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Pattern of connection between papillary muscle and chordae tendineae of left ventricle

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SUMMARY

Mitral homograft replacement requires a good knowledge about anatomy of the papillary muscles. In 60 (38 male, 22 female) cardiac preparations of various age (16-44 ages), branch distribution of the chordae tendineae and level of their fixation to the ventricular surface of the right and left cusps of mitral valves have been studied. Papillary muscles and chordae tendineae were examined and their geometrical arrangement was determined.

Three groups of the left ventricular papillary muscle were defined. In group I (43.3%, 52/120) the basal part and the apex of the muscle were undivided. In group II (30%, 36/120) there were two heads; in subgroup II/A (20%, 36/120) the base of the papillary muscle was undivided and in II/B (10%, 12/120) it was divided into two separate parts. In group III (26.7%, 32/120) the papillary muscle had three heads. It was also observed that 2 to 15 chordae tendineae can originate from the apex of papillary muscle and 9 to 60 chordae tendineae can ended into the corresponding half of the valve insertions.

Thus these definitions and morphologic types may be of great value during endoscopic and conventional mitral valve replacement or reconstruction of the chordae tendineae and in mitral valve homograft implantations.

Key words: *Papillary muscle, chordae tendineae, mitral valve, left ventricular subvalvular apparatus, homograft implantation*

ÖZET

Sol ventrikül'ün musculus papillaris ve chordae tendineae'ları arasındaki bağlantının yapısı

Mitral homograft nakilleri için musculus papillaris'lerin anatomisinin iyi bilinmesi gerekir. Değişik yaşlara ait 60 kalpte (38 erkek, 22 kadın) chorda tendinea'ların dağılımı ve mitral kapağın sağ ve sol küspislerine tutunma seviyeleri incelendi. Papiller kaslar ve chorda tendinea'lar incelendi ve geometrik özellikleri ortaya konuldu.

Sol ventrikül'ün papiller kasları üç grupta tanımlandı. Grup I (43.3%, 52/120)'de bazal bölüm ve kasların apeksi bölünmemişti. Grup II (30%, 36/120)'de iki başlı papiller kas vardı; alt-grup II/A (20%, 36/120)'da papiller kasın tabanı bölünmemişti ve alt-grup II/B (10%, 12/120)'de bölünmüş iki ayrı parça halinde papiller kas mevcuttu. Grup III (26.7%, 32/120)'te üç başlı papiller kas bulunmaktaydı. Aynı zamanda mitral kapağın ortalarında sonlanan 9-60 chordae tendineae olabileceği ve papiller kasın apeksinden başlayan 2-15 chordae tendineae olabileceği gözlendi.

Bu konudaki yeni tiplendirmeler, endoskopik ve mitral kapak değişimleri veya chorda tendinea'ların rekonstrüksiyonu ve mitral kapak homogreft nakilleri sırasında önemli yol gösterecektir.

Anahtar kelimeler: *Papiller kas, chordae tendineae, mitral kapak, sol ventriküler subvalvüler aparat, homogreft implantasyon*

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Introduction

The mitral atrioventricular valve complex consists of functional units, which include the fibrous trigones, chordae tendineae and papillary muscles. Tendinous cords and papillary muscles connect mitral valvular leaflets to the left ventricle free wall like the shrouds of a parachute(1,2). The mitral valve and its subvalvular apparatus are integral parts of the left ventricle and play an important role on its geometry and systolic function. The interactions between the mitral valve, its subvalvular apparatus and the left ventricle are not understood in detail and mitral homograft replacement requires a good knowledge about anatomy of the papillary muscles. It seems that annulo-papillary continuity is the most important factor in this relationship(3,4,5). This theoretical concept was experimentally proved and is clinically applied by preservation of the chordae tendineae and by implantation of mitral valve homografts. Theoretically, artificial chordae implantation and mitral valve homograft implantation is considered the ideal treatment in cases where the preservation of the natural subvalvular apparatus is not feasible(6,7,8). The arrangement and classification of the chordae including the anatomy of the entire valve complex have been described by Walmsley(9) and then more by Lam et al.(10) in details. Anderson and Wilcox(11) have reviewed mitral valve anatomy and described the disposition of chordae in relation to their origin and insertion.

It also stands to reason that in these procedures the morphology of the left subvalvular apparatus is important for surgical strategy. Therefore in order to facilitate the reconstruction of the subvalvular apparatus it is also evident that a detailed understanding of the morphology becomes an important factor for successful intervention. The aim of this study was to

evaluate the morphology of papillary muscles and to describe the geometrical pattern of the chordae tendineae in the left ventricle of the human heart.

Material and Methods

120 papillary muscles were studied in 60 human autopsy hearts collected randomly. This study was performed with permission from National Forensic Institute on specimens harvested by the classical autopsies was performed in Morgue Specialization Department, Ankara Institute of Forensic Medicine. In 60 (38 male, 22 female) cardiac preparations of various ages (16-44 ages) branch distribution of the chordae tendineae and level of their fixation to the ventricular surface of the right and left cusps of mitral valves have been studied. Papillary muscles and chordae tendineae were examined. Then their geometrical arrangement was determined.

Results

Three groups of the left ventricular papillary muscle were defined. In group I (43.3%, 52/120) the basal part and the apex of the muscle were undivided (Fig. 1). In group II (30%, 36/120) there were two heads; in subgroup II/A (20%, 36/120) the base of the papillary muscle was undivided and in II/B (10%, 12/120) it was divided into two separate parts (Fig. 2, 3). In group III (26.7%, 32/120) the papillary muscle had three heads. In subgroup III/A (16.7%, 20/120) the base was undivided, while in III/B (10%, 12/120) it was made up of two parts (Fig. 4, 5).

Additionally it was observed that 2 to 15 chordae tendineae can originate from the apex of papillary muscle and 9 to 60 chordae tendineae can ended into the corresponding half of the valve insertions.

Discussion

Early authors dealt mainly surgical descriptions of papillary muscle morphology in the literature(9,12,13,14). Later, with the advantage of open heart surgery, more knowledge of the mitral valve was gathered by numerous authors(15,16,17). In a previous study classification of the left ventricular subvalvular apparatus based on the macroscopic and endoscopic investigations was proposed(18). Kervancioglu et al. described false tendons as single or multiple, thin, fibrous or fibromuscular structures that traverse the cavity of the left ventricle and have no connections with the valvular cusps(19). Then researchers mentioned that there is no direct attachment of the mitral valve to the ventricular septum, although the papillary muscles are frequently connected to the septum or to the right fibrous trigone by false cords(20). In previous study the authors

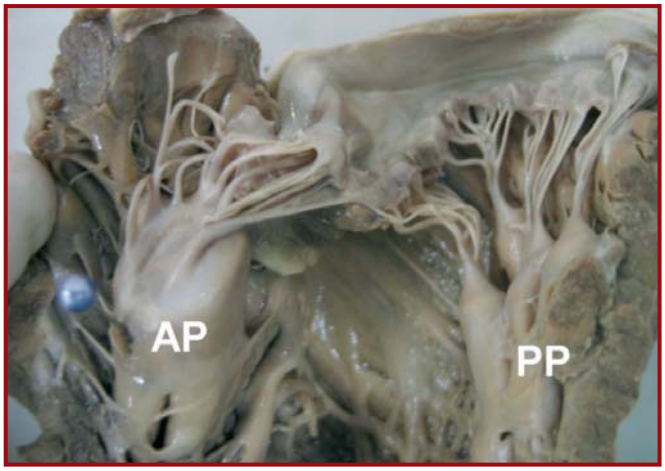

Figure 1. The left ventricular subvalvular apparatus. Type I undivided anterior papillary muscle. AP anterior papillary muscle (needle attached), PP Posterior papillary muscle

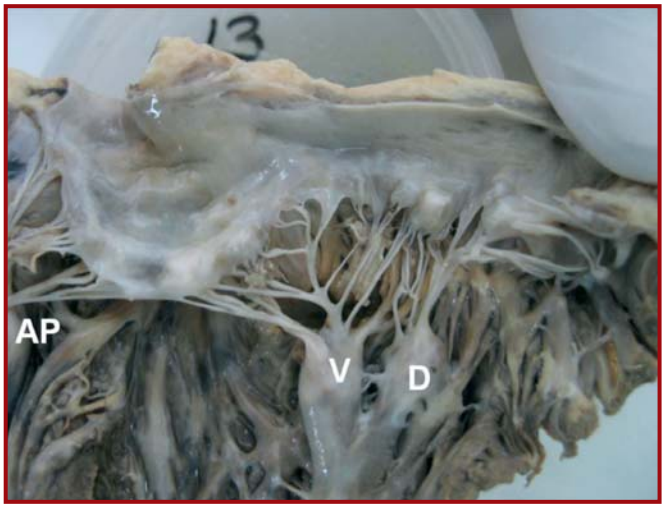

Figure 2. Type II/A posterior papillary muscle. It has two heads; ventral (V) and dorsal (D) ones and its base is undivided.

Figure 3. Type II/B posterior papillary muscle. It has two heads; ventral (V) and dorsal (D) ones and its base is divided into two sides.

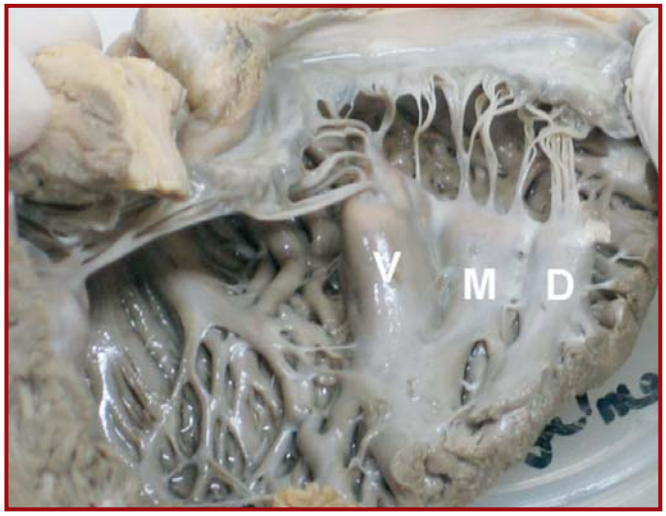

Figure 4. Type III/A posterior papillary muscle. It has three heads; ventral (V), middle (M), dorsal (D) ones and its base is undivided.

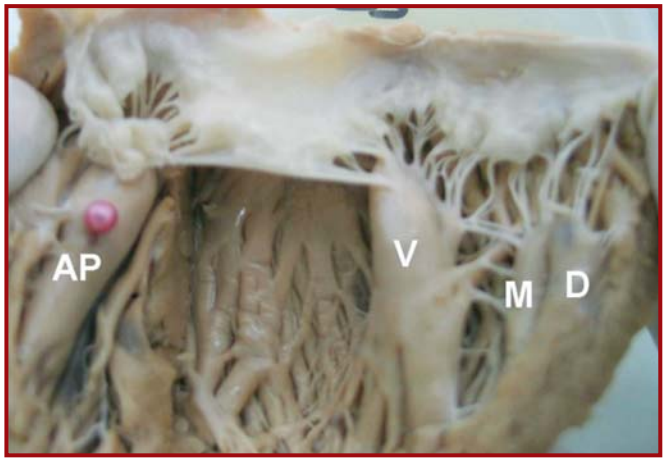

Figure 5. Type III/B posterior papillary muscle. It also has three heads and its base is made up of two sides.

classified and named the papillary muscle(21). The single papillary muscles were conical, mammillated, flat topped, grooved, stepped, wavy, arched, sloped or saucerized. When there were two bellies they presented a two tiered, interlinked, parallel, arched, V, Y, or H configuration(21). Ramsheyi et al.(22) reported that based on presentation of the left ventricular subvalvular apparatus four groups can be established. But basal parts of the papillary muscles were not defined. In our study contributions of basal parts were also used during classification.

Ranaganthan and Lam produced a simplified description of the papillary muscle and chordae tendineae and introduced the nomenclature which has been used widely(17).

Four to 22 chordae originated from the anterolateral papillary group, ending in 14 to 72 chordal insertions into the corresponding half of the valve. Likewise, 2 to 18 chordae arose from the posteromedial papillary group and ended in 12 to 80 leaflet insertions. The chordae in each group are best considered totally as a fan. The configuration of the fan is unique in each heart(21).

A recent study was undertaken to understand the spatial configuration of the papillary muscles and chordae tendineae and to assess the extent to which this configuration may influence the reconstruction of the subvalvular apparatus and homograft implantation. The relevance of chordopapillary variations in rheumatic heart disease, reparative procedures, papillary muscle dysfunction, mitral valve prolapse, mitral valve replacement, and use of mitral valve homograft for mitral/tricuspid replacement have also been discussed(21). Morphology of the left ventricular subvalvular apparatus becomes popular in recent years with homograft implantation and the introduction of endoscopic procedures in mitral valve surgery(23,24).

Thus these results may be of great value in endoscopic and conventional mitral valve replacement or reconstruction of the chordae tendineae and in mitral valve homograft implantation. Because implantation of the papillary muscle to the left ventricular wall is important, types of the muscles will be important during these procedures.

This study differs from previous studies by presenting images of all types of papillary muscle patterns. These data will be helpful for relevant cardiac surgeons performing mitral valve homograft implantation.

References

1. Muresian H. The clinical anatomy of the mitral valve. Clin Anat 2009;22:85–98.
2. Ho SY. Anatomy of the mitral valve. Heart 2002;88 Suppl:iv5–10.
3. David TE. Papillary muscle-annular continuity: Is it important. J Card Surg 1994; 9(2 Suppl.): 252–54
4. Sarris GE, Fann JI, Niczyporuk MA, Derby GC, Handen CE, Miller DC. Global and regional left ventricular systolic performance in the in situ ejecting canine heart:Importance of the mitral valve apparatus. Circulation 1989; 80(3 Pt 1):I24-42.
5. Gams E, Schad H, Heimisch W, Hagl S, Mendler N, Sebening F. Preservation versus severance of the subvalvular apparatus in mitral valve replacement: An experimental study. Eur J Cardiothoracic Surg 1990; 4: 250–56
6. Acar C, Farge A, Ramsheyi A, Chachques JC, Mihaileanu S, Gouezo R, Gerota J, Carpentier AF. Mitral valve replacement using a cryopreserved mitral homograft. Ann Thorac Surg 1994; 57: 746–48.

7. Acar C, Tolan M, Berrebi A, Gaer J, Gouezo R, Marchix T, Gerota J, Chauvaud S, Fabiani JN, Deloche A, Carpentier A. Homograft replacement of the mitral valve. Graft selection, technique of implantation and results in forty-three patients. J Thoracic Cardiovascular Surg 1996; 111: 367–80.
8. Plunkett MD, Schneider DJ, Shah JJ, Bash SE, Bond LM, Geiss DM. Homograft replacement of mitral valve in children. Ann Thorac Surg 1998; 66: 849–52.
9. Walmsley T. The heart, vol. IV, part III. In Quain's Elements of Anatomy (ed. Sharpey-Shaffer E, Symington J, Bryce TH). London: Longman 1929; pp. 46±7.
10. Lam JHC, Ranganathan N, Wigle ED, Silver MD. Morphology of the human mitral valve. I. Chordae tendineae: a new classification. Circulation 41, 1970; 449±458.
11. Anderson RH, Wilcox BR. The anatomy of the mitral valve. In Mitral Valve Disease (ed. Wells FC, Shapiro LM), London: Butterworth 1995; p. 4.
12. Brock RC. The surgical and pathological anatomy of mitral valve. Brit Heart J 1952; 14: 746–48
13. Rusted IE, Scheifl ey CH, Edwards JE, Kirklin JW. Guides to the commissures in operations upon the mitral valve. Mayo Clin Proc 1951; 26: 297-305.
14. Rusted IE, Scheifl ey CH, Edwards JE. Studies of the mitral valve. I-Anatomic features of the normal mitral valve and associated structures. Circulation 1952; 6: 625–883.
15. Chiechi MA, Lees WM, Thompson R. Functional anatomy of the normal mitral valve. J Thoracic Surg 1956; 32: 378–98.
16. Davila JC, Palmer TE. The mitral valve: anatomy and pathology for the surgeon. Arch surg 1962; 84: 174–82.
17. Ranganatham N, Lam JHC, Wigle ED, Silver MD. Morphology of the human mitral valve. II-The valve leaflet. Circulation 1970; 41: 459–67.
18. Berdajs D, Lajos P, Turina MI. A new classification of the mitral papillary muscle. Med Sci Monit 2005 Jan;11(1):BR18-21.
19. Kervancioğlu M, Ozbağ D, Kervancioğlu P, Hatipoğlu ES, Kilinç M, Yilmaz F, Deniz M. Echocardiographic and morphologic examination of left ventricular false tendons in human and animal hearts. Clin Anat 2003; Sep;16(5):389-95.
20. Loukas M, Louis RG Jr, Black B, Pham D, Fudalej M, Sharkees M. False tendons: an endoscopic cadaveric approach. Clin Anat 2007; Mar;20(2):163-9.
21. Victor S, Nayak VM. Variations in the papillary muscles of the normal mitral valve and their surgical relevance. J Card Surg 1995;10(5):597-607.
22. Ramsheyi SA, Pargaonkar S, Lassau JP, Acar C. Morphologic classification of the mitral papillary muscles. J. Heart Valve Dis 1996; 5(5):472-6.
23. Cagli K. A simple method of making artificial chordal loops for mitral valve repair. Ann Thorac Surg 2010; Feb;89(2):e12-4.
24. Chiappini B, Sanchez A, Noirhomme P, Verhelst R, Rubay J, Poncelet A, Funken JC, El Khoury G. Replacement of chordae tendineae with polytetrafluoroethylene (PTFE) sutures in mitral valve repair: early and long-term results. J Heart Valve Dis 2006; Sep;15(5):657-63.