were seen in this study, with posterior patch annuloplasty over absorbable suture annuloplasty, as more than 50% of patients with suture annuloplasty had moderate MR, whereas posterior patch annuloplasty patients had trivial to mild MR.

Mitral valve replacement in infants and children is associated with high reoperation and mortality rate, and the maintenance of adequate anticoagulation is difficult [25,26]. The use of bioprosthetic valve substitutes in children is well known to be associated with reduced durability and early valve failure owing to early degeneration and calcification [36]. In this study, there was no reoperation or mortality in the three patients with mitral valve replacement; only one had pericardial effusion which needed evacuation from anticoagulation, and no bioprostheses were used after failure of repair.

Myers and Kalangos [8] stated that annuloplasty using a biodegradable ring has showed excellent early and mid-term results, with particular advantages compared with traditional rings in specific subsets of patients, namely children, with endocarditis and minimally invasive cardiac surgery, though long-term follow-up is currently being assessed.

In the beginnings of the Kalangos rings, he used the vicryl 2/0 suture before the monofilament polyvinylidene fluoride suture, but he found excessive fibrosis at the annulus posteriorly after 6 months (Kalangos, personal communication), which is why a modification of the suture material of the biodegradable ring was done to show homogeneous growth of the mitral in the anteroposterior and lateral annular diameters, similar to physiologic growth. In this study, we used the initials of Kalangos biodegradable suture with vicryl 2/0 suture in some patients, although there were short times of operation and short ICU and hospital stay, but more than 50% of patients with suture annuloplasty had moderate MR, which was unsatisfactory at mid-term results.

Limitations

This study was an observational study with a small number of patients. All the procedures were done by the author after a consent from the patient and according to the surgeon's point of view, as there were neither standard protocols nor guidelines for mitral valve surgery in pediatrics and children.

Conclusion

Mitral valve repair for mitral valve regurgitation in pediatrics and children improves symptoms, valve function, myocardial performance, and delay replacement. Posterior patch and ring annuloplasty have satisfactory early and mid-term results, low mortality, and a high freedom from reoperation.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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