Doppler mapping of postoperative left atrioventricular valve regurgitation


ABSTRACT Left atrioventricular valve regurgitation often occurs as a postoperative hemodynamic complication from repair of an atrioventricular septal defect. In this study, cross-sectional two-dimensional Doppler flow mapping of the left atrium was used to quantitate postoperative regurgitant flow in 29 patients. Its severity and location was related to the shape of the three leaflets of the left component of the atrioventricular valve, especially to the size of the mural leaflet. To identify which leaflet configuration was likely to cause regurgitation, the position of the leaflets was obtained from the parasternal short-axis view and the angular size of the mural leaflet expressed in degrees of an arc. Doppler mapping was performed in the apical four-chamber and the parasternal long-axis views, dividing the left atrium in nine squares in each. Regurgitation was defined as a jetlike systolic downstroke of the Doppler frequency shift in early systole. The angular size of the mural leaflet varied from 38 to 144 degrees (mean 86 ± 36 SD). Massive regurgitation (six to nine sites) was encountered in seven patients, five with a mural leaflet size of over 110 degrees, one with mural leaflet size between 70 and 110 degrees, and one with a mural leaflet size of under 70 degrees. No or minimal regurgitation was encountered in 10 patients, three having a mural leaflet size of 70 to 110 degrees and seven with a mural leaflet size of less than 70 degrees. These data suggest that massive regurgitation is encountered in patients with large mural leaflets, whereas patients with smaller mural leaflets tend to have no or mild regurgitation. In patients with large mural leaflets and mild regurgitation, the regurgitation was located adjacent to the mural leaflet in the postero-lateral part of the left atrium. We conclude that the size of the mural leaflet is of relevance both to the occurrence and the severity of postoperative valvular regurgitation in atrioventricular septal defects.


WE SUGGESTED previously that the severity of postoperative regurgitation through the left atrioventricular valve in atrioventricular septal defect is related to the size of its mural leaflet. The left-sided valve in atrioventricular septal defect has three leaflets: the left ventricular components of the superior and inferior bridging leaflets and the mural leaflet. It is likely to be the configuration of these leaflets and the absolute deficit in leaflet tissue that promote dysfunction of the valve. To determine the validity of this concept, we quantified regurgitation and correlated it with the extent of the mural leaflet. Our aim was to identify the severity and location of regurgitation in our patients to better define the most appropriate operative technique for repair.

Subjects and methods

Subjects. Twenty-nine patients at the Hospital for Sick Children, Great Ormond Street, London, and at the University of Maryland Medical System, Baltimore, were studied after surgical repair of atrioventricular septal defect. The cases with a common atrioventricular orifice and valve were repaired by a double patch technique in all patients. The left ventricular components of the inferior and superior bridging leaflets were attached to the crest of the Dacron patch used to close the ventricular part of the defect.

Methods. All patients had complete postoperative Doppler echocardiographic evaluation of the left-sided atrioventricular valve with parasternal long- and short-axis views and an apical four-chamber view. The ratio of left atrial and aortic root dimensions was calculated on an M mode study. The position of the atrioventricular leaflets in the parasternal short-axis view was recorded on videotape and freeze frame. The position of these leaflets and their junctions (figure 1) was subsequently marked...
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FIGURE 1. Short-axis view of the left atrioventricular valve in a patient with atrial ventricular septal defect.

on the same acetate overlay. The relative size and position of the valve leaflets were measured. Because the left atrioventricular valve in atrioventricular septal defect is more of a circular shape than is the normal mitral valve, we chose to construct its midpoint by drawing two lines bisecting the valve orifice at right angles to each other. This divided the short-axis view into four equal quadrants. The angles of the three commissures were then measured relative to anterior axis (0 degrees) from the calculated midpoint. From these measurements we calculated the angles of the arc that described and demarcated each leaflet.

Movement of the heart in the chest, particularly rotation along the long axis, could theoretically interfere with this measurement. This possibility has been evaluated in a previous study and found to be of minimal effect.

The transducer was then positioned to obtain apical four-chamber and long-axis views of the heart and pulsed Doppler flow tracings were obtained by mapping the left atrium, dividing it in nine squares as indicated in figure 2. In each position, Doppler samples were obtained in each of the nine squares to evaluate flow over the left atrioventricular valve orifice and to document retrograde flow in systole, the latter indicating regurgitation through the left atrioventricular valve at that particular position.

To weight the data, Doppler tracings of regurgitation in the first three squares immediately behind the valve each counted for one unit. The same tracings in the second line of three squares (in the mid-left atrium) each counted for two units, while those

FIGURE 2. Schematic depiction of the apical four-chamber view and long-axis view with the left atrium being divided in nine squares, in each of which separate Doppler sampling was performed during the study. The indication of 1, 2, and 3 units exemplifies the fashion in which positive findings of regurgitation by Doppler are weighed.

FIGURE 3. Increase of regurgitation expressed in units (0–20) in relation to the mural leaflet size (in degrees) as determined in apical four-chamber (A) and long-axis (B) views.

The transducer was then positioned to obtain apical four-
in the third line (in the back of the left atrium) were counted as three units when positive for regurgitant flow. This method is entirely arbitrary but was designed to compensate for the jet tracings that, because of angling problems, might have been missed in the area between distal sampled squares and the valve.

The data were analyzed with a two-tailed Student's t test after checking for normal distribution. A probability value of $p = .05$ or less was accepted as significant.

**Results**

Good-quality Doppler flow tracings were obtained in all cases. Regurgitation, visualized as a jetlike negative velocity pattern starting in early systole, was found in almost all patients. The units of regurgitation as detected in both the four-chamber views and the long-axis view increased concomitantly with increasing size of the mural leaflet (figure 3).

**FIGURE 4.** Severity of regurgitation varying from mild (1 to 2 sites) and moderate (3 to 5) to severe (6 to 9), compared with the size of the mural leaflet.

**FIGURE 5.** Both panels show the apical four-chamber view and long-axis view. The top panel shows the group of patients with a mural leaflet larger than 76 degrees while the lower panel depicts the groups of patients with a mural leaflet smaller than 76 degrees. The black areas represent the highest frequency of regurgitation found by Doppler. The heavily dotted areas show a moderate regurgitation frequency, the lightly dotted areas show mild regurgitation, and an open square indicates absence of regurgitation. In the bottom panel, only a moderate amount of regurgitation is present at the superioseptal localization near the "cleft." In the top panel, more regurgitation is shown mainly at the lateroinferior compartment of the left atrium, near the mural leaflet. LV = left ventricle; RV = right ventricle; L = lateral; C = central; S = septal.
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FIGURE 6. Excised left atrioventricular valve. SBL = superior bridging leaflet; IBL = inferior bridging leaflet; ML = mural leaflet. Note the tissue deficit at the site of the mural leaflet.

Of nine patients with large mural leaflets (>110 degrees), five had massive regurgitation as judged by Doppler, a negative jetlike appearance of the Doppler frequency shift being recorded in early systole in six to nine squares of each plane of investigation. Four patients had moderate (three to five squares) regurgitation. In nine patients with mural leaflets of 70 to 110 degrees, only one had massive regurgitation, five had moderate regurgitation, and three had mild or no regurgitation (one to two squares). In the patients with small mural leaflets, only one had massive, three moderate, and seven mild or no regurgitation (figure 4).

We divided the patients into two groups at the mean mural leaflet size of 86 degrees. This division showed that regurgitation in the group under 86 degrees was largely in the centromedial part of the left atrium, near the commissure between the bridging leaflets (the "cleft"). In contrast, in the group with mural leaflet over 86 degrees, the regurgitation was predominant near the mural leaflet and was related to the commissure between the mural leaflet and the inferior bridging leaflet in the posterolateral section of the left atrium (figure 5).

Discussion

The method used in this study to evaluate the regurgitation is perhaps the next best method to Doppler color flow mapping, a technique unavailable to the authors. The technique was preferred over other quantitative approaches because it gives a good idea of localization and allows a semiquantitative estimate of the regurgitation. The choice to use the weighted system is an arbitrary one. This choice did not influence the correlation coefficients obtained and was made exclusively to deal with the shortcomings of the technique, particularly the possibility that a regurgitant jet

FIGURE 7. Instead of employing the frequently used annuloplasty technique in this lesion, as shown in 1, we recommend combining Carpentier’s trileaflet repair with the annuloplasty at the base of the mural leaflet, as shown in 2. The anchor points of the annuloplasty should be beyond both lateral commissures, reducing the angle of the mural leaflet by pulling the commissures toward each other.
may have been missed in the squares proximal to the obtained tracings.

Postoperative regurgitation of the left-sided atrioventricular valve has always been a problematic and, occasionally, fatal hemodynamic complication of surgical repair of atrioventricular septal defect.\textsuperscript{9--11} One of the methods traditionally used to abolish this regurgitation was to suture closed part of the so-called cleft (the space between the left ventricular components of the bridging leaflets), presumably hoping to restore the left-sided atrioventricular valve into a two-leaflet structure.\textsuperscript{12} Morphologic studies, however, have shown that this left-sided atrioventricular valve has never been a two-leaflet valve. Instead it is best regarded as a three-leaflet valve. Based on these morphologic findings, Carpentier suggested the valve would best be repaired in three-leaflet fashion treating the cleft as a functional commissure.\textsuperscript{5}

In a previous study\textsuperscript{1} we demonstrated that, when the functional commissure was progressively sewn until the valve was judged to be competent, postoperative central regurgitation could still be an important complication. In that study, we showed a correlation between the existence of regurgitation and the size of the mural leaflet. The current study expands this concept. Cross-sectional Doppler mapping of postoperative regurgitation in the left atrium correlates well with the size of the mural leaflet. Furthermore, we have shown that an important part of the regurgitation takes place at the location of the commissure between the mural leaflet and the inferior bridging leaflet. Figure 6 shows an excised left atrioventricular valve from one of our patients. The remarkable tissue deficit at the site of the inferomural commissure is readily appreciated. Note also that it is poorly supported by papillary muscles. These features together account well for the regurgitation.

In the presence of such a valve, we suggest a combination of Carpentier’s trileaflet repair with an annuloplasty at the base of the mural leaflet. The anchor points of the annuloplasty should be beyond both lateral commissures, reducing the angle of the mural leaflet by pulling the commissures toward each other, as shown in figure 7. This technique has been used successfully by the coauthors (T. E., J. M. Q.) in treating central regurgitation after trileaflet repair of atrioventricular septal defects, with both separate right and left valves ("partial" or ostium primum defects) or a common valve ("complete defect").

In conclusion, our study has shown that a large mural leaflet indicates an increased risk for significant regurgitation after surgical repair of the atrioventricular septal defect. We have demonstrated that the regurgitation takes place at the site of the mural leaflet itself. Modification of the technique for repair may be warranted in the presence of such a large mural leaflet.

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