Mitral Valve Prolapse: Time for a Fresh Look

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To what extent is prolapse of the mitral valve associated with mitral regurgitation and the risk of infective endocarditis, rupture of the chordae tendineae, and sudden death? Earlier studies used differing definitions and criteria, and reported prevalence of this deformity varied widely, especially between referral and general population studies. Advances in echocardiography have clarified the diagnosis, allowing classification of prolapse into subtypes associated with different degrees of risk and prognoses. [Rev Cardiovasc Med. *2001;(2)2:73–81*]

Key words: Mitral regurgitation • Mitral valve • Mitral valve prolapse

Mitral valve prolapse is generally understood to be the displacement of an abnormally thickened, redundant mitral leaflet into the left atrium during systole.[1] The valvular abnormality has been associated with midsystolic clicks and late systolic murmurs and with serious complications such as bacterial endocarditis, severe mitral regurgitation, and sudden death.[2] Mitral valve prolapse has also been linked to a long list of disorders, both related (such as Marfan syndrome[3]) and seemingly unrelated (supernumerary nipples[4]). Unfortunately, our understanding of the prevalence, complication rate, and associated disorders of mitral valve prolapse has been clouded by the use of varying techniques and criteria for diagnosis and by conclusions which are often drawn from highly selected referral populations. Despite this confusion, an understanding of the prevalence of mitral valve prolapse and the identification of possible subgroups most susceptible to complications remains important, since mitral valve prolapse is the most common cause of isolated mitral regurgitation requiring valve replacement and repair in the United States,[5] and the thickened leaflets form a recognized substrate for bacterial endocarditis.[6]

Since the early 1970s, echocardiography has been suggested to be an ideal method for noninvasively recording the movement of the prolapsing mitral leaflets.[1] Unfortunately, the continually changing echocardiographic techniques and criteria for diagnosis of mitral valve prolapse may have obscured rather than clarified the problem.[7] Over the past several years, new echocardiographic criteria for mitral valve prolapse have been established based on an understanding of the 3-dimensional structure of the mitral valve[8] and validated based on association with complications. Recent studies using these criteria have shed new light on the prevalence of mitral valve prolapse in the general population and on its complications. The purpose of this review is to examine these new data and to attempt to relate these findings to those of prior studies using less specific criteria for disease and complication rates defined from selected referral populations.

Background

Pathology. In order to understand the spectrum of prolapse identified by echocardiography, it is useful to review the pathologic features of prolapse that these echocardiographic findings display. The mitral valve consists of a single veil of tissue attached to the mitral annulus that is divided into anterior and posterior leaflets. The anterior leaflet occupies one third of the circumference of the annulus, while the posterior leaflet attaches to the remaining two thirds. The anterior leaflet has greater length from its tip to its annular insertion. The posterior leaflet has 2 indentations, or clefts, on its free edge, giving it a scalloped appearance. The central semi-oval scallop is usually the largest, and there are 2 smaller commissural scallops. Chordae tendineae from the anterolateral papillary muscle support the lateral portions of the anterior and posterior leaflets, while chordae from the inferomedial papillary muscle support the medial halves of both leaflets.

Microscopically, the mitral valve is composed of 3 layers: an outer thin endothelium-covered layer of collagen and elastic tissue, the *atrialis*, which is continuous with the left atrial endocardium; a central layer, the *fibrosa*, composed of dense collagen with occasional elastin fibers toward the annular attachment that forms the basic mechanical support of the mitral leaflet; and a third layer, the *spongiosa*, interposed between the atrialis and the fibrosa that consists of myxomatous connective tissue.[9,10]

In patients with classic mitral valve prolapse, or "floppy mitral valve," myxomatous connective tissue expands the spongiosa and separates bundles of collagen in the fibrosa, weakening the support of the valve. The increase in the amount of connective tissue produces thickening of the leaflets. Advanced lesions show apparent loss, coiling, and disruption of individual collagen bundles. Maximal disruption often occurs around sites of chordal insertion. This weakening of the collagen framework of the leaflet can lead to elongation of the leaflets and often of the chordae. In patients with mitral valve prolapse, the valve cusps are increased in area both longitudinally and in the transverse dimensions, leading to folding, convolution, and doming upward (hooding) of the cusps toward the atrium. The posterior leaflet is more frequently and more severely involved. Partial involvement is most frequently localized to the middle scallop, followed by the medial and lateral scallops, in that order. Elongation, tortuosity, and attenuation of the chordae tendinae are common. Rupture of the chordae leads to thinning of the hooded cusp. The ruptured chordae appear filiform, blunt ended, or folded back and adherent to the surface of the cusp. Missing chordae are common. In surgically excised valves, chordal rupture is common, being present in 77% of valves in 1 series.[11] The ruptured chords were typically those previously supporting the posterior leaflet (90%); chords to the anterior leaflet were ruptured in only 5%. Loss of chordal support to both leaflets was found in the final 5%. Annular dilatation is also reported, but whether this represents a primary manifestation of mitral valve prolapse or is secondary to chronic mitral regurgitation remains to be determined. The pathologic changes that characterize prolapse form a continuum, and even on direct inspection, the distinction between a normal and prolapsing valve can be difficult. Valves initially classified as "floppy" or prolapsing can often be reclassified as normal on further examination, or vice versa.

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M-mode echocardiography. In the early 1970s, a series of reports[12–14] suggested that M-mode echocardiography might offer an ideal noninvasive method for visualizing the abnormal motion of the prolapsing mitral valve, and a pattern of abrupt late systolic posterior leaflet displacement was described. These relatively specific criteria, in small groups of severely affected individuals and often confirmed surgically or angiographically, were soon deemed insufficiently sensitive, and the echocardiographic criteria for mitral valve prolapse were expanded until up to 21% of the "normal" population were deemed affected.[15] Subsequent studies demonstrated that the systolic M-mode appearance of prolapse could be produced in 40%–55% of "normal" subjects if the beam originated from a transducer placed above the apically moving valve apparatus.[16,17] Thus, all M-mode studies have a potential acquisition bias, since the appearance of prolapse can often be produced in subjects in whom it is expected.

Two-dimensional echocardiography. The advent of 2-dimensional echocardiographic imaging made it possible to relate the move-

ment of the mitral leaflets to surrounding structures (typically the mitral annulus) rather than to the transducer positioned on the chest wall, and it appeared that more consistent diagnostic criteria for mitral valve prolapse could be established.[18] Initial criteria relying on displacement of the mitral leaflet above the plane of the mitral annulus in the parasternal, long-axis view were confirmed bycineventriculography.[19] These criteria were subsequently broadened to facilitate diagnosis and increase sensitivity by including displacement of the leaflets above the annulus in the orthogonal apical 4-chamber view.[20] Application of these expanded criteria required the assumptions that the mitral annulus lay in a Euclidean plane (was flat) and that therefore the relation of the leaflets to the annulus would be similar when imaged in orthogonal views (apical 4-chamber versus parasternal and apical long-axis views). These expanded criteria (that is, the use of apical 4-chamber views to diagnose prolapse) led to a reported prevalence for mitral valve prolapse of up to 35% in adolescent subjects preselected to be normal.[21]

Three-dimensional echocardiography. Subsequent studies using 3-dimensional (3D) echocardiography have shown that the annulus is not flat but rather has a saddle-like shape, with the high points of the saddle (closest to the left atrium) positioned anteriorly and posteriorly and its low points (closest to the apex) positioned medially and laterally.[22] Imaging in tomographic planes that include the low points of the saddle (apical 4-chamber views) therefore may show mitral leaflet displacement above the annulus (toward the left atrium) during systole, whereas imaging of the same subject in planes that include the high points of the annulus (parasternal or apical long-axis views) may show the leaflet below the annulus during systole. Studies examining the relationship of leaflet position to the annulus have shown that complications such as moderate or greater mitral regurgitation, left atrial enlargement, and leaflet thickening do not occur until the leaflets are displaced above the high points of the annulus, and this is now used as the reference point for diagnosing mitral valve prolapse.[23]

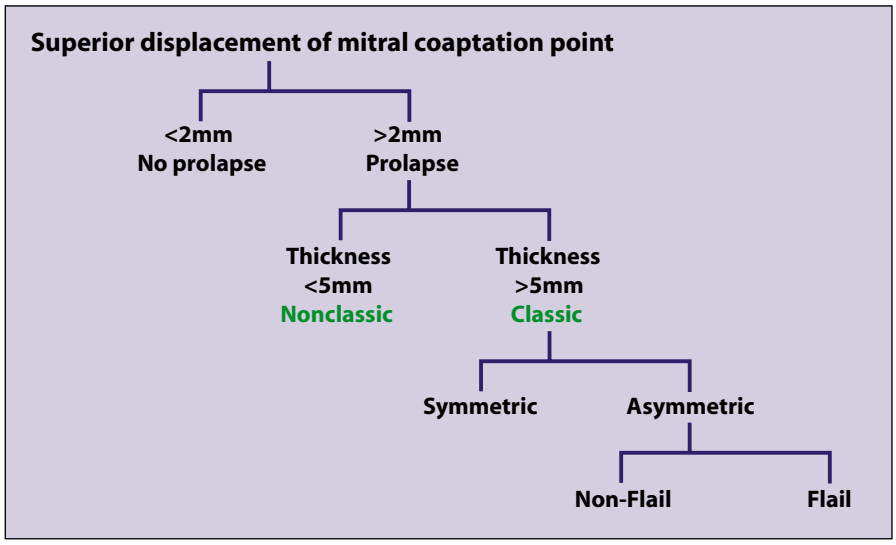
Diagnosis of Mitral Valve Prolapse

Current echocardiographic criteria for mitral valve prolapse. Despite the erratic path of progress, echocardiography continues to offer an ideal method for diagnosing mitral valve prolapse: It permits noninvasive visualization of both mitral leaflets in relation to the mitral annulus. Leaflet-annulus relationships can be recorded in a variety of projections under basal conditions and in response to stress. Figure 1 illustrates the basic echocardiographic criteria for mitral valve prolapse and groups prolapse into various subtypes.

As illustrated, prolapse is defined as the displacement of 1 or both mitral leaflets by more than 2 mm above the high points of the mitral annulus, recorded in either the parasternal or the apical long-axis view. The 2-mm cutoff is based on studies showing that beyond this threshold there was an incremental increase in the prevalence of complications (i.e., >1+ (on a scale from 1-4+) mitral regurgitation, left atrial enlargement, and leaflet thickening).[23] As with any such cutoff, there are undoubtedly patients with otherwise normal leaflets that may extend more than 2 mm above the annular high points. This value, however, has been shown to be best for separating patients with leaflet displacement associated with complications from those with otherwise normal valves.

Prolapse is further subdivided into classic and nonclassic forms based on leaflet thickness, with 5 mm consid-

Figure 1. *Echocardiographic criteria for mitral valve prolapse*



ered the upper limit of nonclassic. Prolapsing valves with leaflets more than 5 mm thick are considered to have "classic prolapse," while those with leaflets less than 5 mm thick are judged to have "nonclassic" prolapse.[24] As described earlier, leaflet thickening represents myxomatous degeneration of the valve, often associated with redundancy.

Patients with thickened, redundant leaflets (classic mitral valve prolapse) can be further subdivided into those with symmetric coaptation, in which the leaflet tips meet at a common point, and those with asymmetric coaptation, in which the tip of 1 leaflet is displaced toward the atrium relative to the other. Patients with asymmetric prolapse are particularly prone to progressive deterioration of the valve, possibly associated with chordal rupture, which may lead to a flail leaflet, whose tip everts and becomes concave toward the left atrium rather than the left ventricle. Flail leaflet is also a spectrum of disorders, ranging from eversion of the tip alone through complete detachment of chordae with unrestrained motion of the entire leaflet and severe mitral regurgitation. Recent data allow examination of the prevalence and complications of mitral valve prolapse based on this diagnostic construct.

Significantly, in addition to leaflet thickness, redundancy, and relationship to the mitral annulus and to each other, echocardiography can detect many of the complications of prolapse, such as the presence and severity of mitral regurgitation, the presence and degree of left atrial and ventricular dilatation, depression of left ventricular function, and the presence of valvular vegetations.

Clinical Features

Prevalence. The reported prevalence of mitral valve prolapse has varied widely depending on the population studied, the methods employed, and the criteria used for diagnosis of mitral valve prolapse. Using the current echocardiographic criteria listed above, a recent population study of 3,491 subjects from the Framingham offspring cohort reported a prevalence of 1.3% for classic and 1.1% for nonclassic mitral valve prolapse.[25] This overall prevalence of 2.4% is strikingly lower than the extreme values noted above and significantly lower than the more generally quoted figures of 4% to 7% for the generalpopulation based on M-mode studies.[1,26] This difference appears to be related to the greater specificity of the current criteria but, as will be discussed later, does not result in a loss of sensitivity for the detection of complications.

Effects of age. Earlier M-mode studies suggested that the prevalence of mitral valve prolapse peaks in early adulthood and declines thereafter.[26] In the more recent Framingham study, prolapse had no predilection for younger or older adult subjects, with a fairly even distribution (2%–3%) among subjects in each decade of age from 30 to 80 years.[25] This is consistent with the pathology of the lesion, which suggests that myxomatous change, once established, can progress but should not disappear with time. The majority of data suggest that prolapse is less prevalent in children, becoming more apparent following the adolescent growth spurt.[21,27]

Relationship to sex. In the Framingham study, there was no significant difference in the percentage of women with prolapse compared to that of the overall population. This again is in contrast to most data from M-mode studies, which have generally reported a higher prevalence of prolapse in women than in men.[26] The reasons for this discrepancy are not clear but may

Table 1
Differences Between Forms of Mitral Valve Prolapse

	Displacement (mm)	AL thickness (mm)	PL thickness (mm)	MR – JA/LAA (%)
Normal	-0.5 ± 2	3.3 ± 0.7	3.4 ± 0.8	2.4 ± 0.6
Nonclassic	3.1 ± 0.6	3.9 ± 0.5	4.1 ± 0.6	8.9 ± 1.5
Classic	3.8 ± 1.0	5.0 ± 0.6	5.6 ± 0.5	15.1 ± 1.3

AL, anterior leaflet; PL, posterior leaflet; MR, mitral regurgitation; JA, jet area; LAA, left atrial area

Data from Freed et al.[25]

relate to the presence of breast tissue in female subjects, necessitating M-mode recording from a higher interspace, which requires approaching the mitral valve from a more basal direction and introducing false-positive diagnoses of mitral valve prolapse.[17]

The prognostic significance of classic and nonclassic prolapse. Dividing patients into classic and nonclassic groups raises the question of whether nonclassic prolapse is a variant of normality or an intermediate stage in the spectrum of abnormality. Table 1 compares leaflet displacement, anterior and posterior leaflet thickness, and degree of regurgitation for the 3 groups, based on the study by Freed and coworkers.[25] In each case, the value for the nonclassic form is intermediate between that for no disease and that for classic mitral valve prolapse. For leaflet displacement, the difference between no prolapse and nonclassic mitral valve prolapse is inherent in the definition of prolapse; however, the difference in leaflet thickness suggests that the nonclassic form may represent an earlier stage in the spectrum of myxomatous change.

Physical signs. Midsystolic clicks and late systolic murmurs have been considered diagnostic hallmarks of mitral valve prolapse since its first recognition.[28–30] As with all other features of mitral valve prolapse, the presence of clinical signs and symptoms differs between population studies and clinical series (in which many patients are referred because of clicks and murmurs). In the Framingham offspring cohort, clicks were present in only 11.1% of patients with classic mitral valve prolapse, in 7.9% of those with nonclassic prolapse, and in 1.5% of controls.[25] Significantly, clicks were present in 16 individuals with mitral valve prolapse but in 82 subjects without prolapse, a ratio of less than 1 to 5, reflecting the much larger percentage of the general population without prolapse. In the referral population of Marks et al, the proportion of patients with clicks was higher (33% in classic mitral valve prolapse, compared with 12% in nonclassic prolapse).[24] Thus, systolic clicks do not appear to be sensitive or specific for mitral valve prolapse.

Freed et al. found systolic murmurs in 22.0% of individuals with classic mitral valve prolapse, 9.6% of those with the nonclassic form, and 4.0% of those without prolapse in the general population.[25] In contrast, in the referred patients studied by Marks et al, 89% of individuals with classic and 60% of those with nonclassic prolapse had systolic murmurs, again emphasizing the effects of referral bias.[24] Clicks and murmurs were not useful in separating the classic and nonclassic forms of the disease. The combination of clicks and murmurs was not addressed in either of these studies but is likely to be more specific but less sensitive than either of these findings alone. As the degree of mitral regurgitation becomes more significant, the proportion of patients with a systolic murmur increases: Holosystolic murmurs were reported in 100% of patients referred for cardiac catheterization[10] or cardiac surgery.[31]

Symptoms. Mitral valve prolapse has been associated in uncontrolled studies with a variety of clinical symptoms, including palpitations, dyspnea, dizziness, chest pain, anxiety, and panic attacks.[2,32–36] In contrast, in the Framingham offspring cohort there was no difference in the prevalence of chest pain, dyspnea, atrial or ventricular ectopy, atrial fibrillation, congestive heart failure, syncope, or cerebrovascular disease in subjects with and without mitral valve prolapse,[16,25] although this may in part reflect the low absolute prevalence of mitral regurgitation in this cohort. An analysis of the relationship between symptoms and mitral valve prolapse based on M-mode studies is difficult, since the prevalence of mitral valve prolapse is generally exaggerated and hence many people without mitral valve prolapse are likely included in the disease group. Despite this, controlled population studies in general fail to show a consistent difference between the presence of these nonspecific symptoms in patients with mitral valve prolapse and in controls.[2,37,38] Population studies contain few, if any, patients with congestive heart failure, and when severe regurgitation with pulmonary venous congestion supervenes, symptoms of cardiac failure can be expected. There are few data from controlled studies, however, to suggest that the prolapsing valve itself, in the absence of significant valvular regurgitation, is responsible for the symptoms attributed to mitral valve prolapse.

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lapse.[25,39,40] The reason for this association remains unclear.

Complications of Mitral Valve Prolapse

Mitral regurgitation. The most common complication of mitral valve prolapse is mitral regurgitation.[25,41] Prior studies of referral populations have reported that a finding of mitral regurgitation, based on the presence of a systolic murmur, is associated with an increased risk for serious sequelae, including progressive valve dysfunction necessitating replacement,[31,42–44] infective endocarditis (IE),[6,44] and sudden death.[44,45] In clinical and necropsy series, most patients with mitral valve prolapse in whom the condition contributed to death had clinical and pathologic evidence of significant mitral regurgitation.[46,47]

The population study of Freed et al suggested that most patients with mitral valve prolapse have only trace or mild regurgitation.[25] Although the degree of MR was slightly higher in patients with prolapse than in controls, trace and mild MR are found frequently in the normal population and are generally considered to be normal variants. However, 7% of patients with classic mitral valve prolapse had severe regurgitation, and one additional patient required mitral valve repair. No patient in the nonclassic group had severe MR. If we assume that the patients with severe MR will eventually require valve replacement, then based on this relatively small sample, a subset of approximately 10% of patients with classic mitral valve prolapse may eventually require valve replacement. Marks et al compared patients with nonclassic and classic prolapse and similarly observed that complications were more common in the classic form than in the nonclassic form: moderate to severe mitral regurgitation in 12% vs. 0% ($P < .001$) and need for mitral valve replacement in 6.6% vs. 0.7% ($P < .02$).[24] Vivaldi et al reported that leaflet thickness, displacement, and development of mitral regurgitation did not significantly progress in patients with nonclassic mitral valve prolapse followed for 10 years.[48]

Prior studies have suggested that severe regurgitation is due to progressive myxomatous change.[11,50] In about 75% of cases, there is sudden deterioration because of chordal rupture.[51] The cumulative risk of severe mitral regurgitation and valve rupture is minimal below the age of 50 but then rises steeply, with the risk in men being roughly 2.5 times that in women after the age of 60.[52] Wilcken et al., using a population prevalence of 4% for mitral valve prolapse, have estimated the probability of requiring surgery for severe MR at age 60 as 1:53 for men and 1:142 for women, which increases by age 70 to 1:28 and 1:83, respectively.[41] If we assume that these cases arise predominantly from the classic mitral valve prolapse group, and that the population prevalence decreases to 1.3%, then the cumulative risk for MR requiring valve replacement increases proportionately to 1:17 for men and 1:46 for women at age 60. At age 70, this risk will be

Table 2
Frequency of Complications in Mitral Valve Prolapse

Category and study	No prolapse (%)	Nonclassic prolapse (%)	Classic prolapse (%)
Severe mitral regurgitation			
Freed et al[25]	0.5	0	7.0
Marks et al[24]	-	0	11.9
Nidorf et al[49]	0	0	37.0
Mitral valve surgery			
Freed et al[25]	0	0	1.2
Marks et al[24]	-	0.7	6.6
Nidorf et al[49]	0	0	10.8
Infective endocarditis			
Freed et al[25]	0	0	2.1
Marks et al[24]	-	0	3.5
Nidorf et al[49]	0	0	2.2
Stroke			
Freed et al[25]	1.5	1.2*	
Marks et al[24]	-	5.8	7.5
Nidorf et al[49]	0.84	0	0.87
Gilon et al[16]	-	2.8†	0†

*1.2% of all patients with mitral valve prolapse.

†Percent of patients with "idiopathic" stroke and mitral valve prolapse, which was not different from that in a control population (2.7%) in this study.

1:9 for men and 1:15 for women. Thus, by age 70, the cumulative risk for men would be roughly 11%, a finding inconsistent with a benign outcome for this subgroup.

Infective endocarditis. Infective endocarditis (IE) has been reported as a complication of mitral valve prolapse in case reports,[53–56] case series[57] and case/control studies.[6,58,59] An increased risk has been reported in men, with increasing age, and in patients with prior MR murmurs. In the population study of Freed et al, only 1 patient was noted to have a history of IE, and that patient also had classic mitral valve prolapse.[25] In the referral-based study of Marks et al, IE or a history thereof was found in 3.5% of patients with classic mitral prolapse and in none of those with nonclassic disease.[24] Nidorf et al found IE in 5 of 325 prolapse patients during a mean follow-up of 5 years.[49] Each of the 5 patients had classic prolapse. Based on a population prevalence of 1.3%, the absolute annual risk of endocarditis in patients with classic mitral valve prolapse would be approximately 1:2,000. Since the risk of IE appears related to both mitral regurgitation and leaflet thickening, and since these occur together, it warrants consideration whether leaflet thickening per se increases the risk of IE. Marks et al found early, late, or holosystolic murmurs in all patients with IE; however, moderate to severe regurgitation was found in only 2 of the 11 patients. Neither moderate nor severe MR was an independent predictor of IE in this study.

Sudden death. By far the most ominous reported complication of mitral valve prolapse is sudden death. The strength of the association with sudden death in patients with mitral valve prolapse without MR is uncertain; however, sudden death appears to be a major risk in patients with mitral valve prolapse with significant MR.[1] Davies found 13 cases of unexpected sudden death in persons with mitral valve prolapse during a 5-year follow-up period among forensic autopsies screened for prolapse.[46] Two thirds of these cases had evidence of significant MR caused by ruptured chordae, an observation that highlights the importance of MR as a potential substrate for sudden death in mitral valve prolapse.

Main Points

- Mitral valve prolapse is defined by displacement and thickening of the mitral valve leaflets.
- Signs, symptoms, and complications often thought to be associated with mitral valve prolapse more likely result from severe MR or congestive heart failure.
- Echocardiography shows degree of prolapse and of leaflet thickening; 3-dimensional imaging is most specific.
- A "nonclassic" subtype of mitral valve prolapse involves less thickening of leaflets and carries a lower risk of complications.
- Complications include severe MR, infective endocarditis, and need for valve replacement.
- Sudden death is rare, usually occurring in the context of severe MR and heart failure; no clear evidence links stroke to mitral valve prolapse.

In a study of 348 patients with flail mitral valve managed conservatively, Grigioni et al reported 25 sudden deaths (25% of all deaths) during a mean follow-up of 48 ± 41 months.[60] The linearized sudden death rate was 1.8% per year. In patients with moderate to severe symptoms, the yearly rate increased to 7.8%. Baseline independent predictors of sudden death included functional class, ejection fraction, and atrial fibrillation. Congestive heart failure developing during the follow-up period was associated with sudden death in univariate and multivariate analyses. Surgery independently and favorably influenced the incidence of unexpected sudden death.

These data are consistent with earlier reports suggesting that arrhythmias in patients with mitral valve prolapse are more likely related to the presence of MR than to any direct structural or functional consequences of prolapse itself.[61]

Stroke. The association between stroke, particularly in young people, and mitral valve prolapse has been the subject of ongoing controversy. Barnett et al initially reported mitral valve prolapse, based on M-mode echocardiographic criteria, in 40% of patients 45 years of age or younger who had acute neurologic events.[62] Others have also reported an increased prevalence of mitral valve prolapse in patients with stroke,[63–65] although there has been increasing evidence to the contrary.[16,66] Using the 3-D echocardiography–based criteria for mitral valve prolapse described above, Gilon et al. found evidence of prolapse in 4 of 213 (1.9%) young patients (<45 yrs) with stroke or transient ischemic attacks, compared with 2.7% in controls.[16] None of the 4 patients had classic mitral valve prolapse. In patients with otherwise unexplained strokes,

prolapse was present in 2.8%, a value not different from that seen in the general population. Marks et al. found no significant difference in the prevalence of stroke between the groups with the classic and nonclassic forms of mitral valve prolapse (7.5% vs 5.8%), suggesting that leaflet thickening in patients with this disorder is not an additional risk factor for stroke.[24] While these studies cannot exclude a small degree of association between mitral valve prolapse and stroke, they provide no clear evidence for one.

Conclusions

Studies based on current criteria for mitral valve prolapse report a prevalence of 2.4% for prolapse in general and 1.3% for classic prolapse. These reports support prior controlled studies that failed to show an association between symptoms such as dyspnea, syncope, fatigue, or dizziness and mitral valve prolapse in the absence of congestive heart failure. Patients with classic mitral valve prolapse represent a subgroup at increased risk for important complications, including severe mitral regurgitation, infective endocarditis, and the need for valve replacement. The data fail to support an association between mitral valve prolapse and stroke or transient ischemic attack in population or referral studies. Sudden death occurs rarely in patients with mitral valve prolapse and is likely related to heart failure from progressive mitral regurgitation rather than to the leaflet abnormality per se. Continuing use of rigorous diagnostic criteria with echocardiography will help clarify these issues in future studies. ■

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