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Original Research Article

A Morphometric Analysis of Adult Human Cadaveric Heart Assessment for Anatomical Variations of Papillary Muscles

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Abstract

Aim: To analyze the papillary muscles of the heart with respect to the variations in their number, length, shape, position and pattern in both ventricles.

Material & Methods: The study was conducted using 50 well preserved adult cadaveric human hearts obtained from the department of Anatomy, MGM Medical College, Kishanganj, Bihar, India. The values of the length of papillary muscles and thickness of both ventricles of cadaveric heart specimens were presented as Mean± SD and p value was calculated using student t-test. Different variables of the papillary muscles were compared between two ventricles and p value was calculated by performing a chi-square test. P-value < 0.05 was considered as statistically significant.

Results: In our study we observed 33.3% conical apex, 4.3% broad apex and 53.4% pyramidal apex in right ventricles whereas 21.3% conical apex, 26.7% broad apex, 21.3% pyramidal apex in left ventricles. Length of papillary muscles in the right ventricle were 1.28±0.46, 1.39±0.50, 0.90±0.56 in anterior, posterior and septal segments. Whereas, it was 2.15±0.46 in the anterior segment and 1.78±0.48 in the posterior segment of the left ventricle.

Conclusion: The papillary muscles have complex and variable anatomy. Knowledge of this variation to the cardiac surgeons during reparative surgical procedures conducted for mitral/ tricuspid valve replacement is of utmost importance to prevent untoward events.

Keywords: Papillary Muscles, Cadaveric Hearts.

Introduction

Papillary muscles are myocardial structures of bilateral ventricle, have importance out of proportion to their small size. Proper functioning of these muscles maintains the integrity of mitral valve, abnormalities of it ranges from a life-threatening emergency (muscle rupture) to an echocardiographic finding of doubtful clinical significance (muscle calcification). [1] Though muscles are two in number as a rule, there are usually groups of papillary muscles arranged fairly close together as a matter of course. At their bases, the muscles sometimes fused or have bridges of muscular or fibrous continuity before attaching to the ventricular wall. Extreme fusion results in parachute malformation with potential for valvular stenosis. [2] Variations of papillary muscle can be explained embryologically. Heart muscle develops from the trabecular myocardial ridge by process of gradual delamination of ventricular wall. Incomplete delamination of trabecular ridge leads to morphological variations of papillary muscles. [3]

Congenital variations are known to be potential candidates for mechanical trauma leading to tricuspid valve lesions [4, 5]. Damage to papillary muscles may occur after a trauma affecting valve function and functional capacity of the body. Also the number, length and shape of papillary muscles are variable. Papillary muscles are of clinical significance as they play an important role in contraction of the right ventricle and closure of tricuspid valves to prevent ventricular blood from passing back into the right atrium [6].

Hence, we aim to analyze the papillary muscles of the heart with respect to the variations in their number, length, shape, position and pattern in both ventricles.

Material & Methods

The study was conducted using 50 well preserved adult cadaveric human hearts obtained from the Department of Anatomy, MGM Medical College, Kishanganj, Bihar, India.

Methodology:

The age (40-60 years approx.) and the cause of death of the cadavers was not known. The ventricles were opened by giving incisions along the anterior wall to expose the interior perfectly. The blood clots were removed and the chambers washed clearly with water in order to accurately visualize the papillary muscles. The variation in number, position, length, pattern and shape of the papillary muscles along with thickness of both ventricles were noted. The digital Verniercalliper (Mitutoyo) with 0.02 mm precision was used to measure the length of the papillary muscle (from tip to the basal attachment). With careful observation, the number of additional heads in papillary muscle was documented. The shape at the tip was classified as conical, broad-based and pyramidal. In both left and right ventricles, the variation of the papillary muscles were observed and divided into separate base & fused apex, single base and divided apex, small projections of papillary muscles, long papillary muscles, perforated papillary muscles and base attached to a large bridge.

The values of the length of papillary muscles and thickness of both ventricles of cadaveric heart specimens were presented as Mean± SD and p value was calculated using student t-test. Different variables of the papillary muscles were compared between two ventricles and p value was calculated by performing a chi-square test. P-value < 0.05 was considered as statistically significant. Statistical software SPSS 21 version was used for statistical analysis. Since the bodies were donated to the institution for teaching and research purpose, there was no ethical issue in reporting the present findings.

Results

In our study we observed 33.3% conical apex, 4.3% broad apex and 53.4% pyramidal apex in right ventricles whereas 21.3% conical apex, 26.7% broad apex, 21.3% pyramidal apex in left ventricles.

We also found the classical papillary muscles in 68%, 2 groups in 24%, 3 groups in 5.3%, 4 groups in 2.6% and multi-apical in 20.7% heart specimens in right ventricle whereas the classical papillary muscles were found in 59.3%, two groups in 30%, three groups in 3.3%

and multi-apical in 12.7% heart specimens in left ventricle [Table 1].

Table 1: Frequency distribution of different variables of right and left ventricular papillary muscles

Variables		Right (N=150)		Left (N=130)		P-Value
		Frequency	%	Frequency	%	
Position	Anterior	46	30.7	50	33.3	<0.001
	Posterior	53	35.3	80	53.3	
	Septal	51	34	0	0	
Number	Classical	102	68	89	59.3	<0.082
	2 Groups	36	24	45	30	
	3 Groups	8	5.33	5	3.33	
	4 Groups	4	2.67	0	0	
Shape	Multiapical	31	20.7	19	12.7	
	Conical	50	33.3	53	35.3	<0.005
	Pyramidal	97	64.7	32	21.3	
	Broad	81	53.4	40	26.7	
	Separate Bases And Fused Apex	35	23.3	68	45.3	
Pattern	Single Base and Divided Apex	101	67.3	68	45.3	<0.005
	Small Projections of Papillary Muscles	8	5.33	0	0	
	Long Papillary Muscles	0	0	12	8	
	Base Attached to a Large Bridge	31	20.7	11	7.33	

In the current study, the thickness of the right ventricle varies from 0.41 to 1.67 cm with a mean thickness of 1.18±0.36 cm whereas in the left ventricle it varies from 1.53 to 2.72 cm with a mean value of 2.14±0.30 cm. [Table 2].

Table 2: Thickness of both ventricles in cm (N=50)

Variable	Right (Mean± SD Range)	Left (Mean± SD Range)	P- Value
Thickness	1.18±0.36 (0.41-1.67)	2.14±0.30 (1.53-2.72)	<0.001

Length of papillary muscles in the right ventricle were 1.28±0.46, 1.39±0.50, 0.90±0.56 in anterior, posterior and septal segments. Whereas, it was 2.15±0.46 in the anterior segment and 1.78±0.48 in the posterior segment of the left ventricle. [Table 3]

Table 3: Length of papillary muscles in cm (N=50)

Variables	Right (Mean± SD Range)	Left (Mean± SD Range)	P-Value
Anterior	1.28±0.46 (0.60-2.30)	2.15±0.46 (1.20-2.70)	<0.001
posterior	1.39±0.50 (0.40-2.40)	1.78±0.48 (0.70-2.70)	0.005
Septal	0.90±0.56 (0.30-2.60)		NA

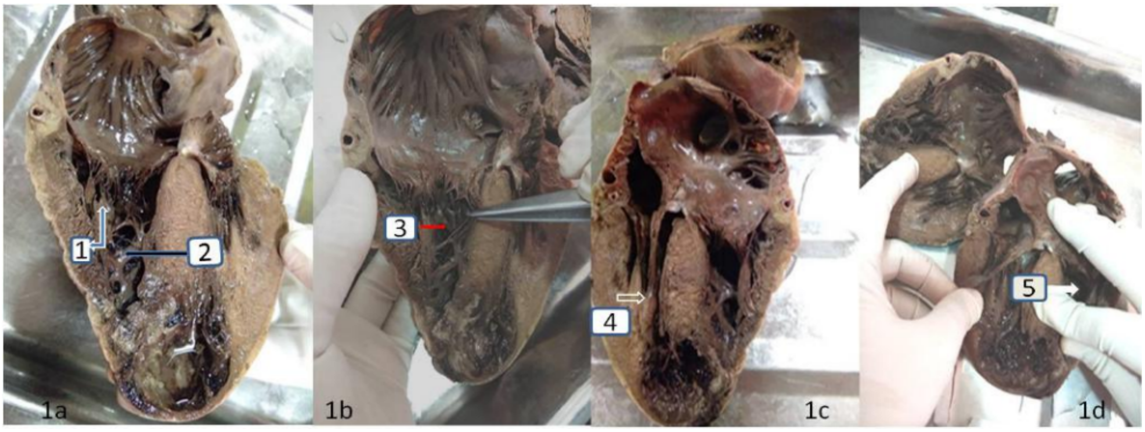

Figure 1: Showing position of papillary muscles in right and left ventricle; 1a: 1= Double anterior papillary muscle of right ventricle, 2= Moderator band of right ventricle attached to anterior papillary muscle, 1b: 3= Double posterior papillary muscle of right ventricle, 1c: 4= Double anterior papillary muscle of left ventricle, 1d: 5= Double posterior papillary muscle of left ventricle

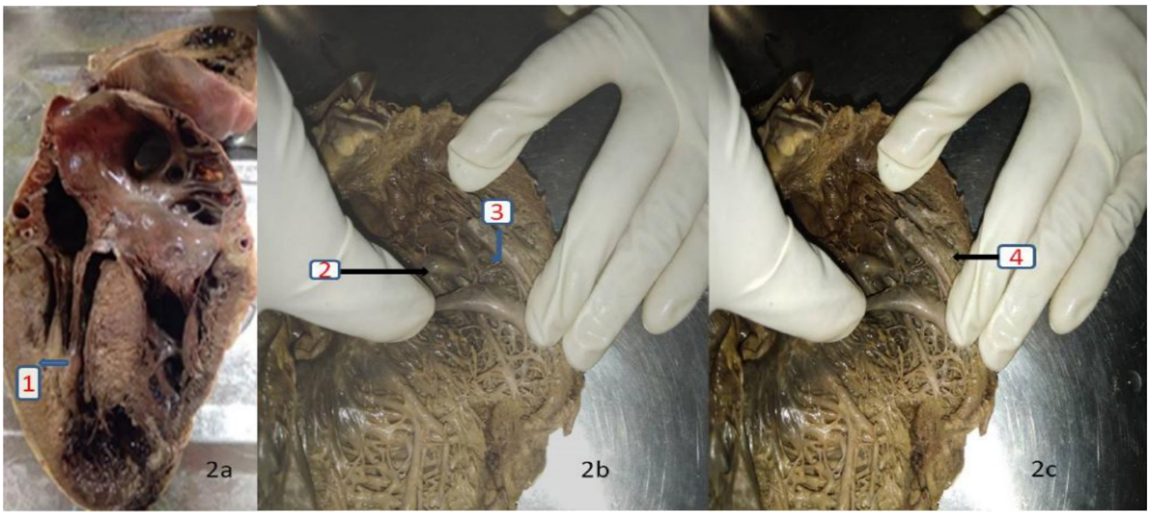

Figure 2: Showing number of papillary muscles in right and left ventricle; 2a: 1= Classical, 2b: 2= 2 groups, 3= 4 groups, 2c: 4= Multiapical

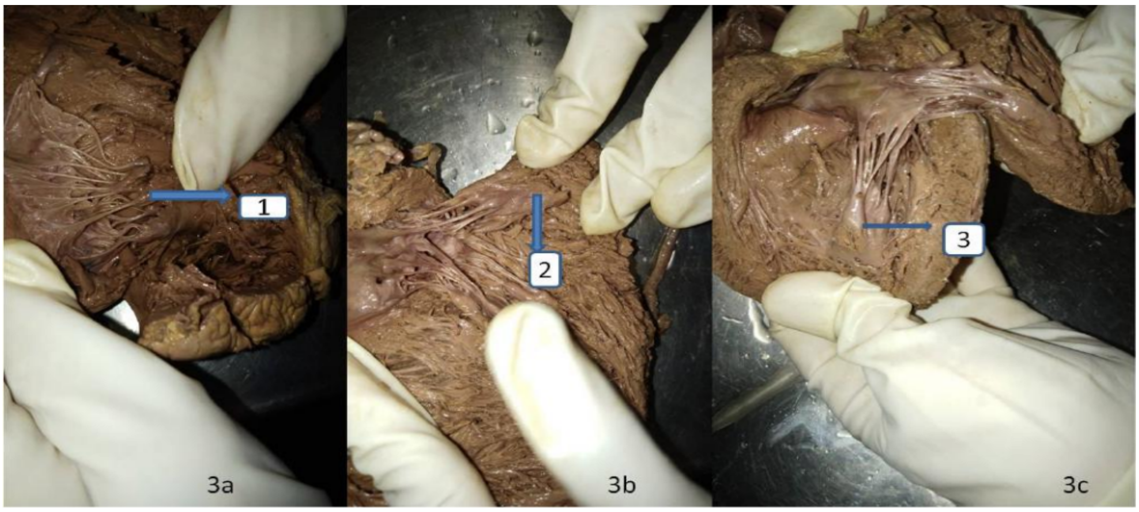

Figure 3: Showing shape of papillary muscles in right and left ventricle; 3a: 1= Pyramidal apex, 3b: 2= Broad apex, 3c: 3= Conical apex

Discussion

Embryologically the heart muscles develop from the trabecular myocardial ridge by process of gradual delamination of the ventricular wall. So, incomplete delamination of trabecular ridge leads to morphological variations of papillary muscles. [7]

Shree B et al., stated that the mean length of ALPM decreased as the number of groups increased [8]. Among PMPM groups, the mean length of bellies decreased as the number of heads increased. This was consistent with the study done by Aulakh KK et al., where the mean length of PMPM was 2.3 cm and was found to be larger in males than in females [9]. The mean length of PMPM was also found to decrease as the number of heads increased. Mohammadi S et al., reported that ALPM (1.9 cm) was longer than PMPM (1.1 cm) [10].

In the right ventricle, papillary muscles are three in number and are named according to their positions - anterior, posterior, and septal, while in the left ventricle, they are only two in number - anterior and posterior [11]. Due to higher blood volume in the left side of the heart and more workload for the left ventricle, the left-sided papillary muscles are believed to be stronger than those of the right ventricle [12]. However, the presence of extra-papillary muscles has also been documented in some previous studies. An extra-papillary muscle is significant, as it might be sometimes mistaken for mural thrombi during a cardiac investigation, such as echocardiography, especially if the left ventricle is infarcted in that area [13].

Systemic circulatory disturbances such as hypotension, anoxia etc. may lead to circulatory insufficiency (ischaemia) resulting in acute and chronic infarction (fibrosis) of papillary muscle. Generalized or localized ventricular aneurysm or dilatation may result in papillary muscle dysfunction. Non ischemic atrophy of papillary muscle associated with cachexia may result in dysfunction of papillary muscles. Rupture of papillary muscle or chordae tendineae and coronary insufficiency are the common causes for papillary muscle dysfunction. Newer surgical techniques like commissurotomy and papillotomy in rheumatic lesions, excision of infective vegetation, rotation and transfer of leaflet segments in traumatic conditions and correction of papillary rupture induced Tricuspid regurgitation requires knowledge regarding anatomical variations of papillary muscles. Knowledge of a detailed morphology of papillary muscle is necessary for cardiothoracic surgeries because abnormally short and thick tendinouschords and papillary muscles can complicate the congenital anomalies like Ebstein's malformations, dysplasia or straddling [14].

The shape of the papillary muscles affects the blood flow. In the papillary muscles with broad apex, the chances of left ventricular outflow tract obstruction are higher. The most ideal shape of the papillary muscles which provides minimum obstruction to the blood flow is conical-shaped, broad-based attached to the ventricular wall away from the centre of cavity. In the present study, we observed that in the left ventricle, there are more number of broad papillary muscles which leads to left ventricular outlet obstruction while in the right ventricle, we observed more conical and pyramidal shape of papillary muscles. The treatment of choice for symptomatic left ventricular outflow tract obstruction and dysfunction is usually the realignment and repositioning of the papillary muscles. [15-17] The papillary muscle hypertrophy, which is defined when at least one of the two papillary muscles is more than 1.1cm in either vertical or horizontal diameter, has been recently shown to be a phenotypic variant of Hypertrophic Cardiomyopathy. [18]

Conclusion

The present study concluded that these various anatomical variations of the papillary muscles may prove beneficial to cardiac surgeons during surgeries done for mitral and tricuspid valve replacement as well as during papillary muscle realignment and relocation done for symptomatic left ventricular outflow tract obstruction and dysfunction. It may also benefit anatomist to help in understanding the embryological development.

References

1. Madu EC, D'Cruz IA. The vital role of papillary muscles in mitral and ventricular function: echocardiographic insights. Clinical cardiology. 1997 Feb;20(2):93-8.
2. Ho SY. Anatomy of the mitral valve. Heart. 2002 Nov 1;88(suppl 4):iv5-10.
3. Oosthoek PW, Wenink AC, Wisse LJ, Gittenberger-de Groot AC. Development of the papillary muscles of the mitral valve: morphogenetic background of parachute-like asymmetric mitral valves and other mitral valve anomalies. The Journal of thoracic and cardiovascular surgery. 1998 Jul 1;116(1):36-46.
4. Chares M, Lamm P, Leischik R, Lenz G, Steinmann EH, Polonius MJ. Highly acute course of ruptured papillary muscle of the tricuspid valve in a case of blunt chest trauma. ThoracCardiovasc Surg. 1993; 41:325-7.
5. Hachiro Y, Sugimoto S, Takagi N, Osawa H, Morishita K, Abe T. Native valve salvage for post traumatic tricuspid regurgitation. J Heart Valve Dis. 2001; 10:276-8.
6. Xanthos T, Dalivigkas I, Ekmektzoglou KA. Anatomic variations of the cardiac valves and papillary muscles of the right heart. Italian Journal of Anatomy and Embryology. 2011; 116(2):111-26.
7. Oosthoek PW, Wenink AC, Wisse LJ, Groot ACG. Development of the papillary muscles of the mitral valve: morphogenetic background of parachute-like asymmetric mitral valves and other mitral valve anomalies. J Thorac Cardiovasc Surg. 1998;116(1):36– 46.
8. Shree B, Singla RK, Sharma RK, Kumar A. A study of papillary muscles of the left ventricle in the adult human cadavers. Int J Anat Res. 2016;4(2): 2285-93.
9. Aulakh KK, Saxena AK, Aneja PS, Bansal S. A morphometric study of the papillary muscles of the left ventricles of human cadaveric hearts in North-West Indian population. J Evol Med Dent Sci. 2016;5(100):7346-53.
10. Mohammadi S, Hedjazi A, Sajjadian M, Ghoroubi N, Mohammadi M, Erfani[12] S. Study of the normal heart size in Northwest part of Iranian population: A cadaveric study. J CardiovascThorac Res. 2016;8(3):119.
11. Harsha BR, Chandrashekar KT. Cadaveric Study on Anterior and Posterior Papillary Muscles of Tricuspid Valve.
12. Gheorghitescu R, Toba M, Iliescu DM, Bordei P. Anatomical consideration of the number and form of the papillary muscle in the left ventricle. ARS Medica Tomitana. 2016;22(2):119-27.
13. Lakhanpal AV, Shrivastava SK, Verma SK. Study of types of papillary muscles of tricuspid valve in central Indians. Int J Contemp Med Res. 2016; 3:2811-4.
14. Joudinaud TM, Flecher EM, Duran CMG. Functional terminology for the Tricuspid valve. J Hear Valve Dis. 2006 May; 15(3):382-8.
15. Madu EC, D'Cruz IA. The vital role of papillary muscles in mitral and ventricular function: echocardiographic insights. ClinCardiol. 1997;20(2):93–8.
16. Bryant R, Smedira NG. Papillary muscle realignment for symptomatic left ventricular outflow tract obstruction. J Thoracic Cardiovasc Surg. 2008;135(1):223–4.

17. Yousefnia MA, Mandegar MH, Roshanali F, FAlaeddini, Amouzadeh F. Papillary Muscle Repositioning in Mitral Valve Replacement in Patients With Left Ventricular Dysfunction. Ann Thorac Surg. 2007;83(3):958–63.
18. IJ O., BU, O., & SO N. Prevalence of Post-Operative Anaemia and its Complications among Obstetric and Gynaecological Patients in Enugu. Journal of Medical Research and Health Sciences, 2022; 5(9): 2250–2255.