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Original Research Article

Adult Human Cadaveric Heart Assessment for Anatomical Variations of Papillary Muscles in Both the Ventricles

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Abstract

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

Material & Methods: The study was conducted using 20 well preserved adult cadaveric human hearts obtained from the department of Anatomy, Vardhman institute of medical sciences, Pawapuri, Nalanda, Bihar, India for four months .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 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 right ventricle were1.28±0.46, 1.39±0.50, 0.90±0.56 in anterior, posterior and septal segments. Whereas, it was 2.15±0.46 in anterior segment and 1.78±0.48 in posterior segment of 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 event.

Keywords: papillary muscles, cadaveric hearts

Introduction

Papillary muscles are myocardial structures of left 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]

The coronary arteries are the first vessels that branch from the aorta, normally originating below the junction between the bulbus and the ascending aorta, i.e. at the Sino tubular junction. The right and left coronary arteries (RCA and LCA, respectively) arise from the ascending aorta. Patency of the LCA is vital for sufficient perfusion of most of the heart. The LCA is responsible for irrigation of most of the left ventricle and also a considerable proportion of the right ventricle [4].

Congenital variations are known to be potential candidates for mechanical trauma leading to tricuspid valve lesions [5,6]. Damage to papillary muscles may occur after a trauma affecting valve function and functional capacity of 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 right ventricle and closure of tricuspid valve to prevent ventricular blood from passing back into the right atrium [7].

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

Material & Methods:

The study was conducted using 20 well preserved adult cadaveric human hearts obtained from the department of Anatomy, Vardhman institute of medical sciences, Pawapuri, Nalanda, Bihar, India for four months. The age (40-60 years approx.) and the cause of death of the cadavers were 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 visualise 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 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].

In 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 left ventricle it varies from 1.53 to 2.72 cm with a mean value of 2.14±0.30 cm. [Table 2].

Length of papillary muscles in right ventricle were1.28±0.46, 1.39±0.50, 0.90±0.56 in anterior, posterior and septal segments. Whereas, it was 2.15±0.46 in anterior segment and 1.78±0.48 in posterior segment of left ventricle. [Table 3]

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

Variables		Right	Left	P-Value
		%	%	
Position	Anterior	30.7	33.3	<0.001
	Posterior	35.3	53.3	
	Septal	34	0	
Number	Classical	68	59.3	<0.082
	2Groups	24	30	
	3 Groups	5.33	3.33	
	4Groups	2.67	0	
	Multiapical	20.7	12.7	
Shape	Conical	33.3	35.3	<0.005
	Pyramidal	64.7	21.3	
	Broad	53.4	26.7	
	Separate Bases And Fused Apex	23.3	45.3	
Pattern	Single Base andDivided Apex	67.3	45.3	<0.005
	Small Projections of Papillary Muscles	5.33	0	
	Long Papillary Muscles	0	8	
	Base Attached to a Large Bridge	20.7	7.33	

Table 2: Thickness of both ventricles in cm (N=20)

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

Table 3: Length of papillary muscles in cm (N=20)

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

Discussion:

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 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].

A short main LCA trunk has been considered a risk factor for the development of coronary arteriosclerosis. [11-12] This is because during systole, a certain degree of twisting of the terminal branches, which increases the mechanical effort undergone by its walls, leads to greater arteriosclerotic degeneration. A short LCA trunk is also considered a risk factor for coronary perfusion during surgical operation, such as during replacement of the aortic valves. In such situations, the catheter may be inserted into one of the terminal branches, leading to ischaemia in the territory of the terminal branch, which may cause ventricular arrhythmia, myocardial infarction, or both. [13] Furthermore, a short trunk length may also cause difficulty when carrying out coronary angiography because when the catheter is inserted into one of the terminal branches, opacification of the other branch does not occur and an incomplete image of the coronary tree is seen.

Systemic circulatory disturbances as hypotension, anoxia etc. may led 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 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 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 event.

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