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Study on Variations in the Anterior Papillary Muscle of the Right Ventricle

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Abstract:
Aim of the study is to document the presence or absence of each papillary muscle in the right ventricle, its variation in the number, attachment, size, shape, anterior papillary muscle and number of tendinous cords at the origin from the papillary muscle and compare the results with previously existing data and to provide clinical correlation. The double head variety is seen more often in the anterior. This study on the variation of papillary muscles of the right ventricle helps to provide categorical outlay for management & provides additional information to the clinicians who will help them in deciding the diagnosis and management.

1. Introduction

Papillary muscles are part of the myocardium and are very important in the proper functioning of the atrioventricular valve. Normal tricuspid valve function depends upon the maintenance of the proper spatial relationship between the papillary muscles, the chordae tendineae and the tricuspid valve leaflets through all phases of the cardiac cycle

In recent years various anomalies of the right ventricular papillary muscles have been observed. These include solitary hypertrophy (as a variant of hypertrophic cardiomyopathy), accessory papillary muscles, inverted papillary muscles giving a "mirror" appearance and anoctopus-shaped variant, leading to mid-ventricular obstruction.

Chordae tendineae are fibrous collagenous structures (approximately 80% collagen, while the remaining 20% is made up of elastin & endothelial cells) supporting the cusps of the atrioventricular valve. False chordae extends irregularly connecting the ventricular walls and are not of much importance. True chordae connect the apical third of the papillary muscles to the free margins and ventricular surface of the tricuspid valve complex; they help in the valve closure during systole and prevent the turning of the leaflets towards the atrium. Papillary muscles are conical muscle columns present in the right ventricle. There are three sets of papillary muscles in the right ventricle, namely anterior, posterior and septal papillary muscles.

- The anterior papillary muscle
  It is the largest and most constant one the base of the muscle is attached to the sternocostal surface close to the septal wall, where the septo-marginal trabeculae usually extend. The chordae of this muscle is attached to the anterior and posterior leaflets of the tricuspid valve.
- The posterior papillary muscle
  It is smaller than the anterior and has 1 to 3 bellies.
- The septal papillary muscle
  It is tiny and arises from the interventricular septum and its tendinous cords attach to the anterior and septal cusps of the tricuspid valve.

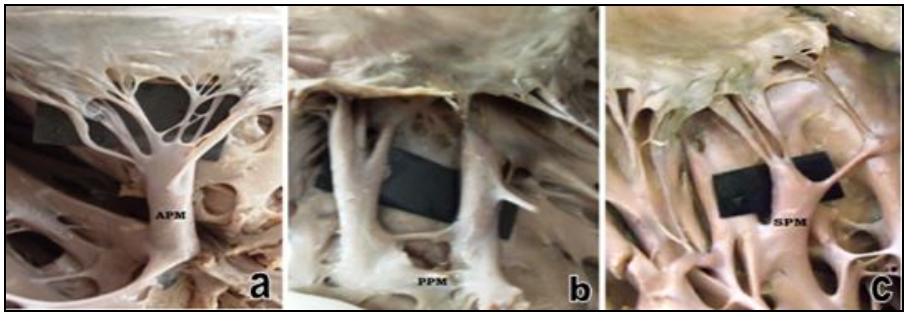

Figure 1: a.Anterior b.Posterior C.Septal, papillary Muscles

The papillary muscle in the right ventricle is supplied by "straight" type arteries. The arteries supplying the anterior papillary muscle arises both from branches of the right coronary and left anterior descending artery.

First, impulses are generated by the sinoatrial node (SA), which is found in the wall of the superior vena cava. It is a small mass of specialized cardiac muscle fibers and associated connective tissue which is supplied by nerve fibers from the autonomic nervous system. Excitation of the sinoatrial node initiates of a wave of depolarization around the atria via gap junctions between the muscle fibers. The atrioventricular node (AV) starts impulse generation around the ventricles. The AV node lies in the interatrial septum. Impulses are sent from the AV node to the atrioventricular bundle or bundle of his, which branches to form purkinje fibers. The AV node is also supplied by nerve fibers from the autonomic nervous system that speed up and slow down the heart rate.

Purkinje fibers lie in the deepest layer of the endocardium and supply the papillary muscles. Hence the apex of the heart contracts first, followed by the papillary muscles. Then the wave of depolarization spreads along the walls of the ventricles from the base upwards.

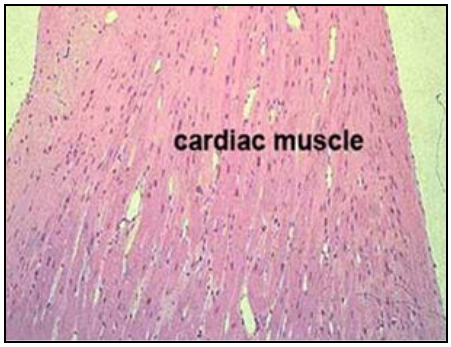

Figure 2

In the normal – sized heart, the long axis of the papillary muscle is oriented almost perpendicular to the atrioventricular ring. This orientation of the papillary muscle provides a mechanical advantage in that the tension developed in the papillary muscle is applied almost perpendicular to the tricuspid valve leaflets.

2. Etiology of Papillary Muscle Dysfunction

Circulatory insufficiency (ischaemia) may result in acute and chronic infarction (fibrosis) of papillary muscle which may be due to systemic circulatory disturbances (hypotension, erythrocytosis, anoxia, hematometakinesia, etc.). Generalized or localized ventricular dilatation / aneurysm may result in papillary muscle dysfunction. Non ischemic atrophy of papillary muscle associated with cachexia may result in dysfunction of papillary muscles. Defective development of papillary muscle apparatus such as congenitally long or short papillary muscles or chordae tendinae, ectopic origin of papillary muscle and ectopic insertion of chordae tendineae will result in dysfunction of papillary muscle. Endocardial disease, heart muscle disease such us myocarditis, degenerative cardimyopathy, or infiltrative (metastatic carcinoma, amyloidosis) diseases may cause disturbances in the time course of papillary muscle activation and contraction resulting in papillary muscle dysfunction. Rupture of papillary muscle or chordae tendineae is one of the common cause for papillary muscle dysfunction.

The most common cause of papillary muscle dysfunction is coronary insufficiency.

Papillary muscle is vulnerable to ischemia because;

- Papillary muscle is a subendocardial structure.
- Papillary muscles are supplied by terminal branches of the coronary arteries,
- Papillary muscle is the thickest portion of the endocardium,
- Papillary muscles develop large amount of tension during ventricular systole.

Aim of the study is to document the presence or absence of each papillary muscle in the right ventricle, its variation in the number, attachment, size, shape, number of heads of the individual papillary muscle and number of tendinous cords at their origin from the papillary muscle and compare the results with previously existing data.

3. Materials and Methods

Fiftysix heart specimens were taken from the department of anatomy, Chettinad hospital & research institute. They were sectioned along its acute margin, by an incision from the right atrium to the apex of the right ventricle. The section passed near the antero-posterior commissure of the right atrioventricular valve to avoid the sectioning of papillary muscles. Each heart was washed in tap water to remove blood clots, opened and flattened with the atrium and ventricular endocardium facing up. The pattern of variation in number, heads, attachment, size and shape of individual anterior, the length and width of each papillary muscle was measured using digital vernier caliper. Then the tendinous cords were counted at their origin from the papillary muscle. The site of their commencement, either from papillary muscle or the ventricular wall was also documented.

In the tricuspid valve the papillary muscles are the large anterior papillary muscle (attached to the anterior wall of the right ventricle), with chordae inserted to the anterior and posterior cusps of the valve.

According to recent functional terminology for the tricuspid valve, the papillary muscles can be grouped according to the distribution of their cords to a definite commissure and its contiguous main leaflets. Therefore, the anterior papillary muscle referred as the anteroposterior, the posterior papillary muscle the posteroseptal and the septal papillary muscle the anteroseptal respectively (Joudinaud T.M et al 2006).

The papillary muscles contract just before contraction of the right ventricle so as to tighten the chordae tendineae and draw the tricuspid annulus toward the apex at the time of ventricular contraction. This causes shortening of the long axis and the chamber becomes spherical for ejecting blood in addition to closure of the tricuspid valve to prevent ventricular blood from passing back into the right atrium.

There might be presence or absence of any of the three papillary muscles namely anterior, posterior or septal. There are also variation in the number, size, shape of the papillary muscle and variation of the heads of the individual papillary muscle. Variations in the number of tendinous cords at their origin from the papillary muscle also are of importance because of their clinical implications. In congenital elongation of papillary muscle and chordae tendineae, there is atrioventricular regurgitation due to defective valve closure. Arrhythmia may arise from one of the papillary muscle, in such patients surgical correction would be needed if the arrhythmia is intractable.

Victor S and Nayak VM (1994) confirmed that considerable variations exist in the number, head and shape of the papillary muscle. Our study confirmed this finding. In current study the incidence of anterior papillary muscles was found to be 29.07%, From the above findings we observed that the posterior papillary muscle is the commonest and most consistent in occurrence followed by the anterior papillary muscle.

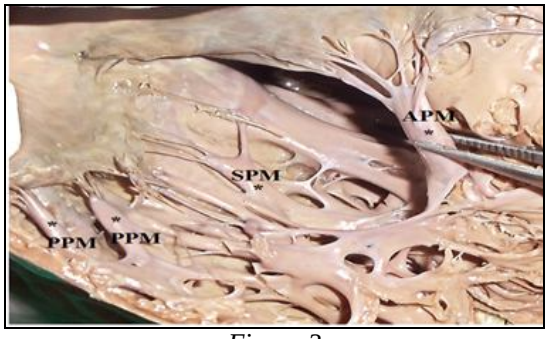

Figure 3

The anterior papillary muscle and posterior papillary muscle were present in 100% of the cases 30% of cases, had a similar absence of septal papillary muscle in our study by 65% of cases.

In our study a single anterior papillary muscle was found in 85% of cases and double anterior papillary muscle in 10% of cases. Our findings correlated with Nigri G.R et al (2001) who observed anterior papillary muscle in 81% of cases and double anterior papillary muscle in 19% of cases.

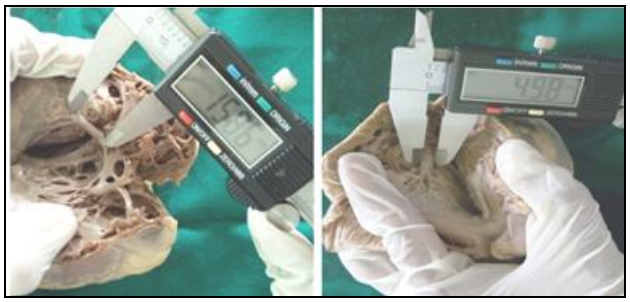

Figure 4: Measurement of papillary muscle. A-Length, B-Width

Nigri G.R et al (2001) has also documented the same, the length of single anterior papillary muscle ranging between 10.44mm to 40.03mm, (mean 20.67) and the double one ranging between 5.19 to 24.45mm, (mean 13.72mm). A double posterior papillary muscle length ranges between 5.22mm to 17.67mm. In our study, up to four papillary muscles were observed in a single specimen. But we never came across single posterior papillary muscle. When the three posterior papillary muscles were found its length ranged between 4.14mm to 13.35mm. When more than two papillary muscles were found, the average length was decreased. So, higher the number of posterior papillary muscles, lower is their length. Nigri G.R et al (2001) also supported the same.

Sl. No	Papillary muscle	Length (mm)	Width (mm)
1.	Anterior	12.65±3.58	4.04±1.53

Table 1: Dimensions of anterior, posterior and septal papillary muscles of right ventricle

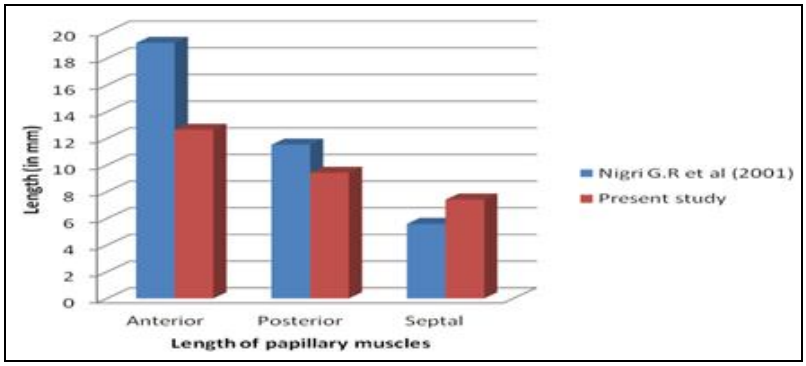

Figure 5: Comparison of length of anterior, posterior and septal papillary muscles of right ventricle – present study Vs Nigri G.R et al

This study shows that, Anterior papillary muscle is the longest of all papillary muscles. The anterior papillary muscle has a larger incidence for the flat topped variety. The most common is the single head variety. The double head variety is seen more often in the anterior and the triple head variety in the posterior papillary muscle. This study on the variations of papillary muscles of the right ventricle helps to provide categorical outlay for management & provides additional information to the clinicians who will help them in deciding the diagnosis and management. A retroscopic study of patients with tricuspid regurgitation, underlying papillary dysfunction is also possible.

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