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ANATOMIE/ANATOMY

A DISTANCE MITRAL ANNULUS-PAPILLARY MUSCLE AND CLASSIFICATION OF THE PAPILLARY MUSCLE

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Background

The mitral valve and its subvalvular apparatus are an integral part of the left ventricle and play an important role in its geometry and systolic/diastolic function. The detailed interactions between the mitral valve, its subvalvular apparatus, and the left ventricle are not well understood. It is intuitive that annulo-papillary continuity is the most important factor in this relationship[1-3]. The importance of the continuity between the mitral annulus and papillary muscle in left ventricular performance is critical for prevention of postoperative mid-ventricular rupture in mitral valve replacement and complex mitral valve repairs[3-7].
Detailed anatomic findings concerning the anterior and posterior papillary muscles within the left ventricle, combined with our previous description of the structures within the left ventricle, hopefully will provide anatomists and cardiac surgeons with valuable knowledge and understanding.

Objective

To measure and assign a distance between mitral annulus and papillary muscles and to evaluate the morphology of the papillary muscles.

Material and methods

Eighty consecutive human hearts were studied at autopsy. All of the subjects were Mongolian aged 20 to 59 years (36.67±10.69 years, mean±standard deviation). The subjects included 49 men and 31 women. Body weights ranged from 52 to 85 kg (68.5±10.2 kg) and the heights of the bodies ranged from 155 to 176 cm (168.5±5.7 cm).
The hearts were normal, without any visual pathological alterations. There as no evidence of valvular or ischemic heart disease, as they were excluded from the study.
Immediately after the heart was taken from the body, the left atrium was excised to allow full visualization of the mitral valve. Without any venticulotomy, the heart was placed on wet gauze sheet loosely covering a well so that the heart was situated in the gauze cradle without any distortion of its shape. With gentle upward tension on the leaflets to straighten the chordae tendineae, the annulo–papillary muscle distances were measured with a caliper (with a metric rule graduated to 1 mm) in 4 directions according to our resuspension method[5]. The 2 distances were measured from the tip of the anterolateral papillary muscle to the annulus: to the left fibrous trigone (10-o'clock position) and to the point between the anterior and the middle scallops of the mural leaflet (8-o'clock position). Also, the 2 distances were measured from the tip of the posteromedial papillary muscle to the annulus: to the right fibrous trigone (2-o'clock position) and to the point between the middle and the posterior scallops of the mural leaflet (4-o'clock position) (Figure 1).

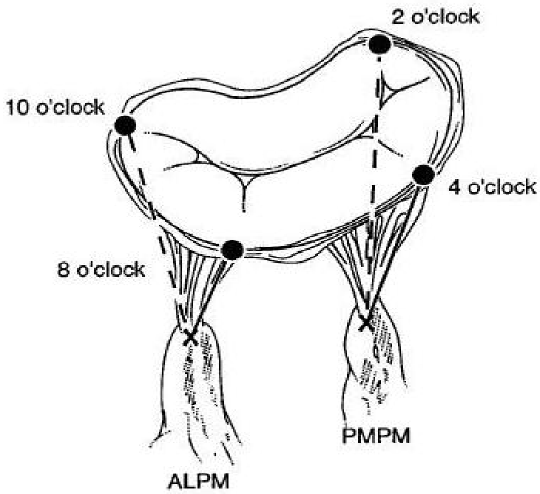

Fig. 1. Diagram of the annulo–papillary muscle distances that were measured in the study: *2-o'clock position,* The annulus at the right fibrous trigone; *4-o'clock position,* the anulus at the point between the middle and the posterior scallops of the mural leaflet; *8-o'clock position,* the anulus at the point between the anterior and the middle scallops of the mural leaflet; *10-o'clock position,* the anulus at the left fibrous trigone; *ALPM,* anterolateral papillary muscle; *PMPM,* posteromedialpapillary muscle.

The anatomy of the papillary muscles was described with special attention to the respective arrangement of the different heads, to the site and number of the basal parts of the different heads on the left ventricular wall (Figure 2).

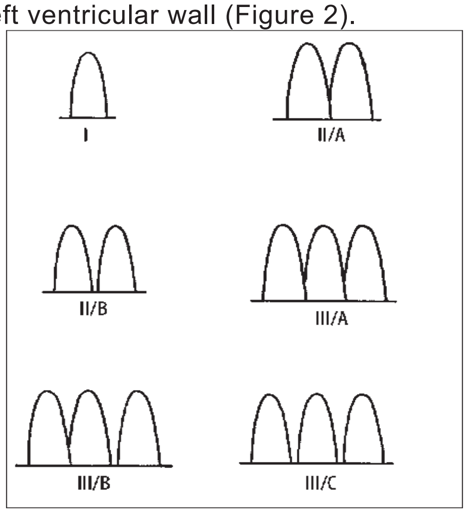

Fig. 2. Classification of the left ventricular papillary muscle. GROUP I: simple single muscle. GROUP II: the apical part forms two individual heads. This group is divided into Type II/A: the origin of two heads is common. Type II/B: vertical divition of the papillary muscle with two separated basal parts. GROUP III: multiple divition of the apical part forms three separated heads. The morphological variants of this group are Type III/A: three heads with common origin, Type III/B: one of the heads has its own origin, and Type III/C: all three heads have their own origins.

Data were analyzed with SPSS software package for Windows version 15.0. All results are shown as mean ± standard deviation. Comparisons of continuous variables in 4 annulo-papillary distances were performed by a 1-way analysis of variance, and significant differences were specified by Duncan's multiple range test. Each annulo-papillary distance was compared by paired *t* test.

Results

Figure 3 illustrates the 4 annulo-papillary muscle distances.

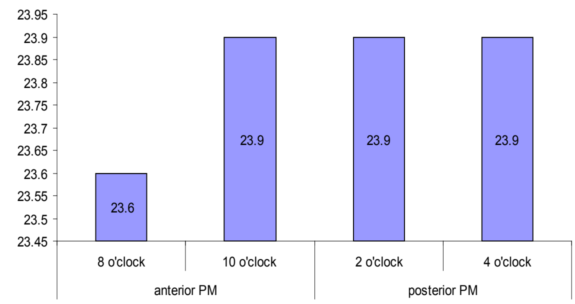

Fig. 3. Annulo-papillary muscle distance

The annulo–papillary muscle distances were similar in all 4 positions ($P = .96$, by 1-way analysis of variance). The distance from the anterior papillary muscle to the 10-o'clock position (23.9±4.9 mm), the distance from the anterior papillary muscle to the 8-o'clock position (23.6±3.4 mm), the distance from the posterior papillary muscle to the 2-o'clock position (23.9±4.2 mm), and the distance from the posterior papillary muscle to the 4-o'clock position (23.9±4.8 mm) was no statistical difference among the 4 distances (p).

We defined three main group of morphological variants of papillary muscle. In the group I the basal part and the apex of the muscle were undivided. In group II there were two heads; In subgroup II/A the base of the papillary muscle was undivided and in II/B t was divided into two separate parts. In group III the papillary muscle had three heads. In subgroup III/A the base was undivided, while in III/B it was made up of two and in III/C three separate parts.

Table I : The percentage disttribution of the papillary muscle.

Group	Anterior papillary muscle (n=80)	Posterior papillary muscle (n=80)
I	20.0	32.5
II/A	30.0	22.5
II/B	33.5	15.0
III/A	7.5	15.0
III/B	10.0	8.8
III/C	-	6.3

II/A (30.0%), II/B type (33.5%) of the anterior and I type (32.5%) of the posterior papillary muscles most common occured in Mongolia.

The annulo-papillary muscle distances were similar in all positions.

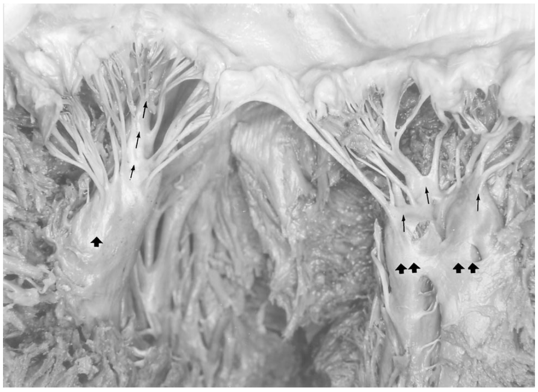

Fig. 4. The appearance of papillary muscles anterior (single thick arrow) and posterior (double thick arrows), and heads of papillary muscle (thin arrows) in the left ventricle.

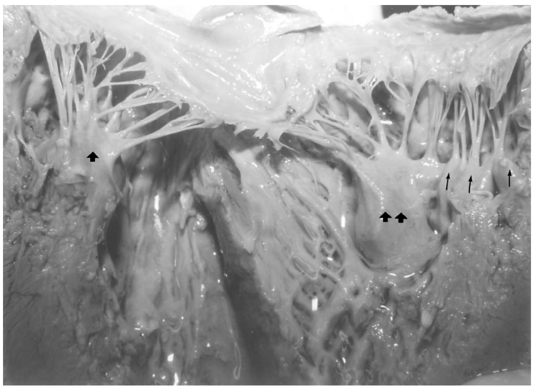

Fig. 5 : The appearance of papillary muscles anterior (single arrow) and posterior (double arrows), small groups of papillary muscle posteriorly (thin arrows) in the left ventricle.

Fig. 6 : The appearance of anterior papillary muscle (thick arrow) and head of papillary muscle (thin arrows) in the left ventricle.

Discussion

All aspects of mitral valve (valva atrioventricularis sinistra) complex including the annulus, leaflets, commissures, chordal structures and papillary muscles are so important to attain integrity and proper geometric modeling of left ventricle for systolic pump function[8,9].

Preservation of the annulopapillary muscle continuity in mitral valve replacement is essential. Even in patients who require excision of the mitral apparatus, the continuity can be restored. However, there is no guide to the proper length for the resuspension[10-12].

Sakai et al.[11] reported that, in normal hearts, the annulopapillary muscle distances of the mitral apparatus were similar in 2-, 4-, 8- and 10-o'clock positions and correlate with the mitral annular diameter. We found in our measurements that the annulopapillary muscle distance of the mitral apparatus was similar to that of Sakai et al.

Sakai et al.[11] reported that the distance from the tip of the anterior papillary muscle and posterior papillary muscle to the mitral annulus was 23.3 and 23.5 mm, respectively, in human. We measured the distance from the tip of APM and PPM to mitral annulus as 24.1 and 24.8 mm, respectively, in human. Our values were consistent with those of Sakai et al.

Acar and associates[13] directly measured the distance from the plane of the mitral anulus to the tip of the anterolateral papillary muscle (D1) and from that to the tip of the posteromedial papillary muscle (D2) in 82 human mitral allografts. They measured perpendicular distance between the plane and the papillary muscle tip, instead of an oblique distance from the tip to the anulus itself. They reported that D1 (21±3 mm) was shorter than D2 (26±4 mm). We did not find such a difference in this study.

Komeda et al.[14] reported that, despite an incomplete knowledge of the geometry and dynamics of the mitral annulus, papillary muscle and the chordae tendineae, chordal sparing was popular.

Bozbuga et al.[8,9] reported that the distribution of chordae tendineae varied slightly in both anterior and posterior groups. Musculus papillaris was not symmetrical in all subjects and four types of musculus papillaris were distinguished.

We observed that the anterior and posterior papillary muscles were present in 100% of cases of human hearts.

Mitral homograft replacement requires accurate knowledge of the anatomy of the papillary muscles. Clinical experience with mitral homografts has revealed unexplored aspects of the morphology of the mitral subvalvular apparatus, i.e. correllation between the papillary muscle subdivisions and the chordal attachment to leaflets[15,16].

Ramsheyi et al.[16] reported a classification based on how the papillary muscles relate to the leaflets via the chordae. Four types were described : In type I, the papillary muscle was single ; In type II, the papillary muscle had two heads, one of which sent chordae exclusively to the posterior leaflet; In type III, the papillary muscle was also divided, one head supported the commissural area exclusively; and in type IV, papillary muscle resembled type III, but was distinguished from it in the way that the head supporting the commissure was very short. In this type, the different heads also originated at different levels on the ventricular wall from the apex to the base. We did not identify these four types of papillary muscles in our study.

Conclusion

We found that the left ventricular papillary muscles have great diversity in appearance. In normal hearts, the mitral annulo-papillary muscle distances are similar in 2-, 4-, 8-, and 10-o'clock positions.

We believe that knowledge of both papillary muscles are very important. Moreover, we believe th that more detailed data collection and development of a model will further enhance our understanding of the functional anatomy of the subvalvular apparatus and advance current concepts of reconstructive subvalvular mitral surgery.

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