IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 1 Ver. VIII (Jan. 2016), PP 15-19
www.iosrjournals.org

Morphological Study of Left Sub-Valvular Apparatus in Human Foetal Hearts

Thounaojam Oken Singh[1], IrungbamDevenSingh[2],
Thounaojam NaranbabuSingh[3], Gaining Gangmei[1], Dipanjana Chakraborty[1],
SanjenbamSonaliDevi[4]

[1]*Postgraduate trainee,*[2]*Assistant Professor,*[3] *Professor,*[4]*Senior resident,Department of Anatomy, Regional Institute of Medical Sciences, Imphal, India.*

Abstract:*Usually two papillary muscles are described in the left ventricle, anterior (superior) and posterior (inferior); either may be multiple. Many authors mentioned presence of accessory papillary muscles and various patterns of the base and apex of papillary muscle. This study was carried out on 25 formalin-fixed human foetal hearts of gestational age ranging from 14 to 40 weeks in the department of Anatomy, RIMS, Imphal. Left ventricles were cut opened and the number, position, pattern of papillary muscle heads at the base and apex, and distribution of chordae tendineae to mitral valvular cusps were observed and recorded. The number of papillary muscles were found to be highly variable in both anterior as well as posterior group of papillary muscle. In both groups, the existence of single muscle was most common (48% in anterior group and 52% in posterior group), the number varying from 1 to 3 papillary muscle in anterior group whereas up to 4 muscles were observed in the posterior group of papillary muscles. Number of heads at the base of a papillary muscles varied from single head to more than 3 heads and also observed to have variable number of apical heads. Knowledge of variations in the sub-valvular apparatus of left side will help clinicians on the echocardiography, function & pathophysiological presentations and planning their treatment.*

Keywords: *chordae tendineae,foetal heart, left ventricle, papillary muscles, variations.*

I. Introduction

The two papillary muscles(PM) supporting the leaflets of the mitral valve vary in length and breadth, and may be bifid. The anterolateralmuscle arises from the sternocostal mural myocardium,the posteromedial from the diaphragmatic region.The chordae tendineae are fibrous collagenous structures that support the leaflets of the atrioventricular valves. Sometimes, false chordae connect the papillary muscles to each other or to the ventricular wall or septum, or pass directly between points on the wall or septum, or both. Approximately 40% of these false cords contain conduction cardiomyocytes. The true chordae usually arise from small projections on the tips or margins of the apical third of papillary muscles, although they sometimes arise from the bases of the papillary muscle or directly from the ventricular walls and septum. True mitral valve chordae may be divided into four types: interleaflet (commissural), rough zone (including the special strut chordae), 'cleft' and basal chordae. In the majority of hearts, the chordae support the entire free edges of the valvular leaflets, together with varying degrees of their ventricular aspects and bases, and there is some evidence to suggest that those valves with unsupported free edges become prone to prolapse in later life.[1]

The number of papillary muscles may be highly variable. Instead of the usual two papillary muscles, many groups of papillary muscles may be found. The base and apex of papillary muscle may show variations as 'separate bases and fused apex', 'single base and divided apex', 'small projections' of papillary muscles, long papillary muscles, 'perforated' papillary muscles and those with 'base attached to a large bridge'.[2]Only two papillary muscles of the left ventricles are described, both of them large; they are designated as anterior (superior) and posterior (inferior); either may be multiple. Each of these muscles sends chordae tendineae to both cusps of the mitral valve.[3]

An accessory PM is defined as one with origins separated from the anterolateral and posteromedial PMs, or one that branched into two or three bellies at the base of the anterolateral or posteromedial PM. Accessory PM is found to be independently associated with sudden cardiac arrest of unknown cause.[4]

II. Materials &Methods

The present cross-sectional study was done on 25 formalin-fixed foetal hearts collected from 14 to 40 weeks old fetuses. Age of the fetus was calculated from crown rump length & obstetric history. Hearts from fetuses with gross malformations were excluded from the present study. These fetuses were collected from the Department of Obstetrics & Gynecology, RIMS Hospital, Imphal with due permission from concerned parents and Institutional Ethics Committee.

Hearts were removed with a midline thoracotomy and cutting open the pericardial sac. Left ventricles were cut opened with an incision from the apex of heart along the left border and extending up to the left atrium. Left ventricular chamber was washed with running tap water to visualize the papillary muscle and chordae tendineae. The number, pattern of papillary muscles and attachment of chordae tendineae were observed and recorded.

In the present study, papillary muscles that had a single base or a single apex were considered to be classical papillary muscles. Papillary muscles that originated from different heads attached on the ventricular wall which may be attached to other heads of papillary muscles by trabeculae carneae away from the wall and those which originated from separate bases were considered as separate PM(Fig.1: a& b). PM attached to the other heads by trabeculae carneaewhich fuses with the ventricular wall andthose originated as single base with divided bellies were considered as single PM with multiple apical heads(Fig.1: c &d). Remaining papillary muscles were categorized according to the number of heads of bases and apices. Papillary muscles that were present along the sterno-costal surface were grouped as anterior and those present on the diaphragmatic surface were grouped as posterior papillary muscle.[1]

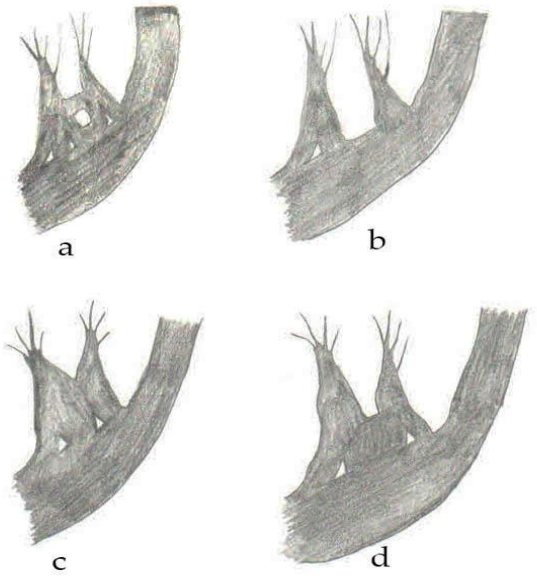

Fig. 1. Diagram showing various schemes of papillary muscles (a,b were considered as separate papillary muscles; c,d were considered as single papillary muscles)

III. Results& Observation

In 25 foetal heart specimens studied, 38 anterior papillary muscles and a higher number of 46 posterior papillary muscles were observed. In the present study,out of the total 25 specimens studied classical pattern with single anterior and a single posterior papillary muscle was most common in 11(44%). In the anterior group of papillary muscle single papillary muscle was most common in 13(52%), 2 anterior papillary muscles were seen in 11(44%) and 3 anterior papillary muscles were seen in only 1 (4%) of the specimens (Fig. 2A). Single posterior papillary muscle was seen in 12(48%), 2 papillary muscles were seen in 8(32%), 3 papillary muscles (Fig. 2B) in 2(8%) and a maximum of 4 papillary muscles were seen in 3(12%) specimen (Table 1).

Table 1. Distribution of anterior and posterior groups of papillary muscle in left ventricle.

Number of Papillary muscle	Anterior group of papillary muscle	Posterior group of papillary muscle
1	13(52%)	12(48%)
2	11(44%)	8(32%)
3	1(4%)	2(8%)
4	0	3(12%)
Total	38	46

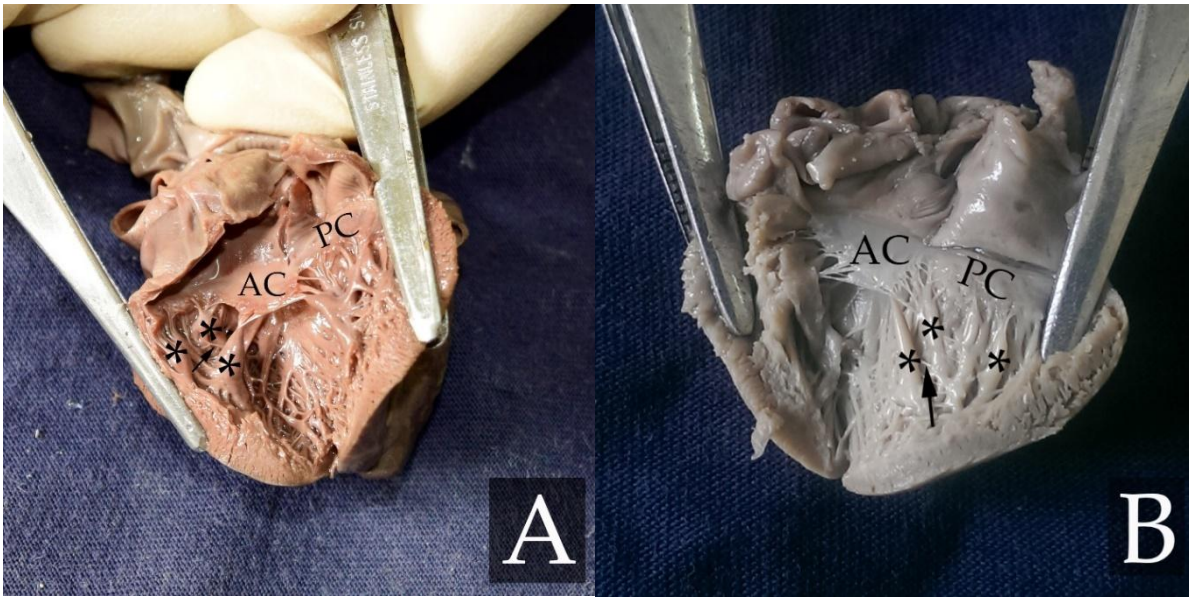

Fig. 2. A. Photograph showing multiple (3) anterior group of papillary muscles. B. multiple (3) posterior group of papillary muscles. (*PM, AC=anterior cusp of mitral valve, PC=posterior cusp of mitral valve, arrow=false chordae)

Regarding the origin of papillary muscle at the base, out of the total 25 hearts, there were 38 groups of anterior papillary muscles and 46 groups of posterior papillary muscles.Out of the total 38 anterior groups of PM, single head was found in 22, double heads in 12, triple heads in 3 and more than 3 heads in 1. Out of the 46 posterior groups of PM, single head was found in 21, double heads in 18 (Fig. 3B), triple heads in 4 and more than 3 heads in 3 (Table 2). Regarding the number of heads at the apex, out of the total 38 anterior group of papillary muscles,single apical head was found in 29 muscles, double apical heads in 7, triple apical heads in 1 and more than 3 apical heads in 1. Out of the total 46 posterior group of papillary muscles, single apical head was seen in 28, double apical heads in 12 (Fig. 3A), triple apical heads in 4 and more than 3 apical heads in 2 (Table 2).

Table 2. Distribution of papillary muscle according to the number of heads in the base and apex of each papillary muscle.

	Number of heads	Anterior papillary muscle	Posterior papillary muscle
Base	Single head	22	21
	2 heads	12	18
	3 heads	3	4
	> 3 heads	1	3
Tip	Single head	29	28
	2 heads	7	12
	3 heads	1	4
	> 3 heads	1	2

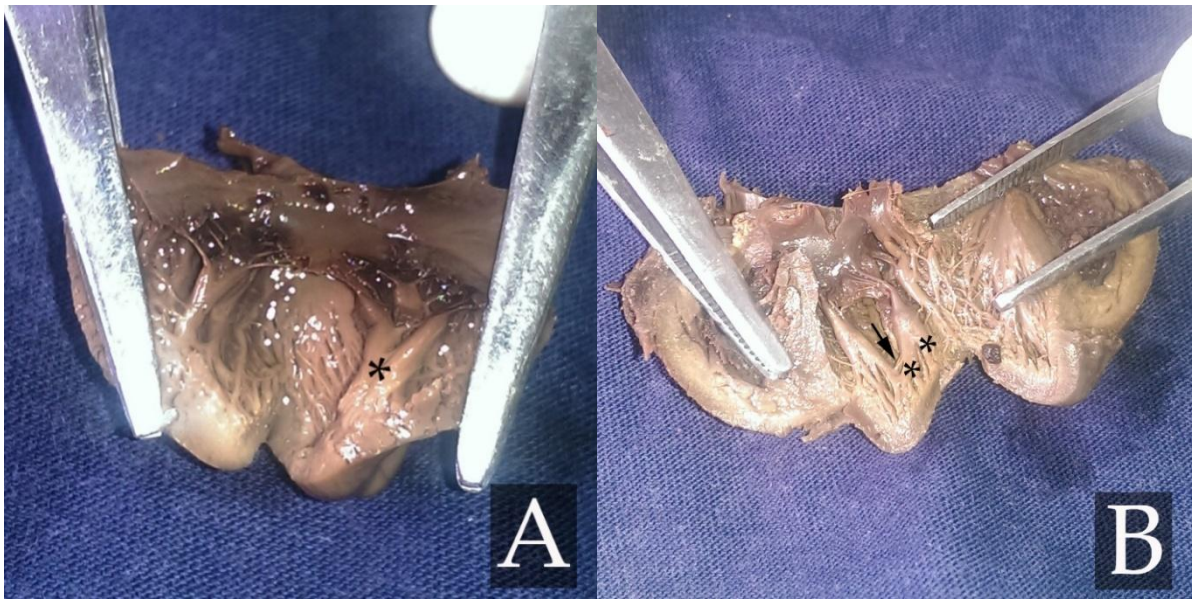

Fig. 3. A. Photograph showing one posterior PM with two apical heads. B. Showing two basal heads of a single anterior PM. (* PM, arrow= trabeculae carnae band connecting two PMs.)

The mitral valve of all 25 foetal heart specimens were having 2 mitral valvularcusps, the anterior and posterior cusps. 9 anterior cusps received chordae tendineae from only anterior papillary muscles, whereas 16 anterior mitral valvular cusp received chordae from both anterior and posterior papillary muscles. 5 posterior valvular cusps received chordae from posterior papillary muscle only whereas 20 posterior valvular cusps received chordae from both anterior as well as posterior papillary muscles (Table 3).

Table 3. Distribution of the chordae tendineae from the papillary muscles to anterior and posterior mitral valvular cusps.

Chordae tendineae	Anterior cusp	Posterior cusp
Anterior papillary muscle only	9 (36%)	0
Posterior papillary muscle only	0	5 (20%)
Anterior and posterior both	16 (64%)	20 (80%)

IV. Discussion

Standring S[1] mentioned presence of two papillary muscles namely anterolateral and posteromedial papillary muscles in the left ventricle.Uhm JSet al[4] defined accessory PM as those with origins separated from the anterolateral and posteromedial PMs, or a PM that branched into two or three bellies at the base of the anterolateral or posteromedial PM. They retrospectively reviewed history, laboratory data, electrocardiography, echocardiography, coronary angiography, and cardiac CT/MRI for 190 patients with sudden cardiac arrest (SCA) and 98 age and sex matched patients without SCA.By logistic regression, they have concluded that accessory PM and PM hypertrophy were independently associated with sudden cardiac arrest of unknown cause. Gunnal SA et al[2] studied the left ventricles in 116 adult human hearts, they observed many groups of papillary muscles instead of the usual two papillary muscles. The classical picture of papillarymuscles – the presence of two papillary muscles in the leftventricle – was found in only four (3.44%) specimens, two groups of papillary muscles were seen in 50 (43.11%) specimens, three groups in 37 (31.90 %) specimens, and four groups in 25 (21.55%) specimens.HosapatnaM et al[5] also observed presence of double Anterior papillary muscle (APM) and posterior papillary muscle (PPM) in the left ventricles in few cases out of 15 cadaveric hearts they studied. SkwarekMet al[6] studied the papillary muscles of the right ventricle in 107 formalin fix adult human heart and they classified the papillary muscles into 16 types which includes presence of multiple papillary muscles. Xanthos T et al[7] observed the number, length and shape of the papillary muscles and chordae tendineae are variable in right ventricle also and concluded that it can be of clinical significance since the papillary muscles play an important role in RV contraction and in the closure of the tricuspid valve so as to prevent ventricular blood from passing back into the right atrium. In the present study, single APM was most common in 13(52%), two APM were seen in 11(44%) and three APM were seen in only 1 (4%) of the specimens. Single PPM was seen in 12(48%), two PPM were seen in 8(32%), three PPM in 2(8%) and a maximum of four PPM were seen in 3(12%) specimen.

Delgado V et al[8] studied 151 patients, including 67 patients with heart failure (HF) and 29 patients with moderate to severe functional mitral regurgitation (FMR), using 64-slice MSCT coronary angiography. They assessed anatomy of the sub-valvular apparatus of the mitral valve. In the majority of patients, the anatomy of the sub-valvular apparatus was highly variable because of multiple anatomic variations in the PPM: the APM had a single insertion, whereas the posterior PM showed multiple heads and insertions in 83% subjects. In the present study the number of muscle heads on base as well as apex of PM were assessed. Single head base was seen 22, double heads in 12, triple heads in 3 and more than 3 heads in 1 out of total 38 anterior group of papillary muscles. In posterior group of papillary muscle single head in base was seen in 21, double heads in 18, triple heads in 4 and more than 3 heads in 3 papillary muscle out 46 posterior group of papillary muscles observed in 25 foetal hearts (as shown in Fig. 2B & 3A).

It has been mentioned that false chordae connecting the PMs, sometimes contain extensions from the ventricular conducting tissues & also suggested that false chordae produce premature ventricular contractions and be the possible cause of functional heart murmurs or innocent murmurs in children and young adults.[1] Such PMs were also recorded in the present study (Fig. 2. A & 3. B).

Twenty-nineAPMs were having single apical head, double apical heads in 7, triple apical heads in 1 and more than 3 apical heads in 1 out of 38 APMs observed. Single apical head was seen in 28, double apical heads in 12, triple apical heads in 4 and more than 3 apical heads in 2 out of 46PPM observed in 25 foetal heart specimens (Fig. 3A).

As described in various literatures, chordae originating from both groups of PM were observed to be inserted on both cusps of mitral valve in majority of the cases i.e. 64% of anterior mitral cusp and 80% of the posterior Mitral cusp received chordae from APM as well as PPM.

V. Conclusion

In the present study on the papillary muscles of left atrio-ventricular orifice, the classical description of single APM & PPM was observed in majority of hearts. However, many variations were observed in many foetal hearts. Knowledge on these variations will help clinicians on the echocardiography, function & pathophysiological presentations and their treatment.

References

[1]. Gatzoulis MA. Thorax. In: Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, editors. Gray's anatomy the anatomoical basis of clinical practice. 40th ed. London: Elsevier Churchill Livingstone; 2008. p. 907-1038.
[2]. Gunnal SA, Wabale RN, Farooqui MS. Morphological variations of papillary muscles in the mitral valve complex in human cadaveric hearts. Singapore Med J. 2013;54(1):44-8.
[3]. Hollinshead WH. Anatomy for surgeons: the thorax, abdomen, and pelvis. 2nd ed. New York: Harper & Row; 1971.
[4]. Uhn JS, Youn JC, Lee HJ, Park J, Park JK, Shim CY, et al. Accessory papillary muscles and papillary muscle hypertrophy are associated with sudden cardiac arrest of unknown cause. Int J Cardiol. 2015;15(197):285-91.
[5]. Hosapatna M, D Souza A, Das AM, Supriya, Ankolekar VH, D Souza AS. Morphology of papillary muscles in human adults: a cadaveric study. Ibnosina J Med BS. 2014;6(4):168-72.
[6]. Skwarek M, Hreczecha J, Grzybiak M, Kosiński A. Remarks on the morphology of the papillary muscles of the right ventricle. Folia Morphol. 2005;64(3):176–82.
[7]. Xanthos T, Dalivigkas I, Ekmektzoglou KA. Anatomic variations of the cardiac valves and papillary muscles of the right heart.Ital J AnatEmbryol. 2011; 116(2):111-26.
[8]. Delgado V, Tops LF, Schuijf JD, de Roos A, Brugada J, Schalij MJ, et al. Assessment of mitral valve anatomy and geometry with multislice computed tomography. JACC: Cardiovascular Imaging 2009;2(5):556–65.