Study of Mitral Valve in Human Cadaveric Hearts

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ABSTRACT

Objectives: The mitral valve is a complex structure that is altered by disease states. The classical image of the mitral valve is a bicuspid valve with two leaflets and two papillary muscles. The reason for the present study is to study the morphology and morphometry of the mitral valve.

Materials and Methods: This study was carried out on 116 human cadaveric hearts. Hearts were opened along the left border through the atrioventricular valve. The diameter and circumference of the annulus was measured and the number of valve leaflets was observed.

Results: The mean annular diameter was 2.22 cm. The mean circumference of mitral valve annulus was 9.12 cm. The standard description of the mitral valve is bicuspid. In the present study, we found the number of cusps to be variable, from monocuspid to hexacuspid and classified them accordingly.

Conclusions: The mitral valve is not always a bicuspid valve. The number of cusps varies greatly. An increase in the number of the cusp and their improper approximation most likely causes various valvular disorders.

Key words: Atrioventricular valve, leaflets/cusps, variation

INTRODUCTION

The mitral valve is a complex structure that is altered by various disease states and therefore is of great importance. Researchers are attracted to its study and clinical-based studies are frequently found in the literature. Anatomic and morphologic studies of the mitral valve are comparatively less. Those anatomic studies vary from paper to paper. Due to its clinical significance, paucity of anatomic studies and existing controversies, we had chosen this topic for research. The present study is about the morphology and morphometry of the mitral valve.

MATERIALS AND METHODS

This study was carried out on 116 human cadaveric hearts. The hearts were washed and opened along the left border through the atrioventricular valve. The cavity of the left atrium was opened. The left atrioventricular orifice was cleared by removing the clots. The maximum diameter of the opening was measured with the Vernier caliper. Then the cavity of the left ventricle was opened and cleaned to visualize the mitral valve complex. Circumference of annulus was measured. Cusps of mitral valve were dissected. Number and the height of valve leaflets were measured.

RESULTS

Morphometry of annular diameter, annular circumference, and height of anterior and posterior cusps are described in Table 1. The mean annular diameter was 2.22 cm, mean annular circumference was 9.12 cm. The mean of maximum height of anterior cusp and posterior cusp was 1.96 cm and 1.50 cm, respectively.

In the present study the number of the mitral valve cusps was measured. The mitral valve was classified according to the number of the cusps [Table 2, Figures 1-9].

DISCUSSION

Variations of cusps described in the present study have
their own morphologic significance: developmental, physiologic and surgical because of its great clinical importance, the mitral valve is the most common choice of research workers. There are numerous studies on mitral valve repair and its morphometry.\(^{[1-9]}\) Table 3 shows the comparison of morphometry of the mitral valve. Results of the present study are in the range of previous studies.

Figure 1: Monocuspid frill like mitral valve. In monocuspid valve, single frill like cusp was present. No well demarcated prominent commissure was seen

Figure 2: Bicuspid mitral valve (Type A). In Bicuspid mitral valve two prominent cusps (1 and 2) were seen divided by two well marked commissures. So it is called as Type A of Bicuspid mitral valve

Figure 3: Bicuspid mitral valve (Type B). In Type B of Bicuspid mitral valve, only one cusp was prominent (1). The next cusp was frill like with uniform height (2). Commissure between the two cusp was not well marked

Figure 4: Tricuspid mitral valve (Type A) Three prominent cusps (1, 2 and 3) of equal size and shape separated by well marked commissure were present in Type A of tricuspid mitral valve

Figure 5: Tricuspid mitral valve (Type B). In Type B of tricuspid mitral valve only one cusp (1) was large and prominent. The other cusp was divided into the two smaller cusps (2 and 3)

Figure 6: Tetracuspid mitral valve (Type A). Four prominent cusps (1, 2, 3, 4) separated by well marked commissures were present in Type A of tetracuspid valve
As compared with the studies on the morphometry of the mitral valve, there are very few studies on the number of cusps present in the mitral valve. Distinctly different from the tricuspid valve, the mitral valve has two (2) leaflets. According to different books of anatomy it is fixed in our mind that there are 2 cusps present in the mitral valve, although some research workers argue that it has 4 leaflets.[10]

The free edge of the posterior leaflet is often divided into 3 or more scallops or described as lateral, middle, and medial or P1, P2, and P3 segments.[11] Although 3 scallops are most common, the scallops are not equal in size. Ranganathan and colleagues[12] found the middle scallop to be larger in the majority of hearts.

### Table 1: Morphometry of the mitral valve

| Parameters of study | Annular diameter (cm) | Annular circumference (cm) | Max. height of the anterior cusp (cm) | Max. height of the posterior cusp (cm) |
|---------------------|-----------------------|-----------------------------|--------------------------------------|---------------------------------------|
| Mean                | 2.2224                | 9.12                        | 1.96                                 | 1.5069                                |
| Minimum             | 1.5                   | 6.5                         | 1.3                                  | 0.5                                   |
| Maximum             | 3.5                   | 12                          | 3                                    | 2.0                                   |
| SD                  | 0.50122               | 1.3607                      | 0.409137                             | 0.379138                              |

### Table 2: Classification of mitral valve according to the number of leaflets

| Classification | Subclassification | No. | Percentage | Total % |
|----------------|-------------------|-----|------------|---------|
| Monocuspid     |                   | 6   | 5.17       | 5.17    |
| Bicuspid       | Type A            | 35  | 30.17      | 56.03   |
|                | Type B            | 30  | 25.86      |         |
| Tricuspid      | Type A            | 13  | 11.21      | 18.10   |
|                | Type B            | 8   | 6.89       |         |
| Tetracuspid    | Type A            | 3   | 2.58       | 15.51   |
|                | Type B            | 15  | 12.93      |         |
| Pentacuspid    |                   | 4   | 3.44       | 3.44    |
| Hexacuspid     |                   | 2   | 1.73       | 1.73    |

Number of cusps varied from 1-6. Thus mitral valve was classified as monocuspid to hexacuspid valve. Bicuspid, tricuspid, and tetracuspid valves were further divided into Type A and Type B. Valves with prominent cusps separated by well-demarcated commissures were classified as Type A. The valves with small, unequal cusps and scallops separated by clefts were classified as Type B.

### Table 3: Comparison of morphometry of mitral valve

| Various studies | Year | Annular circumference (cm) | Annular diameter (cm) | Max. height of each cusp |
|-----------------|------|-----------------------------|-----------------------|-------------------------|
| Present study   | 2011 | 9.12                        | 2.22                  | 1.96                   |
| Walmsley T.     | 1929 | -                           | 1.5-1.8               | 1.0-1.2                |
| E.W.T. Morris   | 1960 | -                           | 2.7                   | 1.3                    |
| Rusted I.E.     | 1952 | 9.9                         | 2.50                  | 2.2                    |
| Sakai T.        | 1999 | 9.33                        | 2.23                  | -                      |
| Chiechi         | 1956 | 10                          | -                     | -                      |
| Bulkley and Roberts | 1975 | 9                          | -                     | -                      |
| R. C. Brock     | 1952 | 10.05                       | 1.5-1.8               | 1.0-1.2                |
| Louis A. DuPlessis | 1964 | 10.1                        | 2.7                   | 1.3                    |
| J. A. Ormiston  | 1981 | 9.3                         | -                     | -                      |

The standard book of Gray’s Anatomy 39th ed.[13]
Skwarek et al.\(^{14}\) had studied the tricuspid valve and divided it into different types and subtypes depending on the number of leaflets and the location of accessory leaflets. On that basis the classification of mitral valve is done in the present study according to the number of leaflets. This easy and simple classification of mitral valve is done for the first time in the present study. There is no such classification found in the literature searched so far by us.

Kalangos et al.\(^{15}\) have reported a rare case of congenital mitral insufficiency characterized by 6 well-demarcated leaflets of mitral valve. Such a type with 6 leaflets was seen in the present study in 1.72%. Increase in the number of cusps in a valve may not show any change in echocardiography unless and until there is any pathology. Increase in the number of cusps may increase the chances of Mitral regurgitation (MR) with the disturbances in edge-to-edge cusp closure.

Carpentier\(^{11}\) developed a functional classification used to describe the mechanism of valvular dysfunction. Type I MR is characterized as normal leaflet motion. Type II MR lesions are related to leaflet prolapsed. Type III MR lesions are caused by restricted leaflet motion. Type IIIA MR shows restricted opening and type IIIB MR shows restricted closure.

Mitral valve repair is considered as the gold standard to treat mitral regurgitation. The re-emergence of the edge-to-edge approximation of the leaflets is commonly called the Alfieri technique.\(^{19}\) This technique involves suturing together anterior and posterior leaflets at a single point midway between the circumferences of the leaflets creating the double-orifice. This technique in mitral valve repair is a simple solution for complex problems.

The mitral valve develops from cushion tissue and myocardium of the ventricle. Abnormal splitting of the cushion tissue may result in the increased number of cusps.\(^{17}\) The technique of cusp commissuroplasty can be used to reconstruct atrioventricular valves that have been damaged by endocarditis of the commissure and adjacent cusps.\(^{18}\)

An increase in the number of the cusp and their improper approximation will more likely cause various valvular disorders.

**CONCLUSION**

The present study has classified the mitral valve from monocusp to hexacusp valve as per the number of cusps. The most commonly described mitral valve is bicuspid but it was present in only 56% in present study. The mitral valve is not always a bicuspid valve. The number of cusps in it varies. Improper cusps approximation may cause mitral regurgitation. This knowledge may be useful for cardiothoracic surgeons in surgical repair of the mitral valve.

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