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 ventrikülün musculus papillaris ve chordae tendineae’lari arastırdıkları kullanılan yapısı.
Mitral homograft nakilleri için musculus papillaris’lerin anatomisinin iyi bilimmesi gerekir. Değişik yaşlarda alt 60 kalpte (38 erkek, 22 kadın) chorda tendineae’iın dağılımı ve mitral kapağın sağ ve sol kuspislerine tutunma seviyeleri incelendi. Papiller kaslar ve chorda tendineae’ler incelendi ve geometrik özellikleri ortaya konuldu.
Sol ventrikülün papiller kasları üç grupa tanımlandı: Grup I (43.3%, 52/120) de bazal bölüm ve kasların aksi bölümü bölünmemiştir. Grup II (30%, 36/120) de iki başlı papiller kas vardi; alt-grup II/A (20%, 36/120) da papiller kasın tabanı bölünmemiştir ve alt-grup II/B (10%, 12/120) de bölümümüştü iki ayrı parça halinde papiller kas mevcuttu. Grup III (26.7%, 32/120)’te üç başlı papiller kas bulunmamaktaydı. Bunun yanında mitral kapağın ortalarında solan 9-60 chorde tendineae olabileceğini ve papiller kasın aksesinden başlayan 2-15 chordae tendineae olabileceğini ziyaret etmiştir. Bu konudaki yeni tiplendirmeler, endoskopik ve mitral kapak değişimleri veya chorda tendineae’lärin rekonstrüksiyonu ve mitral kapak homograft nakilleri sırasında önemli rol göstercektir.

Anahtar kelimeler: Papiller kas, chordae tendineae, mitral kapak, sol ventriküler subvalvular aparat, homograft implantasyon

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...
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


