

Morphology and Morphometry Analysis of Papillary Muscles of Tricuspid Valve: An Anatomical Study Based on Cadaver Dissection and Clinical Significance

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Conflict of interest: Nil

Abstract

Background: Aim of the present study was to analysis the morphology, dimensions and types of papillary. Muscles present in tricuspid valve of human heart. Pillar like projections into the myocardial of the heart is called papillary muscles. The papillary muscles are required components of the tricuspid valve complex. Papillary muscles are three in number and named according to their positions - anterior, posterior and septal. Differences in the number, length, and form of the papillary muscles become clinically significant. Papillary muscle defect cause valve prolapsed and valve replacement surgery.

Material & Method: The study was carried out on 100 fresh formalin fixed cadaveric heart. Hearts are not grouped into any criteria of sex and age. Morphology of shape of papillary muscles observed and morphometry was studied by measuring the length, width of each muscle are measured and documented. These measurements done by the vernier caliper.

Results: Number of papillary muscles was present with a frequency 1-7. Maximum number of papillary muscles 7 seen in 3 % of hearts. 1 anterior, septal and posterior papillary muscle seen in 5%, 23%, 19% hearts respectively. Septal papillary muscle was absent in 11% of hearts. Anterior papillary muscle was seen in 100 % with maximum 6 in numbers. Septal was found in 89% in hearts. Posterior papillary muscle was found 100% in hearts. In measurements of papillary muscle, anterior papillary muscle mean height was 1.65 ± 0.27 cm, mean width was 0.734 ± 0.16 cm. septal mean height was 1.14 ± 0.33 cm., mean width was $.35 \pm 0.14$ cm. Posterior papillary muscle mean height was 1.38 ± 0.36 cm. Mean width was 0.55 ± 0.13 cm. respectively. Tricuspid valve contained three papillary muscles, respectively, in all hearts, conical and broad base and fan shaped papillary muscle pattern were found to be most prevalent. Broad base pattern absent in septal papillary muscle.

Conclusion: These finding suggest that the variation in number, pattern, height and width accepted before any surgical intervention on the valvular apparatus. The knowledge of morphology and morphometry of papillary muscle is essential for cardiologists to detect etiology of different heart related problems to plan the mode of treatment and to predict their prognosis.

Keywords: Cadaveric Study, Tricuspid Valve, Papillary Muscles, Chordate Tendineae, Cusp.

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Introduction

Pillar like projections into the myocardial of the heart is called papillary muscles. The papillary muscles are required components of the tricuspid valve complex. Papillary muscles are three in number and are named according to their positions - anterior, posterior and septal. When the ventricle contracts they prevent the cusps of the valve from everting. All the three papillary muscles in which the anterior papillary muscle is the largest and longest of the right ventricles and the septal

papillary muscle is the short. Papillary muscles are located superior from the sternocostal and inferior from the diaphragmatic surface. Fan-shaped papillary hypertrophy affects blood flow. In papillary muscle defect cause valve prolapse, and valve replacement surgery. Differences in the number, length, and form of the papillary muscles become clinically significant. [1] The number, length, and shape of papillary muscles are variable. The chordo papillary variations found in rheumatic

heart disease, reparative procedures, PM impairment, mitral valve prolapse, mitral valve transfer, and use of mitral/tricuspid replacement by mitral valve homograft. [2] The chordae tendineae attached to each papillary muscle in ventricles varies from two to fifteen in number. During the systolic phase of the cardiac cycle and ventricular contraction, the chordae tendineae taut and the papillary muscles also contract which preventing the prolapse of atrioventricular valves. Damage to papillary muscles or chordae tendineae can lead to papillary muscle dysfunction. [3]

Materials & Method

This is a descriptive observational study to analyze the variations in number, shape, length and width of papillary muscles in tricuspid valve of 100 adult human cadaveric hearts. Present study specimens of heart were collected from the Department of Anatomy, S.M.S. Medical College, Jaipur and RUHS- CMS Jaipur.

Inclusion Criteria:

- Cadaveric heart including more than 18 year.
- Cadaveric heart without any valvular replacement / surgery.

Exclusion Criteria:

- The heart with any gross pathology.
- Traumatic damage.

Materials Used: Forceps (Plain), Forceps (tooth), Scalpel, Knife, Scissors (straight & curved), digital Vernier Calliper, Scale, Pencil, Non elastic cotton thread, hand gloves.

Dissection Method: Dissection of heart was done following Cunningham's Manual of Practical Anatomy volume-2. The heart was exposed and removed from pericardial cavity. The specimen thus collected were serially numbered from 1 to 100 & preserved in 10% formalin solution. The heart specimens were cleaned and cleared of any clots within the chambers. Incision was made along the inferior border of the heart up to the lower end of anterior interventricular groove. Right ventricle for various measurements of cusps of tricuspid

valve, papillary muscle, chordae tendinae was observed. The presence of any accessory papillary muscle was also noted. The number of papillary muscles in each ventricle was noted along with the shape and pattern of each of them.

Each papillary muscle was observed for its shape which can be either broad apex, fan shaped, conical in shape. Length of papillary muscles were recorded from the base/ junction of papillary muscle to the right ventricle to the apex of papillary muscle. Breadth was measured as the width of the muscle at the origin from the ventricular wall. The breadth of each papillary muscle was measured at the mid-level of the muscle. Number of papillary muscle attached to each cusp through chordae were also calculated. The data obtained was recorded in a standardized data collection sheet and entry was done and analyzed in Microsoft Excel.

Measurements:

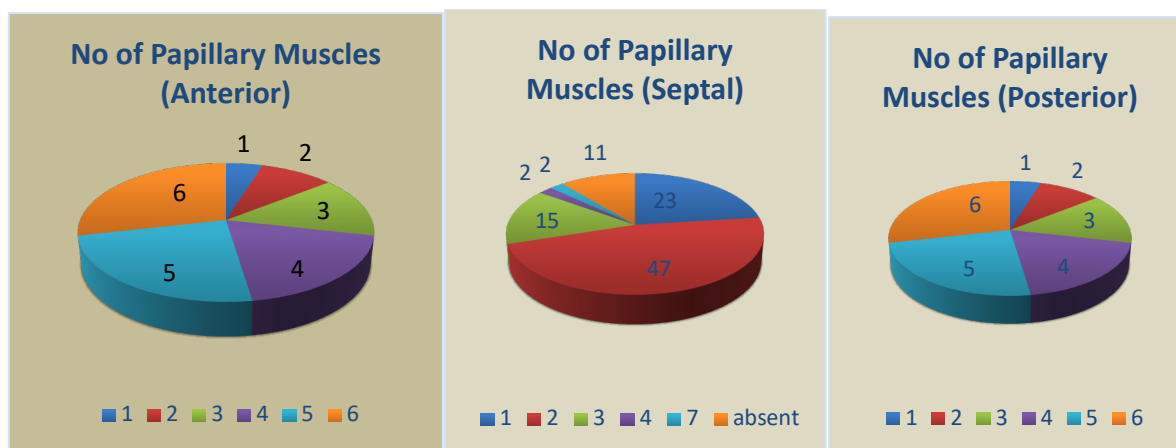
1. No. of papillary muscles
2. Shape of papillary muscles
3. Length, width of papillary muscles

Result

Number of papillary muscles: The Three major papillary muscles seen in the ventricle are located anterior, septal and posterior. Septal papillary muscle attached to the interventricular septum. Anterior papillary muscles were observed in 100 specimens. 1,2,3,4,5,6 anterior papillary muscles were observed respectively in 5, 32,41,1,5,4 specimens. There was no absent of anterior papillary muscles. Septal papillary muscles were showed in 89 % of specimens. 11% anterior papillary muscles were absent in 11 specimens. 1, 2,3,4,5 septal papillary muscles were observed respectively in 23,47,15,2,3 specimens. Posterior papillary muscles were observed in 100 specimens. There were no absent of posterior papillary muscles. 1,2,3,4,5,6 posterior papillary muscles were observed respectively in 19,42,23,12,3,1 specimens. 6 muscle found only 1 specimen.

Table 1: Mean SD and number of Papillary muscles Anterior, septal and posterior

No .of papillary muscle	Anterior papillary muscle N =100 (%)	Septal papillary muscle N =100 (%)	Posterior papillary muscle N =100 (%)
1	5 (5.0)	23 (23.0)	19 (19.0)
2	32 (32.0)	47 (47.0)	42 (42.0)
3	41 (41.0)	15 (15.0)	23 (23.0)
4	13 (13.0)	2 (2.0)	12 (12.0)
5	5 (5.0)	3 (2.0)	3 (3.0)
6	4 (4.0)	-	1 (1.0)
Absent	-	Absent	-
Mean±SD	2.93±1.10	2.07±1.04	2.41±1.08



Graph 1: Number of anterior, septal and posterior papillary muscles

Shape of Papillary muscles: All three papillary muscles of tricuspid valve were observed for their shapes. The shapes of cusp seen were broad base figure no. 1, conical figure no. 4, divided apex figure no. 2, fan shaped figure no. 3.

Table 2: Percentage of shape Papillary muscles Anterior, septal and posterior

Shape of papillary muscles(Cm.)	Anterior N =100 (%)	Septal N =100 (%)	Posterior N =100 (%)
Broad base	23 (23.0)	-	19 (19.0)
Conical	48 (48.0)	87 (87.0)	79 (79.0)
Divided apex	13 (13.0)	1 (1.0)	1 (1.0)
Fan shaped	16 (16.0)	1(1.0)	1 (1.0)
Absent	-	11 (11.0)	-

Table no.2 shows anterior papillary muscle was observed in 100 specimens with their shapes. Broad, conical divided apex and fan shaped were found in 23, 38, 13, 16 specimens respectively.

Septal papillary muscle was observed in 89 specimens with their shapes. Conical, divided apex and fan shaped were found in 87, 1, 1 specimens. Conical shaped of septal papillary muscles was

observed maximum frequency in 87 specimens. Posterior papillary muscle was observed in 100 specimens with their shapes.

Broad, conical divided apex and fan shaped were found in 19, 79, 1, 1 specimens respectively. Divided apex shaped of posterior papillary muscles was observed maximum frequency in 79 specimens.



Figure 1: Showing the broad base shape of papillary muscle



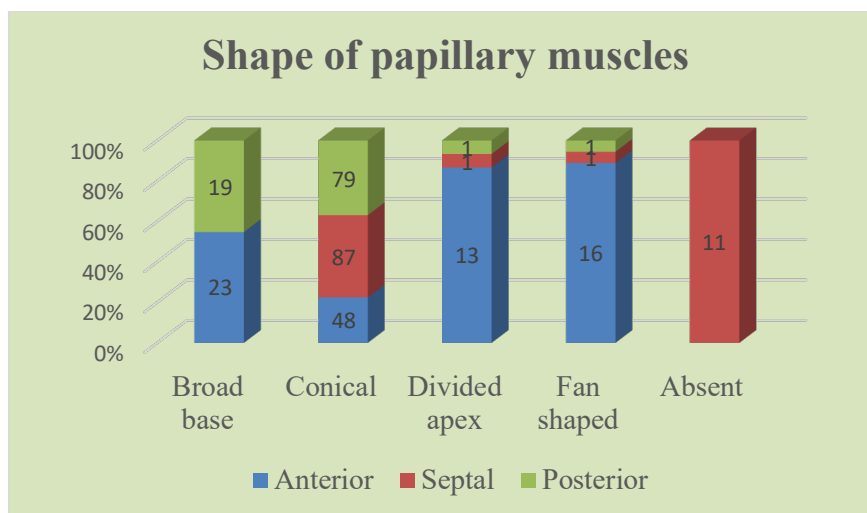
Figure 2: Showing the divided apex shape of papillary muscle



Figure 3: showing the fan shape of papillary muscle



Figure 4: showing conical shape of papillary muscle



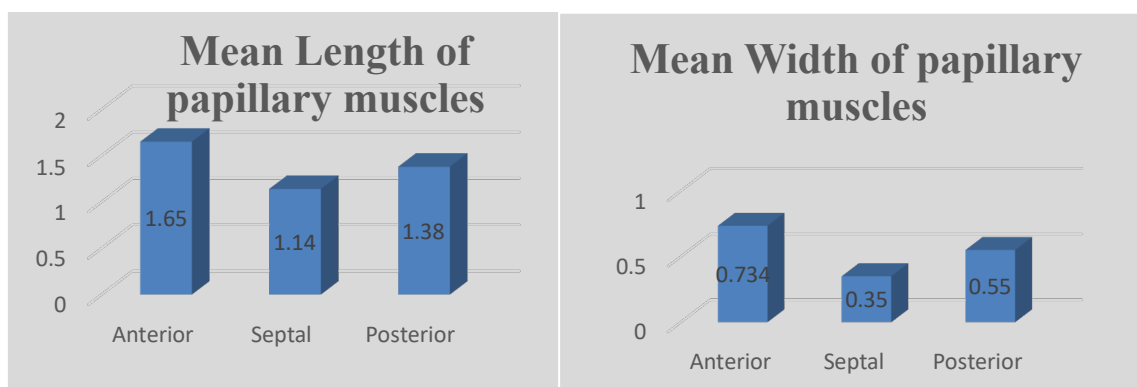
Graph 2: shape of anterior, septal and posterior papillary muscles

Length and width of papillary muscle:

Table 3: Measurements of length and width of papillary muscles

Measurement of papillary muscle					
Mean length			Mean width		
APM	SPM	PPM	APM	SPM	PPM
1.65±0.27	1.14±0.33	1.38±0.36	0.734±0.16	.35±0.14	0.55±0.13

In the present study was mean length of anterior, septal and posterior papillary muscles was 1.65, 1.14, 1.38 cm. In the present study was Mean width of anterior, septal and posterior papillary muscles was 0.734, .35, 0.55 cm.



Graph 3: Length and width of papillary muscles Anterior, septal and posterior

Discussion

Shape papillary muscles: Pooja bhadoria et al. 2022 reported that the shape of the posterior papillary muscle in the right ventricle was observed to be conical in 36% (18) cases; fan shaped in 24% (12), and broad apexed and pyramidal in 20% (10) cases each. While among the left ventricles, the shape of the posterior papillary muscle was seen to be fan-shaped in the majority of cases (38% (19)).

In the present study 19 hearts of papillary muscles were broad base type and 79% hearts of papillary muscles were conical in shape. Divided apex and fan shaped type of papillary muscles were found in 1% of hearts.

Number of papillary muscles: Keith L Moore (1980), R. Wayne, Mohamed A.B. Motabagani (2006) stated that in right ventricle there are 3 papillary muscles.

Babita kujur et al. 2016 stated that the anterior and posterior papillary muscles were found in 100% of cases and in one case (2.3%) septal papillary muscle was absent. In one case, three accessory papillary muscles were found in the posterior wall of right ventricle. It was single headed in 33 cases and double headed in 9 cases.

Harsha B.R et al. 2015 stated that the number of papillary muscles was present with a frequency of 2-10. Maximum numbers of papillary muscles were 10 seen in only one heart (1%) and minimum

numbers of papillary muscles were 2 seen in 3 hearts (3.1%). In the present study septal papillary muscle 1 papillary muscle in 23% of hearts 2 papillary muscle in 47 % hearts 3 papillary muscle

in 15% of hearts 4 papillary muscle in 2 % of hearts and 7 papillary muscle in 3% of hearts. Septal papillary muscles absent in 11% of hearts. (Mean 2.07 ± 1.04 cm.)

Table 4: Comparison of incidence of papillary muscle

Study	No. of specimens	Number of Papillary Muscle		
		APM	SPM	PPM
G R Nigri et al (2000)	79	100%	78.5%	100%
Dr.S.Kavitha et al(2018)	100	100%	100%	100%
Pooja Bhadoria et al (2022)	50	100%	100%	100%
Present study	100	100%	89.0%	100%

Length and width of papillary muscles: A current study on 60 cadaveric hearts Lubna shirin et al. 2022 reported that the length of the anterior papillary muscle in group A (n=41) were (17.27 ± 4.30) mm, and in group B (n=19) was (16.98 ± 3.07) mm, the posterior papillary had (14.04 ± 3.78) mm and (13.81 ± 2.47) mm in group A and group B and septal papillary was in group A, (7.35 ± 2.78) mm and in group B was (6.73 ± 1.94) mm accordingly.

In our study anterior papillary muscle height was 1.65 ± 0.27 cm. The septal papillary muscle height

was 1.14 ± 0.33 cm. and posterior papillary muscle height was range about 1.38 ± 0.36 cm. Harsha B.R et al. 2015 stated that the width was 0.8 cm ranged between 0.3 cm to 1.4 cm. Anterior papillary muscle is the largest muscle compared to posterior papillary muscles. Pooja bhadoria et al. 2022 stated that the mean for the width of anterior papillary muscles in the right and left ventricles was recorded as 6.92 ± 2.55 and 7.98 ± 2.53 cm. respectively. In the present study width of the anterior papillary muscle was 0.734 ± 0.16 cm. The septal papillary muscle width was $.35 \pm 0.14$ cm. And posterior papillary muscle width was 0.55 ± 0.13 cm.

Table 5: Length of papillary muscle

Study	No. of specimens	Length of Papillary Muscle		
		APM	SPM	PPM
G R Nigri et al (2000)	79	19.16mm	5.59mm	11.53mm
Dr.S.Kavitha et al(2018)	100	14.89 ± 4.19 mm	10.27 ± 3.28 mm	14.86 ± 4.05 mm
Pooja Bhadoria et al (2022)	50	12.71 ± 3.81 mm	1.67 ± 0.48 mm	12.40 ± 3.03 mm
Present study	100	1.65 ± 0.27 cm.	1.14 ± 0.33 cm.	1.38 ± 0.36 cm.

Conclusion

The present study was analysed of morphometric parameters of papillary muscles and various parameters which help in better understanding of the anatomy of the papillary muscle appropriate shortening and fusion of papillary muscles.

Our study reported three papillary or more than three papillary muscle most common broad base and conical type observed in the study. The cadaveric study of tricuspid valve in different regions will help to determine the regional variations of tricuspid valve complex and can be baseline data for cardiac surgeons.

Ethical No: 849/MC/EC/2024.

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