Barlow disease: Simple and complex

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Barlow disease is a clinical syndrome characterized by a late systolic murmur and nonejection systolic click. Barlow and colleagues¹ demonstrated by cardiac catheterization and phonocardiography that these auscultatory findings were due to late systolic mitral regurgitation. Barlow and colleagues¹ emphasized that the condition they were reporting was distinct from apical pansystolic murmurs with late systolic accentuation as a result of mitral regurgitation.

In 1964, Segal and Likoff² reported late systolic “bulging” of the anterior mitral leaflet associated with the onset of mitral regurgitation. Barlow and Bosman³ in 1966 reported on 4 patients with late mitral murmurs and midsystolic clicks in whom the posterior mitral leaflet underwent massive protrusion into the left atrium during systole. Elsewhere in that same article, they described the posterior leaflet as “aneurysmal” or “billowing.”³ Also in 1966, Criley and colleagues⁴ performed cineangiographic studies that showed late systolic motion of large mitral leaflets into the left atrium. In 1968, mitral valve tissue excised from 3 patients with Barlow disease during mitral valve replacement was reported to show severe myxomatous degeneration of the leaflets and chordae.⁵

In 1968, Ehlers and associates⁶ were the first to report a left ventricular wall motion abnormality in Barlow disease. They observed a “systolic contraction ring” at the level of the bases of the papillary muscles, which they hypothesized in systole could lift the papillary muscles into the left ventricular cavity toward the mitral annulus, causing the chordae to slacken. In 1973, Liedtke and coworkers⁷ and Scampardonis and colleagues⁸ also independently reported a high incidence of left ventricular “inflow wall” systolic motion abnormalities in the region of the bases of the papillary muscles. Liedtke and coworkers⁷ also noted that in patients with “mitral click syndrome” the papillary muscles moved in systole toward the mitral annulus rather than the left ventricular apex. The definitive explanation of the roles of the left ventricle and papillary muscles in this syndrome was proposed by Nutter and associates⁹ in 1975. They advanced the theory that “when mitral prolapse becomes established the prolapsed leaflet(s) present a greater than normal surface area for the development of pressure stress

Three-chamber cardiac magnetic resonance images of severe Barlow disease.

Central Message

Barlow disease involves leaflets, chordae, annulus, and papillary muscle motion. Good repair requires understanding of these changes.

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and therefore permits excessive stress on the chordae and papillary muscles causing the leaflets to move upwards progressively into the left atrium in systole and impair or reverse downward papillary muscle motion and thus cause the chordae to be relatively elongated upwards in systole.” Subsequent studies have confirmed this concept of systolic papillary muscle traction.⁹⁻¹²

The systolic events producing the midsystolic click, severe bileaflet prolapse, late systolic mitral regurgitation, and left ventricular wall motion abnormalities are now better understood (Figure 1).^{11,12} In these patients, as systole progresses, the elongated chordae are pulled upwards toward the left atrium by the large leaflets, undergoing generalized severe progressive leaflet billowing and causing the click. As the systolic pressure rises in the left ventricle, the already severely dilated annulus has barely contracted and remains relatively flat and very enlarged. The large leaflets, already stretched horizontally by severe annular dilatation, become more stretched and more horizontal as systole progresses. The full surface area of the large mitral leaflets is now lying across the mitral orifice at about 90° to the long axis of the left ventricle. The zone of coaptation is progressively lost. The upward force of the blood at systolic pressure acting at right angles on this large surface area now is sufficient to overwhelm the downward force toward the apex of the contracting left ventricle on the papillary muscles. At this point, “papillary muscle traction”^{10,11} causes the papillary muscle tip to be drawn upward to the plane of

FIGURE 1. Three-chamber cardiac magnetic resonance images of severe Barlow disease. 1, Preoperative diastole. Mitral anteroposterior annular dimension is 58 mm. *p*, Tip of papillary muscles. 2, Preoperative late systole. The large mitral leaflets lie stretched across the dilated flattened mitral annulus and have no zone of coaptation. The entire leaflets are prolapsed above the plane of the annulus. The papillary muscles and left ventricular inferior wall are displaced upward. 3, Postoperative diastole. A 37-mm fully flexible ring has been inserted. 4, Postoperative late systole. The mitral leaflets slope down into the left ventricle and have a good zone of coaptation (15 mm). The left ventricular outflow tract dimensions are preserved. There is no systolic anterior motion. Papillary muscle and inferior wall motion are preserved. No leaflet resection was performed. *LVOT*, Left ventricular outflow tract.

the mitral annulus, instead of the normal downward motion to the apex. This is seen on the left ventricle as a wall motion abnormality. This 1.5-cm paradoxical upward motion of the papillary muscle tip with regard to the position of the free edges of the leaflets essentially represents a functional elongation of the chordae. As the leaflets prolapse further into the left atrium in late systole, the leaflet zone of apposition is abolished and severe mitral regurgitation develops.

Reduction of the size of the large hypokinetic annulus by a precisely dynamically sized flexible ring annuloplasty significantly restores annular size and contractility and dynamic geometric changes, which will properly match the leaflets size when they are not being distorted by annular dilatation or the effects of papillary muscle traction. The leaflets now are not prolapsing and are positioned more vertically with a good zone of apposition. Papillary muscle traction is eliminated, and the tips now descend normally to

FIGURE 2. Intraoperative appearance of Barlow disease. The leaflets are large and billowing. All leaflet segments are affected. The chordae are elongated. The annulus is severely enlarged.

the apex of the left ventricle, bringing the chordae down into the left ventricle by 1.5 cm. These changes are well seen in [Figure 1](#). If the annulus and leaflets are correctly matched with each other during dynamic testing, the leaflets do not appear crowded, because the annulus sizing technique with the left ventricle and left ventricular outflow tract (LVOT) inflated prevents use of a ring that is too small. Accurate sizing of the distended LVOT preserves normal LVOT dynamics. Significant systolic anterior motion has not been observed in any of our 119 Barlow repairs. Four patients (3.4%) had nonsignificant systolic anterior motion at the predischarge echocardiography.¹²

In their article in this issue of the *Journal*, Ben Zekry and colleagues¹³ have stated correctly that no definitive definition exists for “Barlow disease.” To be consistent with the history of this condition and with current usage,^{11,14,15} however, there is reason to suggest that the term “Barlow disease” should only be used to describe patients with severe myxomatous degeneration of the mitral valve; severe enlargement of all leaflet segments; leaflet billowing of all segments, with or without leaflet edge prolapse; and a severely dilated mitral annulus. These changes are illustrated in [Figure 2](#). I would add the presence of papillary muscle traction during late systole. In a recent report of my group that included 119 Barlow repairs, the preoperative annular dimension was 52.5 ± 4 mm in patients with Barlow disease, and all these patients had papillary muscle traction.¹² The description of some of the patients included by Ben Zekry and colleagues¹³ in their study would not fit either our definition of Barlow disease or that used by Carpentier and colleagues¹⁴ and by Adams and associates.¹⁵

FIGURE 3. This figure shows a normal valve for reference (A) and the important differences between true Barlow disease with leaflet billowing and annular dilatation (B) and the functionally different condition of mitral valve prolapse (D-H). In some cases, Barlow disease is complicated by associated mitral valve prolapse (C). (Reproduced with permission from Barlow JB, Pocock WA. Billowing, floppy, prolapsed or flail mitral valves? *Am J Cardiol.* 1985;55:501-2.)

A good understanding of the complexities of the distinction between leaflet prolapse and billowing is very important in the treatment of this pathology. The definitive description of these relationships was reported by Barlow and Pocock,¹⁶ who also acknowledged the work of Carpentier, and is summarized in Figure 3. It is essential that patients with Barlow disease with segmental leaflet edge prolapse in addition to generalized billowing (Figure 3, C)

be recognized and that the segmental prolapse be corrected with neochordae before applying a ring annuloplasty, because isolated annuloplasty will not correct localized segmental abnormalities and mitral regurgitation will therefore persist or recur. In our recent experience, 87.3% of our patients with Barlow disease required correction of localized prolapse before ring annuloplasty could be performed. In both types of valve pathology with symmetric leaflets

illustrated in Figure 3 (B and F), annular dilatation is an important factor producing the mitral regurgitation. In the type F pathology, which has relatively normal leaflets, mitral regurgitation is pansystolic, as in the report of Ben Zekry and colleagues,¹³ and can be corrected by simple annuloplasty that reapposes the separated edges of the leaflets with no other additional surgery. As Ben Zekry and colleagues¹³ note, this has been widely reported for many years. In our own recent series, 9.2% of 633 patients without Barlow disease had type F pathology. Papillary muscle traction was not seen preoperatively. Isolated annuloplasty reapposed the leaflets, producing a good zone of apposition.

In type B pathology, however, the mitral regurgitation is late systolic. The leaflets are very large. The group with this pathology constituted 22.7% of our patients with Barlow disease. If the annuloplasty ring is sized dynamically with the heart inflated, and in reference to a zone of apposition premarked on the leaflets, the annuloplasty will produce a good zone of apposition, make the leaflets more vertical into the left ventricle away from the left ventricular septum, and relieve papillary muscle traction and thereby draw down the papillary muscles and chordae toward the apex, alleviating the leaflet billowing. Significant systolic anterior motion is also avoided. The differences in the sizes of rings used emphasize the importance of recognizing the condition being treated. Ring size was 35 ± 2 mm for our patients with Barlow disease versus 31 ± 3 mm for the patients without Barlow disease.

For those trained in the Carpentier repair techniques, the concept of “excessive leaflet size” to be corrected by leaflet resection is a critical consideration. In the setting of Barlow disease, we have been asked frequently though the years how such large leaflets can be restored to the left ventricular cavity without causing “crowding” or LVOT obstruction. The echocardiographic findings in the study of Ben Zekry and colleagues¹³ are valuable and important, because they show clearly how the large leaflets assume a very acceptable position in the left ventricular cavity after simple annuloplasty surgery.

Our own studies with cardiac magnetic resonance imaging to quantify papillary muscle motion in mitral valve disease continue at present. We believe that further studies such as this of Ben Zekry and colleagues,¹³ in detail what actually happens during mitral repair, will continue to contribute to improved repair techniques.

References

1. Barlow JB, Pocock WA, Marchand P, Denny DM. The significance of late systolic murmurs. *Am Heart J*. 1963;66:443-52.
2. Segal BL, Likoff W. Late systolic murmur of mitral regurgitation. *Am Heart J*. 1964;67:757-63.
3. Barlow JB, Bosman CK. Aneurysmal protrusion of the posterior leaflet of the mitral valve: an auscultatory-electrocardiographic syndrome. *Am Heart J*. 1966;71:166-78.
4. Criley JM, Lewis KB, Humphries JO, Ross RS. Prolapse of the mitral valve: clinical and cine-angiographic findings. *Br Heart J*. 1966;28:488-96.
5. Bittar N, Sosa JA. The billowing mitral valve leaflet. *Circulation*. 1968;38:763-70.
6. Ehlers K, Engle MA, Levin A, Grossman H, Fleming R. Left ventricular abnormality with late mitral insufficiency and abnormal electrocardiogram. *Am J Cardiol*. 1970;26:333-40.
7. Liedtke AJ, Gault JH, Leaman DM, Blumenthal MS. Geometry of left ventricular contraction in the systolic click syndrome: characterization of a segmental myocardial abnormality. *Circulation*. 1973;48:27-35.
8. Scampardonis G, Yang SS, Maranhão V, Goldberg H, Gooch A. Left ventricular abnormalities in prolapsed mitral leaflet syndrome. *Circulation*. 1973;48:287-97.
9. Nutter DO, Wickliffe C, Gilbert CA, Moody C, King SB III. The pathophysiology of idiopathic mitral valve prolapse. *Circulation*. 1975;52:297-305.
10. Lee TM, Su SF, Huang TY, Chen MF, Liao CS, Lee YT. Excessive papillary muscle traction and dilated mitral annulus in mitral valve prolapse without mitral regurgitation. *Am J Cardiol*. 1996;78:482-5.
11. Lawrie GM, Earle EA, Earle NR. Nonresectional repair of the Barlow mitral valve: importance of dynamic annular evaluation. *Ann Thorac Surg*. 2009;88:1191-6.
12. Lawrie GM, Zoghbi W, Little S, Shah D, Ben-Zekry Z, Earle N, et al. One hundred percent reparability of degenerative mitral regurgitation: intermediate-term results of a dynamic engineered approach. *Ann Thorac Surg*. September 22, 2015 [Epub ahead of print].
13. Ben Zekry S, Spiegelstein D, Sternik L, Lev I, Kogan A, Kuperstein R, Raanani E. Simple repair approach for mitral regurgitation in Barlow disease. *J Thorac Cardiovasc Surg*. 2015;150:1071-7.e1.
14. Carpentier A, Adams DH, Filsoufi F, eds. *Carpentier's reconstructive valve surgery*. Philadelphia: WB Saunders; 2010;44:267-71.
15. Adams DH, Anyanwu AC, Rhamanian PB, Abscal V, Abascal V, Salzberg SP, et al. Large annuloplasty rings facilitate mitral valve repair in Barlow's disease. *Ann Thorac Surg*. 2006;82:2096-100; discussion 2101.
16. Barlow JB, Pocock WA. Billowing, floppy, prolapsed or flail mitral valves? *Am J Cardiol*. 1985;55:501-2.