SURGERY FOR CONGENITAL HEART DISEASE

SIMPLIFIED SINGLE PATCH TECHNIQUE FOR THE REPAIR OF ATRIOVENTRICULAR SEPTAL DEFECT

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Objective: Because of the complexity of traditional 1- and 2-patch techniques for the repair of complete atrioventricular septal defect, we modified our repair technique to avoid the use of any ventricular septal patch material. We report our prospective experience with this simplified 1-patch technique. **Method:** Forty-seven consecutive patients between May 1995 and August 1998 underwent repair with the use of this technique without modification. Repair was done in all patients by direct suturing of the common atrioventricular valve leaflets to the crest of the ventricular septum. No division of valve leaflets was necessary. A single pericardial patch was used to close the defect in the atrial septal component. Follow-up included electrocardiography and echocardiographic assessment of ventricular function, atrioventricular valve function, and adequacy of the left ventricular outflow tract. **Results:** There were 2 deaths (4%), only 1 cardiac related, in the series. There were 17 male patients and 30 female patients. Mean age at repair was 5.6 months (median, 3.4 months). Associated lesions were repaired in 19 patients (40%). Mean follow-up was 1.85 years (median, 1.9 years). There was no heart block. There were no significant residual ventricular septal defects detected and no left ventricular outflow tract obstruction seen on echocardiography in any patient to date. Mitral valve status after operation was assessed as no incompetence in 13 patients (28%), minimal in 19 patients (40%), mild in 12 patients (26%), and moderate in 3 patients (6%). **Conclusion:** The repair of complete atrioventricular septal defect by direct suturing of the atrioventricular valve leaflets to the crest of the ventricular septum with a single-patch technique greatly simplifies the repair and does not lead to left ventricular outflow tract obstruction nor interfere with valve function. (J Thorac Cardiovasc Surg 1999;118:642-7)

The first successful repair of a complete atrioventricular septal defect (AVSD) was reported by Lillehei and colleagues¹ in 1955. There have been various tech-

niques described to repair this defect since then that involve the use of a single- or double-patch method, and results have been improving with better anatomic understanding of the lesion and better operative and postoperative management. Both techniques have produced good atrioventricular valve function after operation, and the ventricular patch material is thought necessary to supplement a deficient ventricular septum to avoid left ventricular outflow tract obstruction.²

Wilcox and associates³ recently reported their experience of suturing the common atrioventricular valve to the ventricular septum to close the ventricular component of the AVSD. They, however, elected not to attempt repair in those patients with a large ventricular component by this method. We have not been selective in

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Table I. Preoperative echocardiographic assessment of ventricular septal component in patients with AVSDs

Size of VSD	Patients (n)
Restrictive	6
Moderate	11
Large	30

applying a similar direct suture technique and have included a form of anterior annuloplasty during partitioning of the common valve. We have successfully performed repair in all consecutive patients with complete AVSD using this technique.

Patients and methods

Between May 1995 and August 1998, 47 consecutive patients who were referred to 1 consultant cardiac surgeon for repair of complete AVSD were included in the study. The mean age at operation was 5.6 months (median, 3.4 months; range, 1-25 months). The mean weight at operation was 6.2 kg (range, 2.6-16.8 kg; SD, 3.2 kg). Down syndrome was present in 36 patients (77%).

The size of the ventricular septal component was graded on preoperative echocardiography by cardiology review as restrictive, moderate, or large (Table I) and was representative of a normal AVSD population having repair.

All patients had a modification of repair that involved direct suturing of the common atrioventricular valve to the right side of the crest of the interventricular septum, regardless of the size of the ventricular septal "scoop" interpreted on preoperative echocardiography. The remaining atrial septal defect (primum) was closed with a pericardial patch, and the neomitral cleft was repaired.

Operative technique. Continuous cardiopulmonary bypass through aortic and bicaval cannulae with cooling to 25°C was used. Cold antegrade blood cardioplegia was given at 20-minute intervals, supplemented by topical cold saline solution at the time of cardioplegia delivery.

In all 47 patients, the ventricular component of the defect was closed by direct suturing of the common atrioventricular valve to the right side of the crest of the ventricular septum. Interrupted 5-0 polyester sutures (Tevdek; Deknatel, Inc, Fall River, Mass), with Teflon pledgets, were placed on the right ventricular aspect of the ventricular septal crest (Fig 1). Care was taken to avoid potential conduction tissue. These sutures were then passed through the anterosuperior and posteroinferior common bridging leaflets to partition that valve into right and left components at the point where the leaflets naturally abutted the crest of the interventricular septum and then through the leading edge of the pericardial patch and a Dacron strip as shown (Fig 1). No attempt was therefore made to "gain leaflet tissue area" for the mitral component. The Dacron strip was measured to be approximately 80% of

Fig 1. Diagram shows the valve leaflets being sutured to the crest of the ventricular septum, single pericardial patch for closure of ASD, and Dacron strip annuloplasty.

the length of exposed interventricular septal crest. This acted as both a support for the suture line, and more importantly, as a form of annuloplasty for the mitral valve to bring the anterosuperior and posteroinferior leaflet components closer together and to increase the area of their central coaptation. These sutures were then tied, which obliterated the ventricular component of the defect by approximating leaflet tissue to the septal crest. The suture that effectively joins anterosuperior and posteroinferior bridging leaflets was then used to close the cleft in the anterior leaflet of the neomitral valve. This was done in a continuous fashion, in 2 layers, with the suture brought back through the Dacron strip to allow the knot to be tied on the right atrial side. A 7-0 polypropylene (Prolene; Ethicon, Inc, Somerville, NJ) stay suture was placed at the point of first papillary muscle-derived chordal support of the cleft and placed on tension to facilitate apposition of the 2 leaflet components and prevent purse-string-like effect of the continuous suture line. The valve was tested by insufflating the left ventricle with cold saline solution. At this stage the valve was usually competent, but an additional commissural annuloplasty was done, if necessary, to improve left atrioventricular valve competence.

The pericardial patch was used to close the atrial septal

Table II. Associated lesions repaired with AVSDs

Associated lesions	Patients (n)
Patent ductus arteriosus	10
Left superior vena cava to coronary sinus	5
Additional muscular VSD	4
Total anomalous pulmonary venous return	1
Coarctation of aorta	1
Pulmonary stenosis	1

defect (primum), with a continuous 7-0 Prolene suture staying well to the right side of potential conduction tissue and leaving the coronary sinus draining to the right atrium in all patients. The pericardium was not pretreated in any way. A left atrial and pulmonary artery pressure monitoring line with thermistor for cardiac output measurement was placed. Patients later in the series were assessed with intra-operative transesophageal echocardiography before and after repair.

Follow-up. All patients were seen in follow-up by the surgeon and a cardiologist. An electrocardiogram and echocardiogram were performed on all patients. Particular importance was placed on the assessment of ventricular function, right and left atrioventricular valve function, and evidence of left ventricular outflow tract obstruction.

Results

There were 47 consecutive patients treated with this technique regardless of the size of the ventricular component of their defect. There were 17 male patients and 30 female patients. Associated lesions were repaired in 19 patients (40%); patent ductus arteriosus was repaired in 10 patients; coarctation of aorta was repaired in 1 patient; left superior vena cava to coronary sinus was repaired in 5 patients; pulmonary stenosis was repaired in 1 patient; total anomalous pulmonary venous return was repaired in 1 patient, and additional muscular ventricular septal defect (VSD) was repaired in 4 patients (Table II).

Mean follow-up was 1.85 years (median, 1.9 years). The mean aortic crossclamp time was 72 minutes (range, 37-118 minutes), and the mean cardiopulmonary bypass time was 109 minutes (range, 60-156 minutes). The ischemic times were shorter when compared with the 2-patch technique previously used by the same surgeon.

All patients were in sinus rhythm on follow-up electrocardiography, and no patient required prolonged cardiac pacing in the postoperative period.

There were 2 deaths (4%) in the series. A 3-month-old patient with severe atrioventricular valve regurgitation before the operation did not have a Dacron strip annuloplasty incorporated in her original repair. She continued to have severe regurgitation in the postoperative

Table III. Echocardiographic assessment of left atrioventricular valve function

Atrioventricular valve regurgitation (echocardiography)	No. before the operation	No. after the operation (%)
Competent	0	13 (28)
Trivial	2	19 (40)
Mild	30	12 (26)
Moderate	10	3 (6)
Severe	5	0

period and could not be weaned from the ventilator. She underwent further operation involving annuloplasty and mitral leaflet augmentation with pericardium, which appeared to improve valve function. She could not, however, be weaned from the ventilator and had continuing important mitral incompetence, good left ventricular function, and no left ventricular outflow tract obstruction. She underwent mitral valve replacement but died 24 hours after this procedure, 3 weeks after her original repair. The other patient died of fulminating respiratory failure from respiratory syncytial virus infection with good atrioventricular valve function and ventricular function and no residual lesions.

The cleft in the neomitral valve was closed in all patients, which resulted in a surgical assessment of adequate valve competency during the repair in 36 patients (77%). An additional commissural annuloplasty was required in 9 patients (19%), and closure of an additional mitral orifice was required in 1 patient.

Follow-up echocardiography has been performed on all patients. Valve function improved in most patients from preoperative echocardiographic assessment (Table III). Postoperative left atrioventricular (neomitral) valve function was assessed as competent in 13 patients (28%), trivial regurgitation in 19 patients (40%), mild regurgitation in 12 patients (26%), and moderate in 3 patients (6%). No echocardiographic evidence of mitral stenosis was detected in either early or late postoperative studies.

Two patients who had severe common atrioventricular valve regurgitation before the operation continued to have moderate neomitral valve regurgitation after the operation and required reoperation. One patient eventually required valve replacement and died, as previously mentioned. The other patient was rerepaired with a much improved valve function.

A residual VSD was seen on initial follow-up echocardiography in 13 patients. These were graded as trivial in 11 patients and as mild in 2 patients on echocardiography. However, these improved with time,

and no patient required reoperation for residual VSD or dehiscence of the repair.

Assessment of the left ventricular outflow tract was performed by transthoracic echocardiography. Doppler flow pattern and flow acceleration were calculated, and no patient had evidence of left ventricular outflow tract obstruction. The overall appearance of the repair was similar to the traditional 2-patch technique at postoperative study, with the plane of the atrioventricular valves in systole not apparently more apically positioned.

All surviving patients were well at follow-up with no clinical signs of heart failure.

Discussion

The operative repair of the AVSD (atrioventricular canal) has undergone significant changes since early techniques were described. Improvement in mortality rates is related to advances in myocardial protection and postoperative management and the technique of repair.

Most techniques involve the use of patch material that is placed in the ventricular septal component of the defect to make up for an interpreted deficiency in the ventricular septum. Anatomic studies have shown that it is likely that a heart with complete AVSD has a more deficient ventricular septum than a partial defect. However, this is also variable, and the 2 groups of hearts often have similar septal geometry, as shown by Ebels and associates.⁴ This is the basis for the selective approach applied by Wilcox and colleagues,³ where patients with a large scoop in the ventricular septum did not undergo repair by direct approximation of the valve leaflets to the ventricular septum, to avoid both tension in the valve leaflets and concern about atrioventricular valve competence after repair. Postoperative valve incompetence is a significant risk factor for reoperation and death and has been caused by the dehiscence of the valve suture line in the traditional Rastelli-type single-patch repair.⁵⁻⁷ This technique involves dividing the anterior and posterior common leaflets with reattachment to a single patch,⁸ which requires the incorporation of leaflet tissue in this suture line. This, together with closure of the cleft in the neomitral valve, tends to reduce the mobile valve area and may place undue tension on the valve repair.

We have not been selective in the use of our direct suture technique based on preoperative echocardiography data and have closed defects with apparent large ventricular components, or scoops, by direct approximation of the common atrioventricular valve to the interventricular crest. This has provided a good functional valve after the operation in most patients. The

addition of a Dacron strip in this repair acts as a pledget for the valve leaflet, which (in combination with pledgeted sutures in the crest of the septum) increases the strength of the repair. This Dacron strip, if appropriately sized, acts as an annuloplasty by lifting the anterior component of the neomitral valve away from the left ventricular outflow tract and allows more leaflet area for valve closure by reducing tension in the valve leaflets. We have found that closure of the cleft alone in the anterior leaflet of the neomitral valve results in valve competency in most patients without the need for additional valve repair techniques.

It is thought that the height of the neomitral valve in relation to the ventricular septal crest must be judged carefully when using the 2-patch technique to avoid the complication of left ventricular outflow obstruction.⁹ It has certainly been our experience that the relative size of the ventricular patch used with the 2-patch technique has become smaller over time; this led us to attempt the eventual direct closure of the ventricular component without a patch with this present technique. So we in fact make no intentional height adjustment of the atrioventricular valve from the septal crest in our repair. However, the anterior annuloplasty that forms part of our technique may allow us to be more aggressive in repairing AVSDs with an interpreted large ventricular component or scoop without the need for this height adjustment. Despite initial concerns regarding the size of interpreted and apparently large deficiencies of ventricular septal components in some of our patients, the direct suture technique has not caused left ventricular outflow tract obstruction after the operation in these patients.

The direct suture technique is associated with a shorter ischemic time and a shorter total bypass time in our experience and in others,³ because it eliminates the positioning of an extra suture line required with traditional techniques.

Though not included in this series, we have used this technique in patients with double outlet right ventricle and tetralogy-type right ventricular outflow anatomy in addition to AVSD. These patients underwent repair with the use of a Dacron patch used to augment the septum superiorly and anteriorly to correct the override, then the common valve leaflets were sutured directly to this patch superiorly and to the crest of the septum inferiorly. This resulted in both lower clamp times and competent atrioventricular valve function.

It is also important to consider the tricuspid valve function with this technique, particularly in the presence of pulmonary hypertension. We have not seen any important tricuspid valve incompetence, which corre-

sponds to our results with left atrioventricular valve function after the operation.

We feel that the direct suture technique is a simple method that minimizes ischemic time, provides a reliable valve repair, and is free from LV outflow tract obstruction. We are encouraged to attempt repair of all forms of complete atrioventricular canal using this simplified approach.

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Discussion

Dr John W. Brown (*Indianapolis, Ind*). The authors have described a technique that seems quite similar to that described by Ben Wilcox and his colleagues in 1997, which they have mentioned, in which Wilcox, however, recommended selected patients with a shallow VSD. We in Indianapolis performed this technique more than 10 years ago in 10 or 12 patients who we thought had shallow VSDs; but in 2 of those patients, we had more than acceptable degrees of mitral regurgitation in the operating room on transesophageal echocardiography and had to take the repair down and do a 2-patch technique. One of those, unfortunately, was on the infant daughter of the chairman of pediatrics. So that sort of soured me on the technique because I could not apply it in all situations. We have, subsequent to that, continued to use the 2-patch technique with good results, which we have presented in the recent past.

By sewing the bridging leaflets to the crest of the muscular septum, you are making the muscular septum the anterior annulus of the neomitral valve, and you further add a strip of Dacron, which you state produces an anterior annuloplasty. It would seem that the muscular ventricular septum would be very resistant to shortening. Could you explain how the annuloplasty works? I know you have described it, but I would like to know a little bit more detail. No other mitral annuloplasty technique that I am aware of attempts to shorten the anterior aspect of the mitral valve.

You also state that the Dacron annuloplasty strip, which holds the bridging leaflet to the septum, lifts the anterior component of the neomitral valve away from the left ventricular outflow tract. How does that happen? It would seem that this would increase the likelihood of left ventricular outflow tract obstruction, which you have addressed.

I applaud the authors on their excellent results and their attempt to simplify a complex repair. I remain skeptical that this technique can be applied to all AVSDs. Could the authors expand further on their technical details of the repair and exactly how it works?

Dr Nicholson. It would seem counterintuitive to attempt to narrow the annulus of the mitral valve anteriorly, especially in the normal heart. These hearts are not normal and do not have the normal anterior fibrous trigonal component to support the anterior leaflet of the repaired neomitral valve. Our "annuloplasty" is perhaps not "shortening" the annulus but is providing "rigid" support for the neomitral valve.

In a single-patch repair performed the traditional way, there has been regurgitation seen after the operation if the single patch is made too big, leaving quite a mobile structure that acts as the anterior annulus of the mitral valve. The valve is unsupported in this area. We feel that our Dacron strip annuloplasty is providing some form of rigid support to the valve anteriorly and that this is important for reliable valve function, especially in patients with larger ventricular scoops. This also takes tension off the leaflets and allows them to billow away from the left ventricular outflow tract. Our echocardiographic follow-up does not show the leaflets to be more apically positioned in systole than if we used our traditional 2-patch technique.

The other technical aspects of the repair are similar to a 2-patch repair. We assess the atrioventricular valve with insufflation, partition the valve similarly, and pass sutures on the right of the septal crest. The repair is simpler with this technique.

Dr Carlo F. Marcelletti (*Modena, Italy*). I can easily figure out, like most of us, how to use this technique with the type A Rastelli atrioventricular defect where the anterior common leaflet is divided and attached to the septum. I have noticed that 19 patients, that is 40% of your total cohort, had a nondivided free-floating anterior leaflet, a situation that commonly is associated with conotruncal abnormalities. That is the situation where most of us would approach closing the VSD component of the defect with an atrial and ventricular approach. It is not easy for me to figure out how to perform

such operations in patients who have, let us say, common atrioventricular canal and tetralogy or common atrioventricular canal and other associated conotruncal abnormalities.

Dr Nicholson. In this series, all 47 patients underwent repair without a ventricular patch component whether the anterior leaflet was free floating or not.

We have repaired the defect in patients with tetralogy of

Fallot and double-outlet right ventricle anatomy in addition to common atrioventricular canal. In these patients we have added a ventricular patch anterosuperiorly to correct the deficiency in the region of the conotruncus. We have then proceeded as previously described by sewing the common leaflets to the crest of the septum posteroinferiorly and to the edge of this patch anterosuperiorly.

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