

Cadaveric Study on Papillary Muscles of Human Tricuspid Valve

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Abstract

Papillary muscles are the part of the myocardium and plays an important role in valve function by drawing atrioventricular valve annulus towards apex thus preventing ventricular overextension. The aim of the present study is to find out the variations in the number of papillary muscles of right ventricle and its statistical difference between males and females. The material for the present study comprised of 50 formalin fixed adult human hearts (35 males and 15 females) without macroscopic pathological changes, obtained from different medical colleges in Maharashtra. The number of the papillary muscles varies from two to six. Anterior and posterior papillary muscles were constantly present in all hearts but septal papillary muscle was absent in 24% samples. No statistical significance was observed between males and females. The left atrioventricular valve had been largely studied. The number of papillary muscles of right ventricle varies considerably. Damage to papillary muscles may occur after trauma and further even lead to death. Knowledge regarding variability of papillary muscles will help cardiac surgeons during their corrective procedures.

Keywords: Papillary Muscles; Variations.

Introduction

There are two major and one minor papillary muscles in the right ventricle. The major papillary muscles are located in the anterior and posterior positions. The minor papillary muscle has a medial position along with several smaller and variable muscles attached to the ventricular septum.

Major Papillary Muscles

- Anterior papillary muscle: It is the largest muscle, arising from the right anterolateral ventricular wall below the antero-inferior commissure of the inferior leaflet and it also blends with the right

end of the septomarginal trabecula.

- Posterior papillary muscle: The posterior or inferior muscle arises from the myocardium below the inferoseptal commissure. It is frequently bifid or trifid. It is irregular in size and position.

Minor or Septal Papillary Muscle

Is small but typical, and arises from the posterior septal limb of the septomarginal trabeculae. It is often formed of several muscles of which one may be longer and more constant.

All the major papillary muscles supply chordae to adjacent components of the leaflets they support. A feature of the right ventricle is that the septal leaflet is tethered by individual chordae tendineae directly to the ventricular septum. Such septal insertions are never seen in the left ventricle. When closed, the three leaflets fit snugly together, the pattern of the zones of apposition confirming the trifoliate arrangement of the tricuspid valve.

The papillary muscles project from the ventricular walls and are roughly conical in shape with a rounded end. They keep the atrioventricular valves closed when the ventricles contract and prevents the

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blood from flowing back into the atria. The leaflets of the valves are connected to the papillary muscles by the chordae tendineae. Most chordae tendineae arise from the tip of the papillary muscles, but some also arise from near the base. The papillary muscles contract a fraction earlier than the ventricle itself in order to prevent the valves from being forced open by the rising pressure in the ventricle. Victor and Nayak observed, after studying 100 normal human hearts, that numerous variations are present in the configuration of the cusp tissue and chordal/papillary support of the ventricular wall and these made the interior of the ventricle as unique to each individual as one's finger print [1].

Variations in the number, shape and position of papillary muscles of right ventricle has been studied by many workers [2,3]. 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 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 [6]. Also acute papillary muscle rupture secondary to myocardial infarction leads to cardiogenic shock and survival depends largely on the early surgical repair. We studied this topic as anatomical studies on papillary muscles are rare.

Materials and Methods

The material for the present study comprised of 50 formalin fixed adult human hearts which were obtained from the department of anatomy from various medical colleges in Maharashtra. The hearts with

macroscopic developmental failures or pathological changes were eliminated from the study. The hearts were grouped into two groups, 35 males and 15 females.

To open the right ventricle, cut was taken from the opening of inferior vena cava and then along the right margin of the right ventricle. The tricuspid valve was cut between the anterior and posterior leaflets. The section passed near the antero-posterior commissure of the tricuspid valve to avoid damage to papillary muscles. Hearts were washed in tap water to remove blood clots. Finally results were analysed statistically. Student's t test for two independent variables was used to determine the statistical significance of gender difference.

Result

The total number of papillary muscles in the right ventricle varies from two to six. The anterior papillary muscle was single in 72%, double in 26% and triple in 2% of right ventricles. The posterior papillary muscle was single in 54%, double in 36% and triple in 10% of right ventricles. The septal papillary muscle was absent in 24% of right ventricles. It was single in 56%, double in 12% and triple in 8% of right ventricles (Table 1). The mean value of anterior papillary muscle was 1.34 in males and 1.20 in females. The mean value of posterior papillary muscle was 1.51 in males and 1.67 in females. The mean value of septal papillary muscle was 1.40 in males and 1.33 in females. The standard deviation for anterior, posterior and septal papillary muscles was 0.54, 0.66 and 0.71 respectively in males. The standard deviation for anterior, posterior and septal papillary muscles in females was 0.41, 0.72 and 0.65 respectively. No statistical significance was found for the number of anterior, posterior and septal papillary muscles between males and females (p value > 0.05) (Table 2).

Table 1: Showing frequency of anterior, posterior and septal papillary muscles in right ventricle of adult human hearts (male and female combined)

Papillary muscle	Number of papillary muscles				Total (No. of Sample)
	Single	Double	Triple	Absent	
Anterior	36	13	1	-	50
Posterior	27	18	5	-	50
Septal	28	6	4	12	50

Table 2: Comparison of number of papillary muscles of right ventricle between males and females

Sr. No.	Papillary Muscles	Male		Female		Statistical Significance
		Mean	S.D.	Mean	S.D.	
1.	Anterior	1.34	0.54	1.20	0.41	Not significant
2.	Posterior	1.51	0.66	1.67	0.72	Not significant
3.	Septal	1.40	0.71	1.33	0.65	Not significant

S.D.-standard deviation

Table 3: Comparison of incidence of papillary muscles in percentage

Sr. No.	Studies	Sample size	APM	PPM	SPM
1.	Wafae N et al	50	100	100	100
2.	Gerola LR et al	50	100	84	100
3.	Nigri GR et al	50	100	100	78.5
4.	Motabagani MAB	10	100	100	100
5.	Begum et al	50	92	60	76
6.	Harsha BR	96	100	100	95.8
7.	Present Study	50	100	100	76

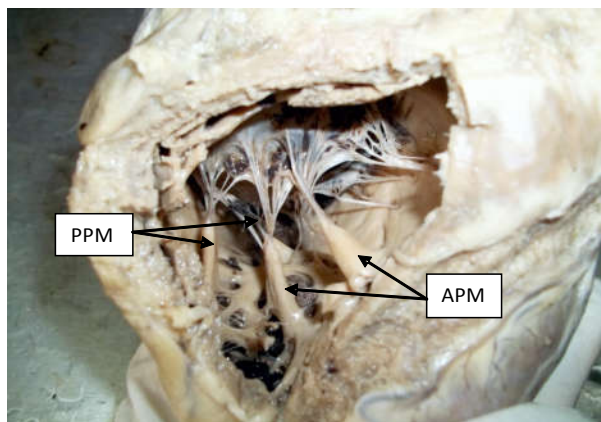


Fig. 1: Interior of right ventricle showing numerous anterior papillary muscles (APM) and posterior papillary muscles (PPM) of human heart

Discussion

Papillary muscle is vulnerable to ischemia as it is a subendocardial structure, supplied by terminal branches of the coronary arteries and develop large amount of tension during ventricular systole. Developmental defect of papillary muscle apparatus such as congenitally long or short papillary muscles or chordae tendineae, ectopic origin of papillary muscles and ectopic insertion of chordae tendineae result in papillary muscle dysfunction. Endocardial disease, heart muscle disease or infiltrative diseases may cause disturbances in the time course of papillary muscle activation and contraction resulting in papillary muscle dysfunction.

In the studies conducted by Wafae N et al and Motabagani MAB, all the three types of papillary muscles were observed in human hearts [7,8]. Gerola LR et al observed anterior and posterior papillary muscles in all the hearts, while septal papillary muscles were absent in 16% samples [9]. In the study of Begum et al on 50 human hearts, anterior papillary muscles were present in 92% hearts, posterior papillary muscles were present in 60% hearts while septal papillary muscles were absent in 24% samples also no statistical significance was observed between males and females [10]. Nigri GR et al and Harsha BR observed the presence of anterior and posterior

papillary muscles in all the samples while septal papillary muscles were absent in some hearts [3]. The findings of present study was in agreement with the work of Nigri GR et al and Harsha BR. From all the studies it is observed that anterior and posterior papillary muscles are constantly present while septal papillary muscle can be absent many times (Table 3).

Aktas et al conducted the study comprised of 400 human hearts and observed that the papillary muscle presented great variability in numbers. The one headed anterior papillary muscle was found to be more often in cardiac deaths. They observed more frequent conical and flat topped configurations in all posterior papillary muscle [12]. Skwarek distinguished the “conal papillary muscle” and the “papillary muscle of the posterior angle of the right ventricle” [13]. Skwarek performed a study on a group of 107 formalin-fixed adult human hearts and observed three types of connection of the tricuspid valve to the papillary muscles. Type 1 – A straight connection, Type 2 A membranous connection and Type 3 A connection by means of tendinous cords [14].

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 tendinous chords and papillary muscles can complicate the congenital anomalies like Ebstein’s malformations, dysplasia or straddling [15].

Conclusion

In the present study, number of papillary muscles varies from two to six in the right ventricle of the human heart and no statistical significance was found between males and females. Number of papillary muscles and the number of cords attached to leaflets are important with the rapid progress in the field of interventional cardiology and the introduction into cardiosurgery of new valvuloplastic methods. Therefore this study will help cardiac surgeons in providing a data for papillary muscles during correction of their defects. It will help clinicians to appreciate valvular anomalies during imaging and also in deciding their diagnosis and treatment.

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