

Morphometric Study of Tricuspid Valve Annulus and Right Ventricular Papillary Muscle: A Cadaveric Study from Marathwada Region

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Abstract

Tricuspid valve complex is commonly involved in various heart diseases like rheumatic heart diseases, congenital cardiac anomalies etc. Studies on Tricuspid valve complex, in Maharashtra are few; so the present work was undertaken. Thirty five formalin fixed embalmed adult heart obtained by dissecting cadavers allotted to undergraduate students in GMC, Aurangabad, were studied irrespective of gender and cause of death. In present study circumference of tricuspid valve annulus was (mean \pm SD) 10.96 \pm 1.36 cm with range 8.6 cm to 13.6 cm; Diameter at minimum separated points (D1) was in the range of 2 cm to 3.5 cm and diameter measured at maximally separated points (D2) were in range 2.8 cm to 4.4 cm. Occurrence of papillary muscle was noted, anterior and posterior papillary muscle were present in all specimens however septal papillary muscle was absent in 9 out of 35 specimens. Anterior papillary muscle dimensions were noted; mean length for it was 1.224 cm \pm 0.478 cm with range 0.4 cm to 2 cm and mean thickness was 0.488 cm \pm 0.182 cm (range 0.3 cm to 0.9 cm). Knowledge of anatomy of tricuspid valve complex bears importance for operative procedures on tricuspid valve abnormalities. Present study data might be useful for cardiothoracic surgeons for newer surgical techniques like papillotomy, correction of papillary rupture induced tricuspid regurgitation.

Keywords: Anterior papillary muscle; Tricuspid valve.

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Introduction

Tricuspid valve complex is commonly involved in heart diseases due to rheumatic, age related and congenital causes. As cadaveric study is still best way to study human anatomy; in present work embalmed heart allotted to undergraduate students were studied for tricuspid valve annulus dimensions, and occurrence of papillary muscles. Readings were taken for anterior papillary muscle because of its easy accessibility.

As Grays clinical anatomy mentions "The tricuspid valve orifice is best seen from the atrial aspect and measures on average 11.4 cm in circumference in Males and 10.8 cm in Females." There exist a clear line of transition between atrial wall and the lines of attachment of the valvular cusps. The tricuspid valve orifice margins are not precisely in a single plane but are almost vertical making at a 45° angle to the sagittal plane with slightly inclination to the vertical, such that its ventricular aspect faces anterolaterally to the left and somewhat inferiorly. Tricuspid valve orifice is roughly triangular.¹

The atrioventricular valvular complex, include orifice and its associated annulus, the cusps, the supporting chordae tendinae of various types and the papillary muscles.¹

Usually there are three papillary muscles in the right ventricle (1) large posterior papillary muscle attached to inferior wall (2) A larger anterior

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papillary muscle, attached to anterior wall and (3) several small septal papillary muscles, or simply chordae tendinae, pass from septum to the anterior and septal cusp. The anterior and posterior papillary muscles are occasionally divided into a number of smaller projections.²

Victor S and Nayak³ described about interior of the ventricles that it is as unique to each individual as one's fingerprint as they observed that numerous variations were present in the configuration of the cusp tissue and chordal/papillary support of the ventricular wall.³

Present study did observation for occurrence of right ventricular papillary muscles. Anterior papillary muscle and posterior papillary muscle were present in all specimens but septal papillary muscle was absent in 9 out of 35 specimens. In hearts with absent septal papillary muscle chordae were directly tethered to septal wall (Fig. 7).

Readings were taken for tricuspid valve orifice and anterior papillary muscle; data of it adds to previous study data and might be useful for cardiac surgeons for procedures like valvuloplasty, papillotomy, papillary muscle repair etc.

Materials and Methods

With prior permission of HOD of Anatomy Department; study was conducted on 35 embalmed adult heart specimen obtained by dissecting cadavers allotted to undergraduate students in Government Medical College, Aurangabad. Irrespective of gender and cause of the death specimens were studied.



Fig. 1: Showing incision starting from IVC and extending into atrial wall above right atrio ventricular groove

Method of dissection for extracted heart specimen

Dissection was performed according to standard techniques (base of heart method) for tricuspid valve. To expose tricuspid orifice incision started at junction of the inferior vena cava with right atrium with scissors and extended into the right atrium, staying about 0.5–1.0 cm above the tricuspid valve annulus. Blood clots if present were removed (Fig. 1).

To study interior of right ventricle standard autopsy technique were followed. Cut was taken parallel to interventricular groove from point near right atrium to the inferior border of heart. Another cut was taken from first point to the inferior border; parallel to atrioventricular groove. Triangular flap was pooled downward and clots were removed to observe interior of right ventricle (Fig. 2).

Readings for tricuspid valve circumference were done by firmly applying malleable metal wire to tricuspid annulus and then straightening the wire and taking readings on measuring scale. Maximum and minimum diameters were recorded by Vernier Caliper (Fig. 3).

Similarly Length of anterior papillary muscle was recorded from the base/junction of papillary muscle to right ventricle to the apex of papillary muscle (Fig. 5). Maximum width of Anterior papillary muscle was recorded with Vernier Calliper (Fig. 6). Interior of Right ventricle was observed (e.g., Fig. 8). Observations were done about occurrence of three papillary muscles in right ventricle: APM, PPM, SPM. Mean, Standard Deviation and Range were obtained for study parameters. Results obtained were compared with previous studies.



Fig. 2: Showing incision on Right ventricle exposing interior of right ventricle



Fig. 3: Method of measurement of diameter of tricuspid valve with Vernier Caliper



Fig. 4: Measurement of tricuspid valve annulus by applying malleable metal wire to the circumference of tricuspid annulus



Figs. 5 and 6: Method of taking length and thickness of APM taken with the help of Vernier Caliper



Fig. 7: Specimen no. 5 with chordae tendinae directly teethered to interventricular septum (Arrow)

Results and Observations

The results of the study are shown in (Tables 1-5) as follows:

Table 1: Measurements for Tricuspid Valve annulus

Tricuspid valve parameter	Mean in cm	S.D. in cm	Range in cm
Circumference	10.96	± 1.36	8.6-13.6
Diameter at minimum separated point D1	2.97	± 0.383	2-3.5
Diameter at maximum separated point D2	3.51	± 0.417	2.8-4.4

Table 2: Measurements of Anterior Papillary Muscle

Anterior Papillary muscle Parameter	Mean in cm	S.D. in cm	Range in cm
Length	1.224	± 0.478	0.4-2.0
Thickness	0.4885	± 0.1827	0.3-0.9

Observations

In the study sample Anterior and Posterior papillary muscle were present in all hearts; Septal papillary muscle was least prominent and in 9 out of 35 specimens; septal papillary muscles were absent (25.71%). In those specimens with absent septal papillary muscle Chordae were directly teethered to interventricular septum. (Fig. 7). Anterior papillary muscle was the most prominent, longest and was frequently (16 out of 35 specimens) (45.71%); bifid/biheaded (e.g., Fig. 11).

Few noticeable variations in papillary muscle were:

- In specimen no 7 anterior papillary muscle was fused with thick bridge from interventricular septum at apex (instead of base) and at the junction of two the chordae were attached. (Fig. 9)
- In two specimens; two APM; almost of same size were observed (Fig. 10)
- One large APM and another thin APM (with almost of same length but with few 1 or 2) chordae attached at its apex) were observed in 3 specimens. (e.g., in Fig. 11).
- One of the specimens had three APM (Fig. 12).



Fig. 8: Specimen showing Anterior papillary muscle arrow) and septal papillary muscle (triangle)



Fig. 9: Specimen showing AP and Moderator band fused at apex and chordae tendinae arising from the junction of two



Fig. 10: Two specimens with two APM of almost same size





Fig 11: Specimen showing APM with 2 heads; small SPM near pulmonary orifice is present. Thin papillary muscle almost of same length is noted to left of that of bifid large APM



Fig 12: Specimen with three APM (Black arrow)

Discussion

As observed by Victor S and Nayak (1994) in 100 normal human heart specimen; numerous variations were present in the configuration of the cusp tissue and chordal/apillary support of the ventricular wall and these made the interior of the ventricles as unique to each individual as one’s fingerprint.³

Comparison of study result was done with previous studies:

Range D1 2–3.5 cm; D2 2.8–4.4 cm; Thus from **Table 1 and 2** present study result were comparable with previous study data.

Dimensions of Anterior Papillary muscle

Dimension of Gerola *et al.*¹² are for paediatric population so they are smaller than present study. Readings by Negri *et al.*¹³ is of higher range (1.9 cm). Racial factor may be the cause for higher values by this study. Study by Harsha BR, Chandrashekar KT⁹ on Indian population shows; APM mean height was 1.49 ± 0.44 cm; mean width was 0.82 ± 0.21 cm and mean thickness was 0.64 ± 0.15 cm.¹⁴ While present study has mean height of APM 1.224 ± 0.478 cm and Max thickness of Anterior papillary muscle as mean 0.4885 ± 0.1827.

In study by Farzana T *et al.*¹⁶ the specimens were grouped according to age into three categories.

Table 3: Comparison of circumference of Tricuspid Valve annulus with previous studies

Sl. no	Studies	Circumference of TV annulus
1	Grays Anatomy ¹	11.4 cm in males 10.8 cm in females
2	Tie C. <i>et al.</i> (1982) ⁴	11.3 ± 0.9 cm
3	Silver <i>et al.</i> (1971) ⁵	11.4 ± 1.1 cm in males 10.8 ± 1.3 cm in females
4	Motabagani (2006) ⁶	11.8 to 13.9 cm in males 11.3 to 12.4 cm in females
5	R. Kalyani (2012) ⁷	8.9–10.7 cm in males 8.5–10.4 cm in females
6	Babita Kujur ⁸	9.7 ± 1.029 cm
7	Balchandra N <i>et al.</i> ⁹	mean 10.01 ± 1.31 cm range 5.7–14.8 cm
8	Present Study	mean 10.96 ± 1.36 cm range 8.6–13.6 cm

Table 4: Comparison of Tricuspid Valve annulus with previous studies

Sl. no	Studies	Diameter of TV annulus in (cm)
1	Singh B and Mohan JC (1994) ¹⁰	2.26
2	John F Secombe <i>et al.</i> (2004) ¹¹	2.13 ± 0.03
3	Babita Kujur ⁸	2.1 ± 0.43 (D1); 3.03 ± 0.546 (D2)
4	Balchandra N <i>et al.</i> ⁹	2.74 ± 0.78 D1; 2.48 ± 0.63 D2
5	Present Study	D1 mean 2.97 ± 0.383; D2 mean 3.51 ± 0.417

Table 5: Comparison of Anterior Papillary Muscle Dimensions with other studies

Sl. no.	Name of studies	Length of Anterior Papillary Muscle cm	Thickness of Anterior Papillary Muscle cm
1	Gerola <i>et al.</i> ¹²	0.9 ± 0.2	1.2 ± 0.3
2	Negri GR <i>et al.</i> ¹³	1.9	
3	Harsha BR, Chandrashekhar KT ¹⁴	1.49 ± 0.44	0.64 ± 0.2 cm
4	Saha A, Roy S ¹⁵	2.19 ± 0.59 cm	0.76 ± 0.26 cm
5	Farzana T <i>et al.</i> ¹⁶		
	Group A (upto 20 years)	1.07 ± 0.48 cm	
	Group B (21 to 40 years)	1.50 ± 0.37 cm	
	Group C (41 to 60 years)	1.60 ± 0.25 cm	
6	Present study	1.224 ± SD 0.478 cm	0.4885 ± SD 0.1827 cm

They measured length of each papillary muscle in both ventricles in different age groups and observed that the mean length of anterior, posterior and septal papillary muscle was increased with age.

Presence of Papillary muscle

In present study APM was most prominent and SPM was least prominent of the three papillary muscles; in 9 specimens out of 35 specimens; SPM were absent (25.71%). In study by Begum¹⁷ on 49 fixed hearts from 39 male and 11 female Bangladeshis aged 20 to 70 years and without any known cardiac disorder; the SPM was single in 46% cases while in 30% cases it was absent. In the right ventricle, the APM were the longest and the SPM were the shortest.¹⁷

Conclusion

Findings for tricuspid valve circumference and diameter were within the range given in literature¹ and those given in previous studies^{4,5,6,7}. APM being largest and frequently biheaded. The SPM itself was the least prominent and frequently absent; in specimens with absent SPM chordae tendinae were directly attached to interventricular septum. Dimensions of APM were comparable with previous studies.^{13,14,15,16}

Present study data adds to previous studies on tricuspid annulus morphometry especially performed on Indian population from Marathwada region. Present study might be useful for cardiothoracic surgeons for tricuspid valve complex procedures like papillotomy, papillary muscle repair.

Abbreviations:

APM-Anterior Papillary Muscle;

PPM-Posterior Papillary Muscle;

SPM-Septal Papillary Muscle.

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