Effect of Atrial Septal Defect Repair on Left Ventricular Geometry and Degree of Mitral Valve Prolapse

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with the technical assistance of Janie Stewart

SUMMARY To ascertain the effects of surgical closure of atrial septal defect on left ventricular geometry and degree of mitral prolapse, 14 patients with atrial septal defect were studied by cross-sectional and M-mode echocardiography preoperatively and 7 days postoperatively. Seven of the 14 patients (50%) had mitral valve prolapse preoperatively by cross-sectional echocardiography. To quantify the degree of prolapse, we measured the net algebraic area subtended by the apposed mitral valve leaflets in systole (MVAS) with respect to the mitral ring. The mitral valve prolapse group had an MVAS of 0.3 ± 3.1 units (mean ± SEM) preoperatively, while the group without mitral valve prolapse had an MVAS of 12.5 ± 3.1 units (p < 0.02). Postoperatively, prolapse either decreased in degree or was abolished in six of seven patients (86%), associated with an increase in MVAS to 14.7 ± 4.4 units (p < 0.02). In all patients, septal curvature in diastole on short-axis view normalized either partially or completely postoperatively, resulting in decreased left ventricular eccentricity (1.34 ± 0.06 preop vs 1.06 ± 0.07 postop, p < 0.001). Atrial septal defect closure, therefore, leads to normalization of left ventricular geometry and in patients with evidence of mitral valve prolapse, is associated with a decrease in the degree of prolapse.

ABNORMAL LEFT VENTRICULAR shape has recently been demonstrated in patients with atrial septal defect by cross-sectional echocardiography.1, 2 This altered left ventricular configuration is produced by a leftward shift of the interventricular septum, apparently in response to right ventricular dilatation. The degree of left ventricular deformity may vary from a slight decrease in the normal septal curvature or septal flattening to total reversal of the direction of septal curvature with resultant bulging of the septum into the left ventricular cavity. The prevalence of reported abnormal left ventricular geometry has varied from 38–100%.1, 2 This variation in prevalence may, in part, be explained by the fact that abnormality in shape has only been assessed qualitatively by visual inspection. Despite this variation in reported prevalence, however, the occurrence of abnormal left ventricular shape in a significant percentage of patients with atrial septal defect appears established.

A high incidence of mitral valve prolapse has also been reported in patients with atrial septal defect.3, 4 In ventriculographic studies, this incidence has been approximately 35%. Using phased-array, two-dimensional echocardiography, Lieppe et al.7 found anatomic mitral valve prolapse in 95% of their patients with atrial septal defect. Forty-one percent of these patients had no auscultatory evidence of prolapse, while 37% did not have prolapse by biplane ventriculography. Betriu et al.8 found that 17% of their patients with atrial septal defect and mitral prolapse on right anterior oblique ventriculography had “silent prolapse.” Thus, mitral valve prolapse also occurs commonly in patients with atrial septal defect and is frequently undetected clinically.

The reason for this high incidence of mitral valve prolapse in patients with atrial septal defect remains unexplained. We reasoned that mitral valve prolapse should be due either to some intrinsic abnormality of the mitral valve itself or to some distortion of the left ventricle that affects the closing pattern of the mitral leaflets. Because no pathologic abnormality of the mitral valve has been demonstrated consistently in patients with atrial septal defect, the high incidence of mitral valve prolapse might be related to the distortion in left ventricular shape. If so, an intervention that would tend to normalize the configuration of the left ventricle should be associated with a decrease in the degree of prolapse of the mitral valve. Because abnormal shape is associated with atrial septal defect, acute closure of the defect might provide such an intervention. This study, therefore, examines the effect of atrial septal defect closure on left ventricular geometry and the relationship of changes in left ventricular geometry to the tendency of the mitral leaflets to prolapse.
Materials and Methods

The study group consisted of 14 consecutive patients who underwent surgical repair of atrial septal defect without associated complex cardiac pathology during a 2-year examination period. There were 12 females and two males whose average age was 20 years (range 3–58 years). Twelve patients had ostium secundum atrial septal defect, of whom two had associated valvular pulmonic stenosis of mild and moderate severity. Two patients had ostium primum defects, one of whom had associated left atrial valve. Preoperative hemodynamic studies were available on each patient (table 1).

Echocardiographic Methods

Cross-sectional and M-mode echocardiographic studies were obtained in each case preoperatively and 7 days after surgery. The cross-sectional studies were performed using either a mechanical sector scanner developed in collaboration with the Fortune Fry Research Laboratories at the Indiana University School of Medicine or a commercially available scanner (Smith-Kline Instruments EkoSector I). These systems consisted of a modified Ekoline 20A Echograph with a pulse repetition rate of approximately 4 kHz/sec and a scanner probe containing a 2.25-MHz transducer mechanically driven through a 30° sector at 30 cycles (60 frames)/sec. The operating characteristics of these systems have been previously described.19–22 Cross-sectional images were recorded on videotape using a Sanyo VTC-7100 cassette recorder. The images were then available for analysis in real-time, slow-motion or single-frame formats. An R-wave-triggered electronic counter was superimposed on the left-hand edge of the raster to allow precise timing of each frame in the cardiac cycle. A depth scale, calibrated in centimeters, permitted quantitative measurement of image echoes with respect to each other and the anterior chest wall. Single frames at specific points in the cardiac cycle could be converted to hard copy using a Polaroid photographic system.

For the echocardiographic studies, patients were examined in either the supine or 30° left lateral position. Because the areas of greatest interest were the mitral valve and the left ventricle in the region of the mitral valve, all studies were performed with the transducer placed on the anterior chest wall at a level directly anterior to the mitral valve, which was usually to the immediate left of the sternum in the fourth or fifth intercostal space.

To assess left ventricular geometry, short-axis views of the left ventricle were obtained at the level of the mitral chordal transition. Short-axis views were chosen because this projection most clearly displays interventricular septal position and motion patterns. The mitral chordal transition was selected for plane placement because it represents a reproducible level in the left ventricle and is the area at which standard assessment of left ventricular function is commonly obtained. In this imaging plane, the pattern of septal

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**Table 1. Clinical and Hemodynamic Features of the Study Group**

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<th>Sex</th>
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<th>PAP (mm Hg)</th>
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*Mitral valve prolapse preoperatively.

Abbreviations: ASD = atrial septal defect; MV = mitral valve; NI = normal; PS = pulmonic stenosis; PAP = pulmonary artery pressure (systolic/diastolic/mean); PVR = pulmonary vascular resistance; Qp/Qs = ratio of pulmonic to systemic flow.
motion and variation in geometric configuration of the left ventricle were first evaluated in real time. In order to quantify the maximum degree of left ventricular deformity, single end-diastolic frames were then obtained. End-diastole was selected because this represents the point of maximal leftward shift of the interventricular septum and, therefore, maximum distortion in left ventricular configuration. End-diastole was defined as occurring at the point of maximum posterior displacement of the posterior left ventricular wall.

To quantitate the degree of abnormality of left ventricular geometry, an index of short-axis left ventricular eccentricity (e) was obtained as the ratio of the two minor axes of the left ventricle in this plane (fig. 1). To define these axes, an ellipse was constructed with the posterior wall left ventricular endocardium comprising the posterior arc of its circumference. The minor and major axes of this ellipse were then determined. The major axis of the ellipse (b) corresponded to the longer of two minor axes of the left ventricle. The smaller of the two minor axes of the left ventricle (a) was determined as the length of a chord defined by the intersection of the minor axis of the ellipse with the septal and posterior wall endocardium, respectively.

The degree of deformity of the ventricle was then expressed as the ratio of these two axes, where e = b/a. If the ventricle is circular, these two axes will be equal and “e” will equal 1. As the septum shifts leftward toward the posterior wall, however, “a” will become shorter relative to “b” and the value for “e” will increase. The greater the value of “e,” therefore, the greater the degree of deformity of left ventricular shape (fig. 1).

To analyze mitral leaflet motion and geometry to detect the presence and severity of mitral valve prolapse, long-axis views of the mitral leaflets and mitral ring were obtained (fig. 2). Because prolapsing motion of the mitral leaflets is motion relative to the plane of the mitral valve ring, this particular spatial plane was initially defined. The mitral valve ring by definition lies in the plane of a line connecting the aortomitral junction anteriorly and the atrioventricular groove at the insertion of the posterior mitral leaflet posteriorly. The mitral ring dimension was determined as the length of this line at end-diastole. To quantitatively study the systolic geometry of the mitral valve in respect to the mitral ring, we introduce the acronym MVAS (mitral valve area subtended) to denote this parameter.

Mitral valve segments located on the ventricular side of the mitral ring, by definition, subtended positive areas. Prolapse occurred, by definition when any part of the mitral valve in systole was situated on the atrial side of the ring. The area that the prolapsing segment subtends with respect to the mitral ring is by definition negative and the MVAS in such a case will equal the sum of the area subtended by the nonprolapsing segments (positive) and the prolapsing segment (negative). Should the area of the prolapsing segment be exceeded by that of the nonprolapsing segment, MVAS will be positive, yet mitral valve prolapse will nonetheless exist. As the degree of prolapse increases, MVAS approaches zero, and when the area subtended by the prolapsing segment exceeds that of the nonprolapsing segment, MVAS becomes negative. MVAS therefore does not define the presence or absence of prolapse, but rather indicates
the tendency of the mitral leaflets to prolapse.

In each case MVAS was derived from a Polaroid still frame of the mitral valve at the time of its maximum superoposterior displacement in systole. The contour of the mitral valve, as well as the position of the mitral ring, was traced on 340-M Dietzgen millimeter graph paper. One MVAS unit was the area enclosed by one small square of this graph paper (1.0 cm² = 13 MVAS units. Finally, the MVAS index (MVASI) was obtained by dividing MVAS by body surface area. MVASI permits comparison of mitral geometry among patients of different ages and sizes.

Figure 2 illustrates how the above parameters were obtained for patient 12, who did have prolapse. Figure 3 illustrates these measurements for patient 4, who had coexistent mitral prolapse preoperatively.

M-Mode Echocardiographic Recordings

M-mode recordings were also obtained pre- and postoperatively to precisely quantify changes in left ventricular internal dimension at end-diastole (LVID), right ventricular internal dimension at end-diastole (RVID), and left atrial dimension. M-mode studies were performed using an Ekoline 20A echograph with a 2.25-MHz transducer focused at 7.5 cm. Standard techniques for patient positioning and left ventricular recordings were used. In addition, the relative anteroposterior position of mitral coaptation was observed and annotated qualitatively.

Preoperative and postoperative measurements of all parameters were available for all except patient 5. Records were analyzed by two of the authors, with one observer blinded to the patient’s name and operative status. Postoperative trends in each parameter were analyzed for significance using the paired t test.

Results

Preoperative and postoperative parameters describing left ventricular geometry are detailed and summarized in Table 2. Parameters describing patterns of mitral coaptation are detailed in Table 3. M-mode echocardiographic measurements are listed in Table 4.

Left Ventricular Geometry

Short-axis, end-diastolic septal curvature and, therefore, left ventricular cavity geometry were abnormal in all 14 patients studied preoperatively. Postoperatively, septal curvature ameliorated partially or completely in all 14 patients, with the eccentricity (e) decreasing from 1.34 ± 0.06 (mean ± SEM) to 1.06 ± 0.07 (p < 0.001). The left ventricle thus became more circular in all patients after surgical closure of the atrial septal defect. Initial systolic septal motion, which was abnormal in all patients preoperatively, normalized in 12 of the 14 patients.

Although no direct relationship between preoperative “e” and Qp/Qs could be established, the most eccentric left ventricles were found in patients 3 and 4, who had the highest and fourth highest Qp/Qs ratios, respectively. Further, shunt closure by surgery, and thus presumed normalization of Qp/Qs to 1.0 in all 14 patients, led to significant normalization of short-axis left ventricular geometry, as gauged by “e.”

Patterns of Mitral Valve Coaptation in Systole

Seven of the 14 patients (50%) had associated mitral valve prolapse preoperatively by long-axis, cross-sectional echocardiography. Of the six adult patients, four (67%) had mitral valve prolapse, while three of the eight children (38%) had associated prolapse. Five of the seven patients had clearly demonstrable prolapse of the anterior mitral leaflet, while the remaining two patients had prolapse of both the anterior and posterior leaflets. In the five patients having only anterior leaflet prolapse, the pattern of prolapse was characteristic, with superoposterior arching of the anterior mitral leaflet, and coaptation of the two leaflets in very close proximity to the atrioventricular groove. In these cases, the posterior leaflet could not be clearly identified, but no evidence of posterior leaflet prolapse was evident.

For the entire group, MVAS preoperatively was 5.9 ± 3.8 units (mean ± SEM) and increased postoperatively to 16.2 ± 2.4 units (p < 0.02). This in-
### Table 2. Preoperative and Postoperative Parameters Describing Left Ventricular Geometry

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<th>Postoperative eccentricity</th>
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*Mitral valve prolapse preoperatively.

Abbreviations: B = bulging into left ventricle; F = flat; Nl = normal; P = paradoxic, anterior.

### Table 3. Preoperative and Postoperative Parameters Describing Mitral Valve Geometry

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*Mitral valve prolapse preoperatively.

†13 units = 1.0 cm².

Abbreviations: MVAS = area subtended by the apposed mitral valve in systole on long-axis, cross-sectional echocardiography, with respect to the mitral ring; BSA = body surface area; MVASI = MVAS/BSA.
indicates a decreased tendency to prolapse acutely after atrial septal defect repair, for the group as a whole.

Preoperatively, the mean MVAS in the seven patients with prolapse was 0.28 ± 3.12 units, which was significantly less than the mean for the group without prolapse (12.5 ± 3.10 units, \( p < 0.01 \)). No direct relationship was demonstrable preoperatively between MVAS and "e." The two patients with the greatest degree of prolapse were also those with the greatest preoperative eccentricity (patients 3 and 4).

Good correlation between the tendency to prolapse (MVASI) and the Qp/Qs ratio was observed (\( r = -0.70 \)). This apparent negative regression of MVAS on Qp/Qs is illustrated in figure 4. Repair of the atrial septal defect, as indicated above, resulted acutely in partial or complete normalization of short-axis left ventricular geometry. It also led to a significant decrease in the degree, or abolition, of prolapse in six of the seven patients (86%) who had mitral valve prolapse preoperatively. MVASI for the prolapse group increased from 1.8 ± 2.5 units/m² pre-

![Graph showing relationship between MVASI and Qp/Qs ratio](image)

**FIGURE 4.** Relationship of the tendency to mitral valve prolapse, as quantitated by MVASI (index of the net algebraic area subtended by the apposed mitral valve with respect to the mitral ring) to the Qp/Qs (pulmonic-to-systemic flow) ratio. There is good negative correlation between the tendency to prolapse and the Qp/Qs ratio (\( r = -0.70, p < 0.01 \)). ○ = adult patients without mitral valve prolapse; • = adult patients with mitral valve prolapse; Δ = pediatric patients without mitral valve prolapse; ★ = pediatric patients with mitral prolapse.

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<td>13*</td>
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<tr>
<td>14</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

*Mitral valve prolapse preoperatively.

Abbreviations: RVIDI = index of right ventricular internal dimension at end-diastole; LVID = left ventricular internal dimension at end-diastole; LA = left atrial dimension; NI = normally located; P = posteriorly located.
operatively to 13.8 ± 4.6 units/m² postoperatively
(p < 0.02).

There were no significant changes in mitral ring
dimension postoperatively, either for the entire group
of 14 patients, or for the group with prolapse. Pertinent
features regarding left ventricular geometry and mitral
valve coaptation for the seven patients with prolapse
are detailed in tables 2 and 3.

Chamber Dimensions

Right ventricular internal dimension index (RVIDI)
diminished significantly after atrial septal defect
repair, from 2.69 ± 0.16 cm/m² to 2.19 ± 0.17
cm/m² (p < 0.01). With the exception of patient 3,
postoperative RVIDI values remained elevated above
the upper limit of normal.

Mean LVID appeared to increase postoperatively,
from 3.16 ± 0.21 cm to 3.64 ± 0.19 cm. This trend,
however, was not statistically significant at the
p = 0.05 level. Similarly, for the seven patients with
prolapse preoperatively, LVID increased from
3.40 ± 0.29 cm to 3.82 ± 0.31 cm, but this trend was
also not statistically significant at the p = 0.05 level.

No significant change in left atrial dimension after
atrial septal defect repair was found. Finally, the loca-
tion of mitral coaptation by M-mode echocardiog-
diaphy appeared to occur relatively posteriorly in
10 of the 14 patients, preoperatively. Specific values
for M-mode parameters are given in table 4.

Discussion

This study describes quantitative cross-sectional
echocardiographic methods for assessing abnor-
malities of left ventricular and systolic mitral valve
geometry in patients with atrial septal defect. Using
these methods, we ascertained the acute effects of
atrial septal defect repair on left ventricular geometry
and, in patients with associated mitral valve prolapse
preoperatively, the alterations in the degree of
prolapse.

Left Ventricular Geometry

Septal curvature at end-diastole was abnormal pre-
operatively in all 14 patients, and normalized partly or
completely in each patient after defect closure. Left
ventricular contour, therefore, became more circular
and the eccentricity of the ventricle in short axis
diminished significantly after atrial septal defect repair.
No direct relationship between the preoperative eccen-
tricity and the magnitude of the left-to-right shunt, as
assessed by the Qp/Qs ratio, could be established. The
observation that left ventricular geometry is ameliorated
acutely after termination of interatrial shunting suggests,
however, that a major etiologic determinant of abnormal
gender in these patients is the shunt itself.

Lieppe et al.² suggest that abnormal septal cur-
vature occurs less frequently in patients with atrial
septal defect and is primarily related to pulmonary
arterial hypertension. The lower prevalence of abnor-
mal septal position in Lieppe’s study may be explained
in part by the relatively more inferior level along the
base-to-apex axis at which they assessed short-axis left
ventricular geometry, namely, the papillary muscles
and chordae. Both Weyman et al.¹ and Hagan et al.¹³
observed that in some patients with right ventricular
volume overload the more inferior part of the inter-
ventricular septum moved posteriorly in systole. This
implies that in such patients the lower septal segment
may have normal end-diastolic curvature. In addition,
prior studies have made only qualitative assessment of
left ventricular geometry and hence may be less sen-
sitive to small changes in configuration. Our data tend
to refute an exclusive role for pulmonary hyperten-
sion in the etiology of left ventricular eccentricity.
Although all 14 of our patients had abnormal septal
curvature preoperatively, 12 had systolic pulmonary
artery pressures of 30 mm Hg or under, and none had
a systolic pressure greater than 50 mm Hg. All 14 had
normal pulmonary vascular resistance.

Interventricular Septal Motion

We observed that all 14 patients had paradoxic,
atrial septal motion preoperatively. By 7 days after
defect repair, septal motion normalized in 12 of the 14
patients (86%). The other two patients had a flat sep-
tum during systole postoperatively. Our study, then,
confirms the high prevalence of abnormal systolic sep-
tal motion in patients with nonoperated atrial septal
defects previously reported by M-mode echocar-
diographic studies. The high rate of normalization of
septal motion postoperatively that we report,
however, differs significantly from that in the M-mode
studies of Pearlman et al.,¹⁴ Meyer et al.¹⁵ and Kerber
et al.¹⁶ More recently, however, Wanderman et al.¹⁷
using M-mode echocardiography, found normal sep-
tal motion in 87% of 45 patients with repaired atrial
septal defect.

The explanation for the discrepancy in normaliza-
tion rates between our study and other studies is not
clear. The likelihood of normalization of septal motion
after atrial septal defect repair may in part be related
to the duration of the shunting, i.e., the patient’s age at
operation. Ten of 14 patients in our series were 23 years or younger, and eight of these
were 8 years or younger. All of the patients in the
series of Meyer et al.¹⁶ were in the pediatric age range,
and they had a relatively high rate of normalization
of septal motion. However, the three oldest patients
in our study also had postoperative normalization of sep-
tal motion. An alternative explanation may be that
whereas M-mode echocardiography only images a
small segment of the septum and hence records mo-
tion of only an isolated and frequently selected area,
the cross-sectional technique permits the entire inter-
ventricular septum to be viewed in the short-axis pro-
jection, and, consequently, the net motion of the entire
septum in this plane can be assessed. M-mode echo-
cardiograms in some of our cases showed abnormal
postoperative septal motion in the selected areas
recorded, while cross-sectional, short-axis views
showed normal overall septal motion. Further, the widely varying prevalence rates of abnormal septal motion reported after defect repair may in themselves support the hypothesis that by selecting limited areas of the system the M-mode may not truly reflect the general pattern of septal motion.

Chamber Dimensions

All 14 of our patients had abnormal RVIDIs preoperatively. After atrial septal defect repair, RVIDI decreased significantly and acutely, but with the exception of one patient, postoperative RVIDI still remained above the upper limit of normal. This finding confirms previous reports\(^\text{15, 17, 18}\) and may be explained by chronic changes in right ventricular systolic and diastolic function induced by longstanding interatrial left-to-right shunting.

We found that LVID increased acutely after defect repair, but this finding was not statistically significant at the \(p = 0.05\) level. Wanderman et al.\(^\text{17}\) however, compared mean LVID in 13 patients with repaired atrial septal defect with a group of 10 patients with unrepaired atrial septal defects, and found a significantly larger LVID in the former group (\(p < 0.001\)).

Our cross-sectional and M-mode echocardiographic data indicate that short-axis left ventricular geometry normalizes soon after atrial septal defect repair. Presuming that the long axis of the left ventricle at end-diastole does not diminish postoperatively, total left ventricular volume can also be expected to increase after atrial septal defect repair. No significant changes in left atrial dimension, however, could be demonstrated by our study.

Mitral Valve Coaptation Geometry

We report herein, for the first time, a quantitative method for assessing the geometry of the closed mitral valve in systole, using cross-sectional echocardiography. MVASI measures the tendency of the valve to prolapse. As MVASI approaches zero or becomes negative, the overall position of the opposed mitral valve is relatively more atrial, and therefore less ventricular, and the valve has an increased tendency to prolapse. We found that repair of the atrial septal defect was associated with a significant increase in MVASI for the 14 patients. This implies that termination of the interatrial shunt is associated not only with normalization of left ventricular geometry, but also of systolic mitral valve geometry and a decreased tendency toward prolapse.

Repair of the defect led acutely to either significant amelioration or complete abolishment of prolapse in six of seven patients. Remarkably, the one patient who did not show amelioration in the degree of prolapse still had significant deformity of left ventricular geometry after defect repair (patient 3, \(e = 1.23\) postop).

Cross-sectional echocardiography appears to be superior to both ventriculography and M-mode echocardiography for the study of mitral valve geometry.\(^\text{1, 19}\) Ventriculography cannot differentiate among structures that are situated colinearly in the path of the x-ray beam. Right anterior oblique ventriculography often cannot identify the anterior mitral leaflet, as this structure overlaps with the posterior leaflet and aortic root in this projection.\(^\text{20}\) Conversely, M-mode echocardiography, which has excellent axial resolution, has no lateral resolution. In certain instances of mitral valve prolapse, the prolapsing segment may only have a superior component to its displacement. In these cases, if the M-mode echo beam is directed straight posteriorly (as standard methods for the M-mode examination of the mitral valve prescribe\(^\text{20}\)), the prolapse will be missed completely and only drop-out of echoes may be recorded. Isolated anterior leaflet prolapse is an example of such an instance.

Long-axis, cross-sectional echocardiography is presently the only noninvasive technique that can image both mitral leaflets in systole along their long axis. This technique has good axial and lateral resolution, and can be used quantitatively, as we have described above. We thus believe that cross-sectional echocardiography is the best technique presently available for in vivo clinical study of mitral valve geometry.

Incidence and Possible Mechanism of Mitral Valve Prolapse in Atrial Septal Defect

We found prolapse preoperatively in 50% of our 14 patients; it was present in 67% of six adult patients and in 38% of the eight pediatric patients. The pattern was anterior leaflet prolapse only in five of seven patients and prolapse of both mitral leaflets in the remaining two patients. Our overall incidence of prolapse in atrial septal defect is considerably smaller than the 95% figure that Lieppe et al.\(^\text{8}\) reported. Eight of our 14 patients were children and in this pediatric age group we found an incidence of only 38%. Lieppe's group was predominantly adults, and our 66% incidence of prolapse in adults more closely approaches theirs. We have found a direct relationship between the magnitude of interatrial shunting (Qp/Qs) and the tendency to prolapse (MVASI). Although we cannot presently supply conclusive data to support it, an attractive hypothesis to explain the apparently greater incidence of prolapse among adult atrial septal defect patients compared with pediatric patients might be progression of the magnitude of the shunt with age.

Current speculations regarding the relatively high incidence of mitral valve prolapse associated with atrial septal defect center on two hypotheses: 1) anatomic manifestations of a common, single connective tissue defect on a congenital basis and 2) acquired abnormalities of left ventricular geometry.

We have reported that atrial septal defect repair leads acutely to amelioration of abnormal left ventricular geometry and to a decrease in the degree of prolapse. Further, patients with large Qp/Qs ratios had a greater likelihood of mitral prolapse preoperatively. Thus, the mechanism of mitral valve prolapse in atrial septal defect is related to abnormal left ventricular geometry attendant on left-to-right interatrial shunting.
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