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Original Article

MORPHOLOGICAL VARIATIONS OF PAPILLARY MUSCLES IN NORTH INDIANS: A CADAVERIC STUDY

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ABSTRACT :

Background: Aim of the present study was to observe the morphology, number, shape, position and pattern of papillary muscles. Morphological study of papillary muscles of the right and the left ventricle is important for the surgeon in reparative procedures, papillary muscle dysfunction, mitral valve replacement and use of mitral valve homograft for mitral/tricuspid replacement due to its anatomical variability. Material and Methods: - 60 formalin preserved hearts of human cadavers were used for the study. Dissection was performed according to standard techniques. The number, shape, position and pattern of papillary muscles were observed, photographed and documented. Results: - Classical papillary muscles in the left ventricle were observed in only 23.33% specimens. Two groups (multi - segmental) of papillary muscles were observed in 53.33% specimens, three groups in 18.33% specimens and four groups in 1.67% specimens. While 3.33% of specimens were found to be having multi-apical papillary muscle. Conical shaped papillary muscles were observed in 45% specimens, broad-apexed were observed in 51.67% specimens and pyramidal in 3.33% specimens The patterns of papillary muscles were also observed .Separate bases and fused apex in 36.66 % specimens, single base and divided apex in 1.66% specimens. Small projections of papillary muscles in 14.17 % specimens. Long papillary muscles in 30.83% specimens .Perforated papillary muscles in 9.17 % specimens and papillary muscles with base attached to a large bridge in 7.5% specimens.

Conclusion : Morphological study of papillary muscles may help cardiac surgeons during surgical procedures conducted for correction of their defects as well anatomists to help in understanding the development and variations.

INTRODUCTION : As a requirement for the pumping function, the heart must have a determined arrangement of the ventricular muscle fibers[1].The structure of left atrioventricular valve apparatus is composed by the mitral annulus, mitral valve leaflets, chordae tendineae and papillary muscles[2]. Mechanical properties of mitral valve apparatus depend to large extend on the link between papillary muscle and valve that transmit contractions of the muscle to the valve leaflets[3]. Rupture and dysfunction of papillary muscles and chordae are very much responsible for this by causing mitral valve prolapse. Various operative procedures such as resection, repositioning and realignment are routinely done to maintain its normal anatomy and physiology. Hence it is very important to have clear cut knowledge about the normal anatomy of papillary muscles as well as its variations.

The objective of this research work is to study the gross architecture of papillary muscles and its variations.

Material and Methods : 60 formalin preserved hearts of human cadavers were used for the study. Heart samples were procured from Department of Forensic Medicine, Department of Anatomy , Institute of Medical Sciences, BHU , Varanasi (U.P). All necessary consents were taken prior to the commencement of our study. Hearts with morphological variations and those with diseased, fibrosed valves were excluded

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from study. Firstly the heart samples were properly washed with water and then the left ventricular chambers were opened by giving a longitudinal incision starting from left auricle up to the apex of the heart. Clots were removed and then the chambers were washed under running tap water to have a clear view of papillary muscles. Dissection was performed according to standard techniques. The number, shape, position and pattern of papillary muscles were observed and recorded.

RESULTS : We followed the same method which is mentioned by Shwarek et al[4]. Shwarek et al had used the concepts of 'multi-apical' and 'multi-segmental' papillary muscles. In this study, papillary muscles with a single base and single apex were considered as classical papillary muscles. Papillary muscles with a single base and divided apex were considered as multi-apical or multi-bellied, whereas papillary muscles with separate bases were categorized as multi-segmental or groups of papillary muscles.

Classical papillary muscles in the left ventricle were observed in only 23.33% specimens. Two groups (multi - segmental) of papillary muscles were observed in 53.33% specimens, three groups in 18.33% specimens and four groups in 1.67% specimens. While 3.33% of specimens were found to be having multi-apical papillary muscle as depicted in Table 1.

No. of papillary muscles	No. of specimens (%)
Classical	14 (23.33)
Two groups	32 (53.33)
Three groups	11 (18.33)
Four groups	1(1.67)
Multi-Apical	2 (3.33)

Table 1. Showing variations in the number of papillary muscles of left ventricle.

Conical shaped papillary muscles were observed in 45% specimens, broad-apexed were observed in 51.67% specimens and pyramidal in 3.33% specimens as shown in Table 2.

Shape of papillary muscles	No. of specimens (Anterior and Posterior Papillary Muscles) (%)
Conical	54 (45)
Broad-apexed	62 (51.67)
Pyramidal	4 (3.33)

Table 2. Showing variations in the shape of papillary muscles of left ventricle.

The patterns of papillary muscles were also observed. Separate bases and fused apex in 36.66% specimens, single base and divided apex in 1.66 % specimens. Small projections of papillary muscles in 14.17%

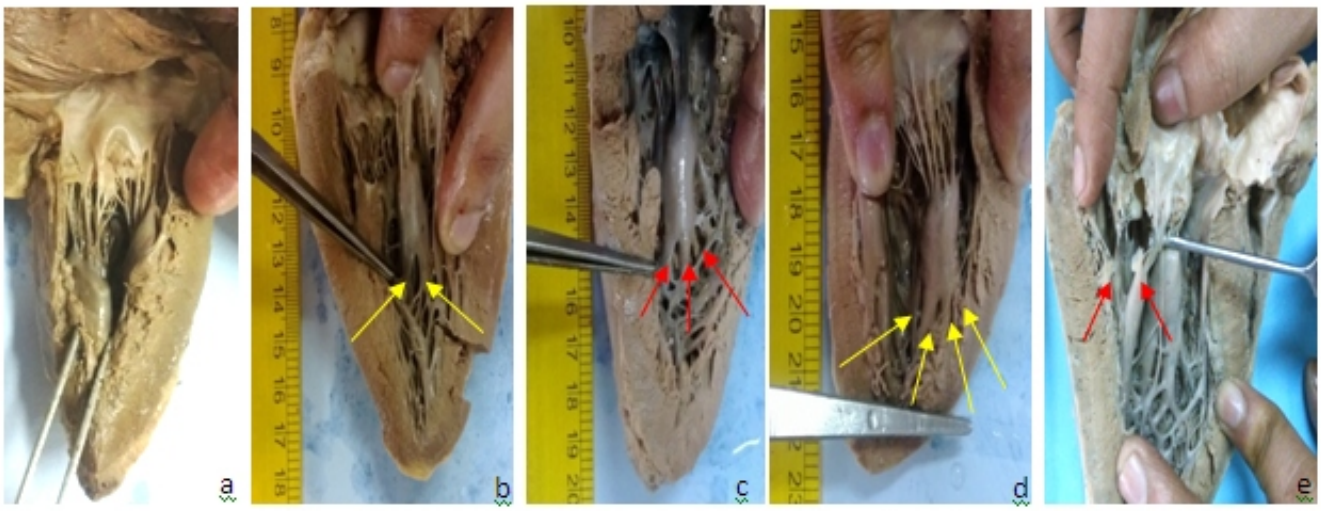

Figure 1. Images showing variations in the number of papillary muscles of left ventricle. (a) Classical papillary muscle; (b) Two groups of papillary muscle; (c) Three groups of papillary muscle; (d) Four groups of papillary muscle; (e) Multi-apical papillary muscle.

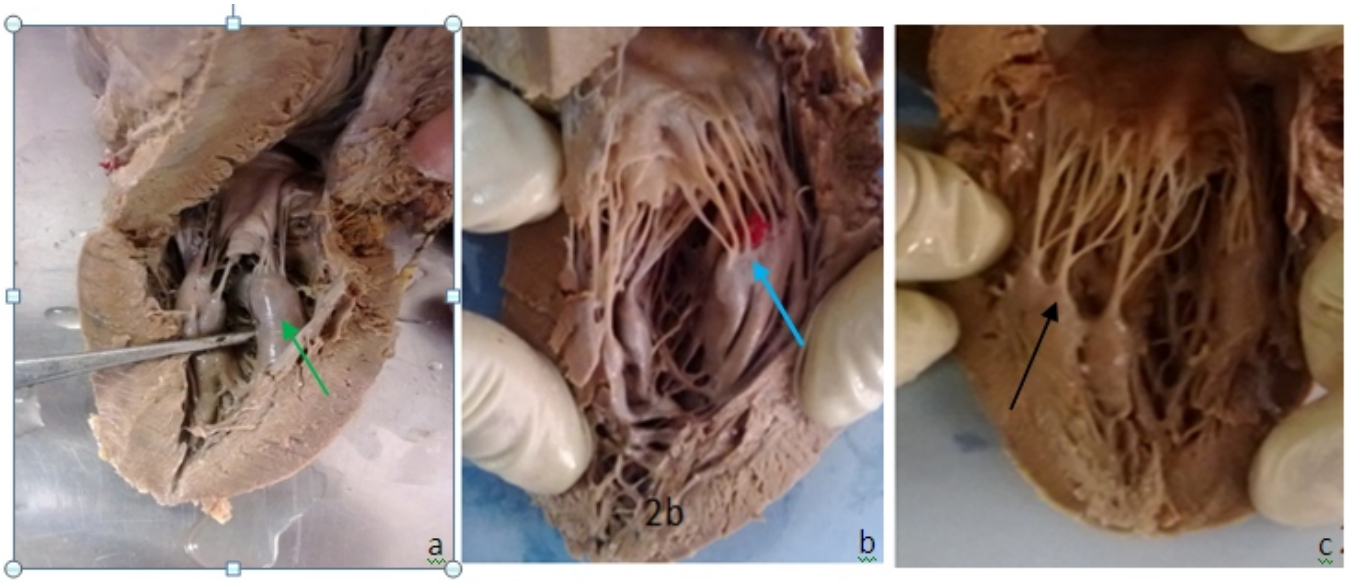

Figure 2. Images showing variations in the shape of papillary muscles of left ventricle. (a) Conical shaped papillary muscle; (b) Broad-apexed papillary muscle; (c) Pyramidal shaped papillary muscle.

specimens. Long papillary muscles in 30.83% specimens. Perforated papillary muscles in 9.17% specimens and papillary muscles with base attached to a large bridge in 7.5% specimens as shown in Table 3.

Pattern of papillary muscles	No. of specimens (Anterior and Posterior Papillary Muscles) (%)
Separate bases and fused apex	44 (36.66)
Single base and divided apex	2 (1.66)
Small projections of papillary muscles	17 (14.17)
Long papillary muscles	37 (30.83)
Perforated papillary muscles	11 (9.17)
Base attached to a large bridge	9 (7.5)

Table 3. Showing variations in the pattern of papillary muscles of left ventricle.

DISCUSSION : Mitral valve is the most common choice for research but very few studies have been done on morphology of papillary muscle of the mitral valve complex. Mitral valve complex is very much different from other valvular complexes in a way that it is very much prone to wear and tear due to high pressure gradient across it. Victor and Nayak stated in their study on variations in the papillary muscles of the normal mitral valve in 100 cases, that the mitral valve apparatus including the papillary muscles is as unique to each individual as one's own fingerprints[5].

Gray's anatomy states that there are only two papillary muscles in the left ventricle[6]- one large anterior papillary muscle and one small posterior papillary muscle. According to Ho's study, there are usually groups of papillary muscles arranged fairly close together.[7]

In our study , the presence of two papillary muscles with a 'single base and single apex' in left ventricle was found in only 23.33% of the specimens, while two or more groups of papillary muscles were seen in rest of cases. Left ventricular outflow tract obstruction and mitral regurgitation may be caused by an increase in the number and size of the papillary muscles. Where there are only two papillary muscles in left ventricle, half the chordae are under the control of one single papillary muscle. Thus in case of ischemia affecting the base of papillary muscle will render half the chordae dysfunctional, and this leads to mitral valve prolapse and severe mitral regurgitation. Whereas in cases where there are groups of papillary muscles, the severity of infarction

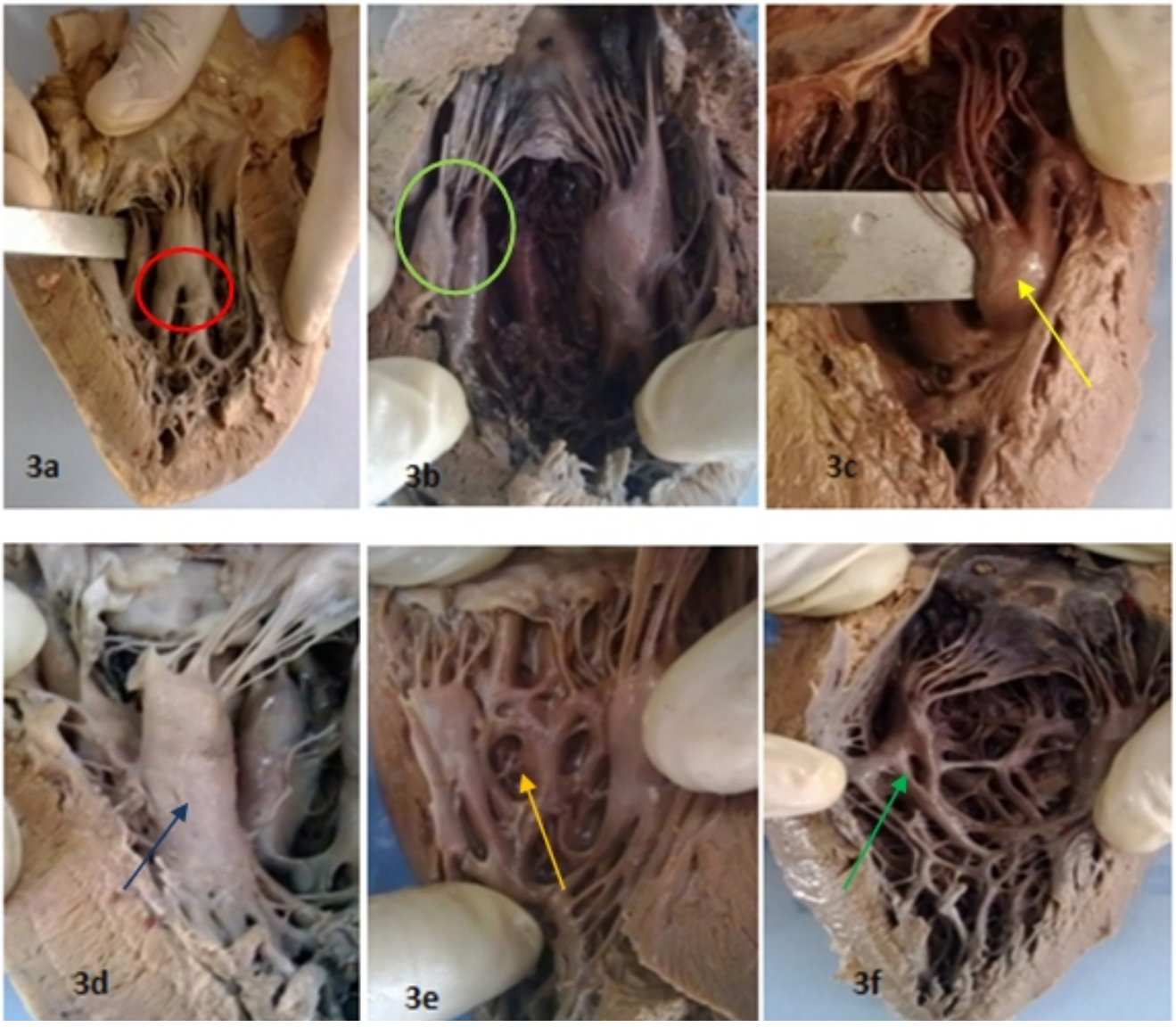

Figure 3. Images showing variations in the pattern of papillary muscles of left ventricle. (a) Separate bases and fused apex; (b) Single base and divided apex; (c) Small projections of papillary muscle; (d) Long papillary muscle; (e) Perforated papillary muscle; (f) Base of papillary muscle attached to a large bridge.

is much less as papillary muscles in groups being partially affected and consequently fewer dysfunctional chordae. Passage of blood flow is also affected by the shape of papillary muscles. In standard textbooks, papillary muscles are usually described as conical shaped. In our study, 45% of the specimens had conical shaped papillary muscles. Other shapes found in our study included broad-apexed and pyramidal. The chances of left ventricular outflow tract obstruction are higher in papillary muscles with a broad apex. The ideal shape of papillary muscles which provides minimum obstruction to the blood flow is conical –shaped, broad-base attached to the ventricular wall away from the centre of cavity and with a narrow apex occupying minimal space in the centre of cavity. Papillary muscle realignment and repositioning is the treatment of choice for symptomatic left ventricular outflow tract obstruction and dysfunction[8-11]. Surgery for papillary muscle realignment is done using two or three mattress sutures with a pledget, passed through the base and body of the anterior and

posterior papillary muscles. The sutures are then tied till both the papillary muscles come in contact with each other[12]. Many studies have shown that variations in the morphology of papillary muscles are of significance in surgical procedures,[13]. The two papillary muscles are stitched together in all surgical procedures to correct the disorder, or one of the heads of the anterior papillary muscle is resectioned and then stitched together with the posterior papillary muscle. The number of options deciding the direction and degree of realignment increases with increase in the number of papillary muscle bellies , as found in our study and this facilitates the restoration of normal functioning of mitral valve complex.

Conclusion : Morphological study of papillary muscles may help cardiac surgeons during surgical procedures conducted for correction of their defects as well anatomist to help in understanding the development and variations.

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