THE MITRAL VALVE

A Pluridisciplinary Approach

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7 Pathology of the Mitral Valve

Introduction to Plastic and Reconstructive Valve Surgery

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The development of techniques for mitral valve reconstruction presupposes a precise knowledge of the lesions encountered. The present study analyzes the anatomic findings at autopsy of 100 human hearts with either rheumatic or dystrophic noncalcified valvular disease, and those observed at the time of operation in a series of 400 mitral valve repairs. Anatomic study consisted of a precise measurement of the various valve structures; intra-operative observations allowed us to analyze accurately the shape of the annulus and the physiology of the leaflets of the living, beating heart.

TERMINOLOGY

Since several terms are used in the literature to define the same structure of the mitral valve, it is necessary to begin by reviewing the terminology used in the present study. Aortic (anterior) and the mural (posterior) leaflets are separated by anteroseptal and postero-medial

commissures, which can be identified by the tips of the corresponding papillary muscles,[9,10] and by the commissural chordae.[7] The commissural chordae arise from the tip of the papillary muscle as a single stem that branches radially in a fan-like fashion to insert into the free margin of the commissural regions[6] (Fig. 1).

The anterior and posterior leaflets present a rough zone which is the area of contact of both leaflets during systole. In this study, this zone is called the "closure area." The margin of the mural leaflet generally presents two indentations, giving rise to a scalloped appear-

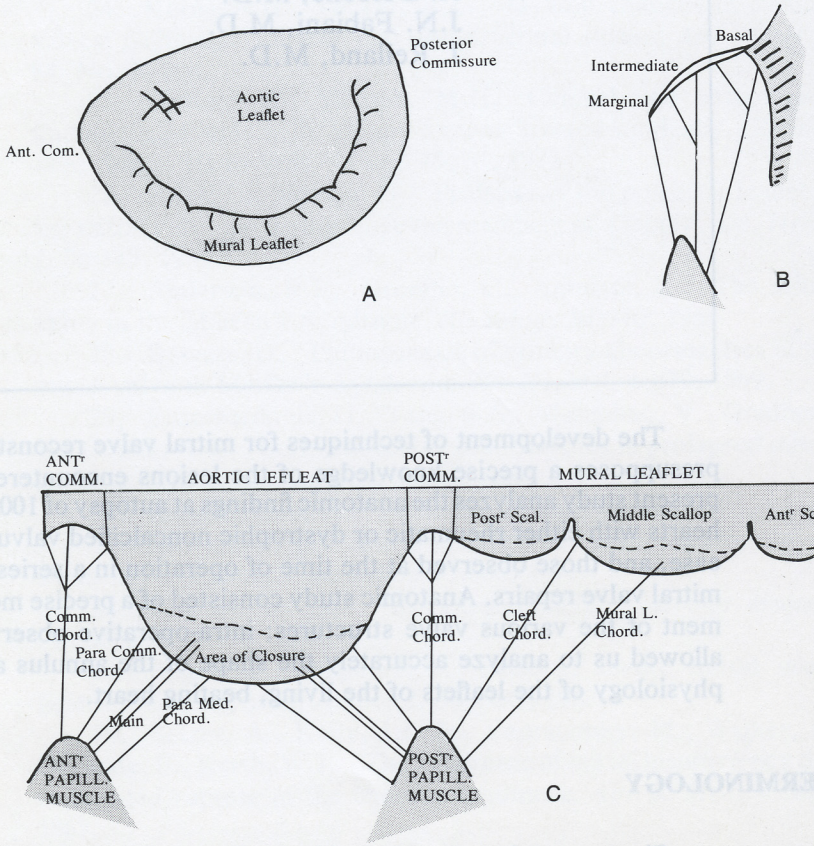


Figure 1. Schematic representation of the normal anatomy of the mitral valve apparatus. A—View from left atrium. B—Cross sectional view showing site of insertion of the chordae on the leaflet. C—Mitral apparatus opened showing the various components.

Mural leaflet chordae: Chordae of the middle scallops—thin chordae of the marginal intermediate or basal type. Cleft chordae corresponding to the indentations of the leaflet—thin chordae of the marginal type.[6]

MATERIAL AND METHODS

The 100 human hearts with rheumatic or dystrophic valvular disease were compared with 50 normal hearts which served as reference. The average weight of the normal hearts was 340 gm. The 100 pathological hearts were divided into four groups.

Rheumatic valvular insufficiency: 30 specimens—average weight: 620 gm. This group was characterized by major insufficiency with a commissural fusion of less than 5 mm and without ruptured chordae.

Rheumatic combined valvular insufficiency and stenosis: 30 specimens—average weight: 580 gm. This group consisted of cases of non calcified mitral valve disease with associated insufficiency and mild stenosis (1 to 2 finger breadths).

Dystrophic mitral insufficiency: 20 specimens—average weight: 630 gm. This group included cases of mitral valve insufficiency with no previous history of rheumatic fever, and without typical rheumatic lesions, i.e., fusion of the commissures, shortening and fusion of the chordae, thickening and shrinkage of the leaflets.

Dystrophic mitral insufficiency with ruptured chordae: 20 specimens—average weight: 560 gm. Ruptured chordae of rheumatic origin or due to bacterial endocarditis were excluded from this group. The ruptured chordae belonged to the mural leaflet in 11 cases, to the aortic leaflet in 5 cases, and to both leaflets in 4 cases.

The hearts used in the anatomic study were obtained at autopsy. In contrast to most studies, no distinction was made between the measurements on the basis of sex, because it was felt that the differences were related more to body size than to sex. The average height of the subjects studied measured 1.66 m, with a range of 1.50 m to 1.82 m (± 10%). All measurements represent averages which have been rounded off to the nearest millimeter.

Intra-operative observations were made on a series of 400 mitral valve repairs carried out under extra-corporeal circulation. The mitral valve was approached through a median sternotomy and a left atriotomy. The heart was kept beating. The shape of the annulus was analyzed while the aorta was unclamped. The motion of the leaflets was observed, with the aorta crossclamped to avoid air embolism.

RESULTS

Table 1
Normal Heart

Circumference: 116 mm ± 3.5	
Aortic leaflet	
Attachment	32 mm ± 1.3
Height	23 mm ± 0.9
Closure area	14 mm ± 1.1
Main chordae anterior	19 mm ± 0.4
posterior	17 mm ± 0.2
Para-commissural anterior	17 mm ± 0.3
Para-medial anterior	15 mm ± 0.5
Mural leaflet	
Attachment	55 mm ± 2.2
Height middle scallop	14 mm ± 0.9
anterior scallop	9 mm ± 1
posterior scallop	10 mm ± 1.2
Closure area middle scallop	8 mm ± 0.9
Middle scallop chordae marginal	14 mm ± 2.9
basal	8 mm ± 1.7
Cleft chordae	13 mm ± 3.7
Anterior commissural leaflet	
Attachment	12 mm ± 3.3
Height	8 mm ± 1
Commissural chordae	13 mm ± 0.2
Posterior commissural leaflet	
Attachment	17 mm ± 0.8
Height	8 mm
Commissural chordae	15 mm ± 0.05

Table 1 shows the measurements of the **normal heart.** The shape of the normal orifice is ovoid, the main axis being transverse from one commissure to the other. However, the orifice becomes kidney-shaped when the aorta is filled, due to the redundance of the aortic root. With the heart beating, the orifice area is reduced during systole by the advancement of the base of the aortic leaflet and the contraction of the annulus at the mural leaflet. This reduces the orifice area by approximately 25%.

Table 2 presents the measurements of hearts with **rheumatic valvular insufficiency.** Comparison of these measurements with those of normal valve (N =. . .) and operative findings suggested the following (Fig. 2):

> Dilatation of the annulus was significant, being approximately 25% more than normal, and affected mainly the posterior commissure. Dilatation of the aortic leaflet was not significant.

Table 2
Rheumatic Valvular Insufficiency

Circumference: 147 mm ± 4.9 (normal 116 mm) $p < 0.05$	
Aortic leaflet	
Attachment	35 mm ± 1.9 (N = 32 mm)†
Height	24 mm ± 1.9 (N = 23 mm)†
Closure area	17 mm ± 1.6 (N = 14 mm)*
Main chordae anterior	22 mm ± 0.7 (N = 19 mm)*
posterior	15 mm ± 0.6 (N = 17 mm)*
Para-commissural anterior	23 mm ± 1.2 (N = 17 mm)*
Para-medial anterior	23 mm ± 1.5 (N = 15 mm)*
Mural leaflet	
Attachment	71 mm ± 3.6 (N = 55 mm)*
Height middle scallop	15 mm ± 1.1 (N = 14 mm)†
Closure area middle scallop	7 mm ± 1 (N = 8 mm)†
Middle scallop chordae marginal	10 mm ± 0.3 (N = 14 mm)*
basal	6 mm ± 0.6 (N = 8 mm)†
Cleft chordae	11 mm ± 0.8 (N = 13 mm)†
Anterior commissural leaflet	
Attachment	15 mm ± 1 (N = 12 mm)*
Commissural chordae	14 mm ± 1.2 (N = 13 mm)†
Posterior commissural leaflet	
Attachment	25 mm ± 2.3 (N = 17 mm)*
Commissural chordae	19 mm ± 0.2 (N = 15 mm)*

* Statistically significant (Student's test)
† Not statistically significant.

The chordae of the anterior leaflet were elongated, particularly the paramedial and the paracommissural chordae.

The posterior commissural chordae were also elongated, whereas the anterior commissural chordae were not.

In contrast with these, the chordae of the mural leaflet were shortened and often thickened, which seems to be characteristic of rheumatic mitral valve insufficiency.

The height of the leaflets was not significantly changed.

It should be pointed out that all of the structures were altered, but not necessarily in the same manner. In spite of the fact that the average length of the chordae was increased, some chordae were shortened, particularly the intermediate chordae of the mural leaflet.

The valvular tissue displayed marked changes: the mural leaflet was thickened and the clefts were no longer visible. The anterior leaflet was less altered, with the exception of the closure area, which was thickened and sometimes calcified. Commissural areas were thickened, making it difficult to recognize the exact site of the com-

missures. The shape of the annulus was changed: the main axis became vertical instead of horizontal, and in most cases the deformation was asymmetrical, the dilatation being more marked at the posterior commissure. With the heart beating, there was no change in the shape of the orifice and no reduction in its size during systole.

Table 3 shows that, in the case of **combined mitral valve disease and insufficiency,** the size of the annulus was significantly reduced due to the retraction of the commissures and the mural leaflet. The aortic valve attachment was normal or even slightly dilated. The valvular tissue was thickened and retracted, particularly at the mural leaflet and the commissure (Fig. 3).

All of the chordae were shortened, thickened, or fused. Some were selectively elongated. It is of some practical importance to point out that thickening and rigidity of the mural leaflet were often due

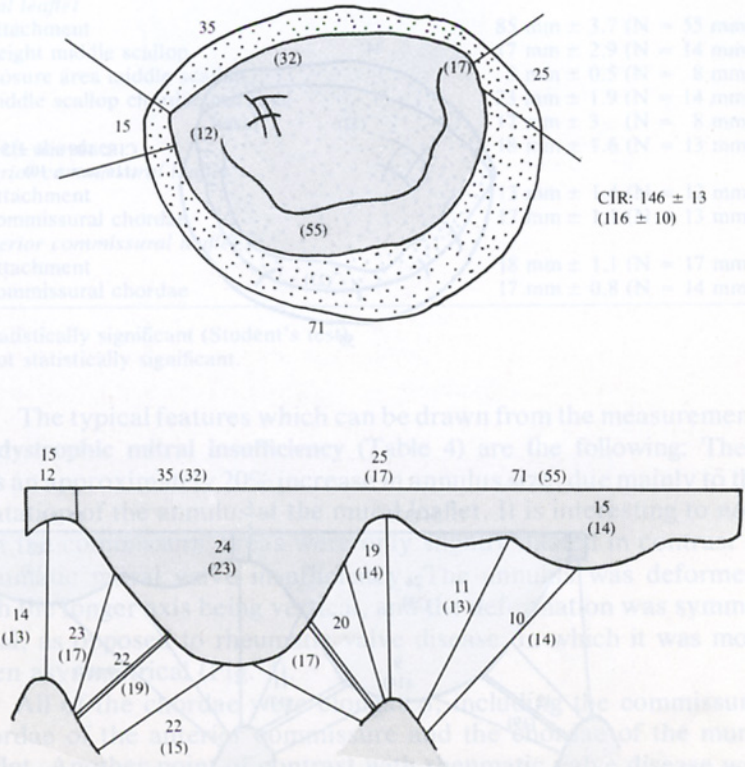
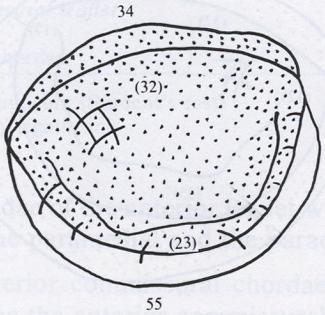


Figure 2. Rheumatic valvular insufficiency. Measurements of the various structures in comparison with normal measurements shown in parentheses.

Table 3
Combined Mitral Valve Disease and Insufficiency

Circumference: 106 mm ± 1.7 (N = 116 mm) $p < 0.005$*	
Aortic leaflet	
Attachment	34 mm ± 2 (N = 32 mm)†
Height	24 mm ± 1.7 (N = 23 mm)†
Closure area	9 mm ± 0.8 (N = 14 mm)*
Main chordae anterior	12 mm ± 1.9 (N = 19 mm)*
posterior	11 mm ± 1.7 (N = 17 mm)*
Para-commissural and para-medial chordae were most often fused with the main chordae. In some cases, however, they were well individualized and elongated.	
Mural leaflet and fused anterior and posterior commissural leaflets:	
Attachment	72 mm ± 2.05 (N = 84 mm)*
Height middle scallop	12 mm ± 1.4 (N = 14 mm)†
Closure area	5 mm ± 0.7 (N = 8 mm)*
Middle scallop chordae marginal	9 mm ± 0.8 (N = 14 mm)*

* Statistically significant (Student's test)
† Not statistically significant.



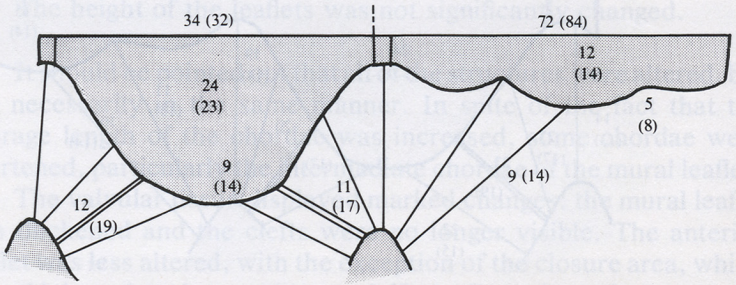


Figure 3. Combined mitral valve disease and insufficiency. Measurements of the various structures in comparison with normal measurements shown in parentheses.

more to retracted and hypertrophied intermediate chordae than to the thickening of the leaflet tissue itself. After resection of intermediate chordae, the leaflet became more pliable. The ventricular cavity was much smaller than in mitral insufficiency. With the heart beating, little change was observed in the annulus size area.

Table 4
Dystrophic Mitral Insufficiency

Circumference: 148 mm ± 5.5 (N = 116 mm) $p < 0.005$*	
Aortic leaflet	
Attachment	35 mm ± 2 (N = 32 mm)†
Height	30 mm ± 1.4 (N = 23 mm)*
Closure area	18 mm ± 1 (N = 14 mm)*
Main chordae anterior	21 mm ± 0.9 (N = 19 mm)†
posterior	19 mm ± 0.5 (N = 17 mm)*
Paracommissural anterior	24 mm ± 1.8 (N = 17 mm)*
Paramedial anterior	28 mm ± 2.1 (N = 15 mm)*
Mural leaflet	
Attachment	85 mm ± 3.7 (N = 55 mm)*
Height middle scallop	17 mm ± 2.9 (N = 14 mm)*
Closure area middle scallop	8 mm ± 0.5 (N = 8 mm)†
Middle scallop chordae marginal	23 mm ± 1.9 (N = 14 mm)*
basal	17 mm ± 3 (N = 8 mm)*
Cleft chordae	18 mm ± 1.6 (N = 13 mm)*
Anterior commissural leaflet	
Attachment	13 mm ± 1.4 (N = 12 mm)†
Commissural chordae	17 mm ± 1.1 (N = 13 mm)*
Posterior commissural leaflet	
Attachment	18 mm ± 1.1 (N = 17 mm)†
Commissural chordae	17 mm ± 0.8 (N = 14 mm)*

* Statistically significant (Student's test)
† Not statistically significant.

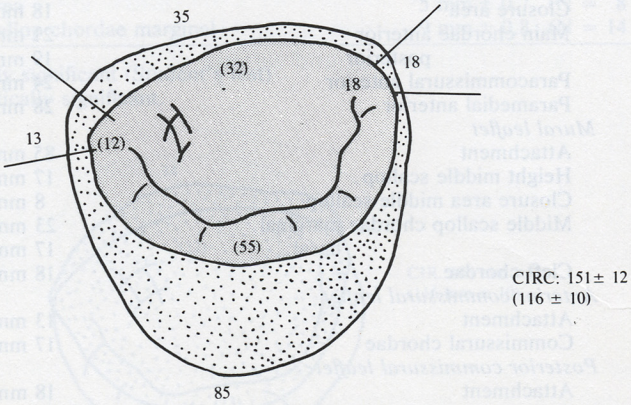
The typical features which can be drawn from the measurements of **dystrophic mitral insufficiency** (Table 4) are the following: There was an approximately 20% increase in annulus size, due mainly to the dilatation of the annulus at the mural leaflet. It is interesting to note that the commissural areas were only slightly dilated in contrast to rheumatic mitral valve insufficiency. The annulus was deformed, with the longer axis being vertical, and the deformation was symmetrical, as opposed to rheumatic valve disease, in which it was most often asymmetrical (Fig. 4).

All of the chordae were elongated, including the commissural chordae of the anterior commissure and the chordae of the mural leaflet. Another point of contrast with rheumatic valve disease was that the chordae were thinner than normal.

The leaflet tissue was abnormal in certain areas. The height of the

leaflet was significantly increased in contrast to rheumatic valve disease. In some areas, it appeared to have an excess of tissue, resulting in a ballooning effect of the leaflets. Unlike rheumatic valve disease, certain areas appeared absolutely normal. This heterogeneity in the distribution of the lesions may be considered as a significant difference from the homogeneous lesions of rheumatic valvular disease. With the heart beating, the annulus was completely immobile.

These measurements for **dystrophic mitral insufficiency with ruptured chordae** (Table 5, p. 76) are similar to those obtained in the



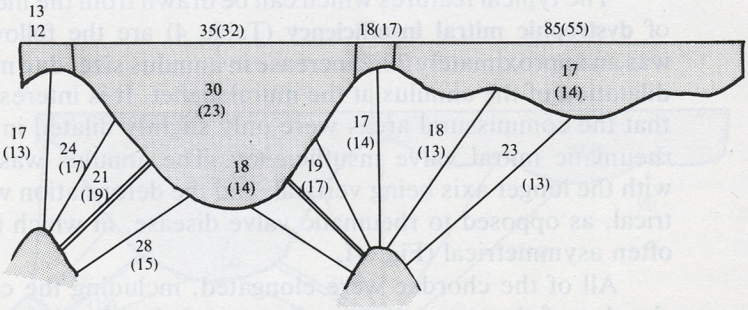


Figure 4. Dystrophic mitral insufficiency. Measurements of the various structures in comparison with normal measurements shown in parentheses.

preceding group. They show that both groups represent different evolutions of the same pathological process (Fig. 5).

CONCLUSION

This study is, to our knowledge, the first to present detailed, numerical data on the pathological findings of usual causes of mitral valve insufficiency. The differentiation of these heterogeneous lesions into their components provides a rational basis for the development of a variety of new mitral-valve reconstructive techniques and for the specific indications governing their use in each of the disease groups.

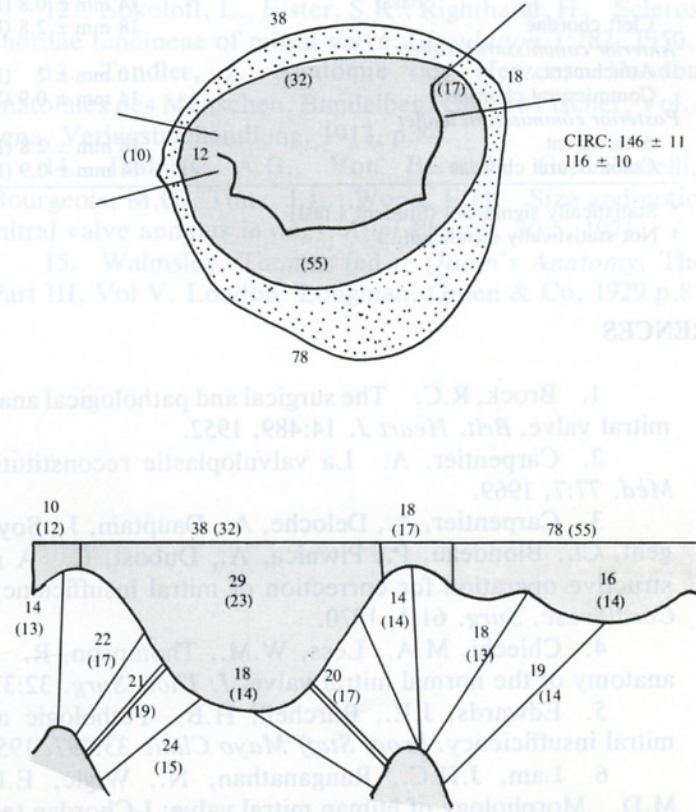


Figure 5. Dystrophic mitral insufficiency with ruptured chordae. Measurements of the various structures in comparison with normal measurements shown in parentheses.

Table 5
Dystrophic Mitral Insufficiency with Ruptured Chordae

Circumference: 144 mm ± 5.1 (N = 116 mm) p 0.005	
Aortic leaflet	
Attachment	38 mm ± 2.2 (N = 32 mm)*
Height	29 mm ± 1.5 (N = 23 mm)*
Closure area	18 mm ± 1.2 (N = 14 mm)†
Main chordae anterior	21 mm ± 0.3 (N = 19 mm)*
posterior	20 mm ± 1.9 (N = 17 mm)†
Paracommissural anterior	22 mm ± 1 (N = 17 mm)*
Paramedial anterior	24 mm ± 0.9 (N = 15 mm)*
Mural leaflet	
Attachment	78 mm ± 3.6 (N = 55 mm)*
Height middle scallop	16 mm ± 1.5 (N = 14 mm)†
Closure area middle scallop	9 mm ± 0.9 (N = 8 mm)†
Middle scallop chordae marginal	19 mm ± 1.4 (N = 14 mm)*
basal	14 mm ± 0.8 (N = 8 mm)*
Cleft chordae	18 mm ± 2.8 (N = 13 mm)*
Anterior commissural leaflet	
Attachment	10 mm ± 2 (N = 12 mm)†
Commissural chordae	14 mm ± 0.9 (N = 13 mm)†
Posterior commissural leaflet	
Attachment	18 mm ± 2.8 (N = 17 mm)†
Commissural chordae	14 mm ± 0.9 (N = 14 mm)†

* Statistically significant (Student's test)
† Not statistically significant.

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