Section: Anatomy

Original Research Article

MORPHOMETRIC ANALYSIS OF TRICUSPID VALVE LEAFLETS AND CHORDAE TENDINAE IN HUMAN CADAVERIC HEART

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ABSTRACT

Background: The understanding of morphometry and morphology of the tricuspid valve complex holds significant clinical relevance for cardiovascular surgeons. The proper functioning of the tricuspid valve is contingent upon the anatomical and mechanical integrity of the chordae tendinae. This investigation was conducted to evaluate the morphometric characteristics of the tricuspid valve.

Materials and Methods: This study consists of 68 formalin fixed adult human heart. Parameters including circumference, frontal and sagittal diameter of tricuspid valve, right atrioventricular orifice area, height of anterior, posterior and septal leaflet, average number and average length of chordae tendinea attached to anterior leaflet were noted meticulously and the analysed.

Results: The mean frontal, sagittal, circumference dimension and area of tricuspid valve was 27.84mm, 25.88mm, 104.52mm, and 581.2mm respectively. The mean height of anterior leaflet was 15.3 mm, posterior leaflet was 15.12 mm, and septal leaflet was 13.67 mm. Three chordae tendinae are most prevalent, occurring in 47.18% of specimens. The mean length of chordae tendinae was 12.64 mm.

Conclusion: This discovery may help cardiac surgeons who use right atrioventricular morphological evaluations. In addition, precise leaflet measurements help build bioprosthetic valves for tricuspid valve replacement. Understanding the tricuspid valve's complicated nature may help develop customised surgical methods and improve patient outcomes. Clinical practice must incorporate new findings to ensure that surgical procedures are successful and tailored to individual anatomical variances.

Keywords: Chordae tendinae, Tricuspid valve, Tricuspid leaflets, Morphometry.

INTRODUCTION

The initiation of a novel domain within surgical practice frequently stimulates a keen examination of the intricate anatomy pertaining to the specific region of the body in question. Consequently, the findings of these studies may lead to a transformation and expansion of existing concepts, facilitating a deeper understanding. The recent advancements in tricuspid valve surgery have necessitated a re-evaluation of our understanding of normal anatomical structures.[1,2] Investigations into the morphometric characteristics and standard anatomical features of the tricuspid valve remain perpetually sought after. Understanding the morphology of the normal tricuspid valve can be advantageous, particularly in scenarios such as the transfer of a tricuspid valve leaflet for the repair of mitral valve insufficiency, the reconstruction of the tricuspid valve following blunt chest trauma, and various other surgical procedures within this anatomical area.[3-5] Such data is notably scarce within the realm of Indian literature. This study was undertaken to assess the morphometry of the tricuspid valve, providing foundational data pertinent to the Indian population.

MATERIALS AND METHODS

This study was conducted in the Department of Anatomy at M.M. College of Medical Sciences and Research, Ambala, Haryana from June 2024 to January 2025. A source of 68 adult human cadaveric hearts stored in formalin without any gross abnormalities, and without visible damages in the tricuspid valve were included. Patients died with vascular diseases, and with developmental anomalies were excluded.

We performed the dissection according to the protocols outlined in Cunningham's manual. The hearts were meticulously dissected with minimal damage to the valves following a thorough cleaning under tap water. The initial incision was made from the right side of the inferior vena cava to the superior vena cava, leading to the opening of the right atrium. The second incision was made along the inferior border of the heart, extending to the inferior margin of the anterior interventricular groove, specifically along the acute margin of the heart. We precisely executed the third incision adjacent to the anterior interventricular groove. We meticulously retracted the walls and thoroughly cleansed the interior under running tap water to eliminate the clots. We examined the morphology of the tricuspid valve. A clean cotton cloth was used to absorb the excessive water.

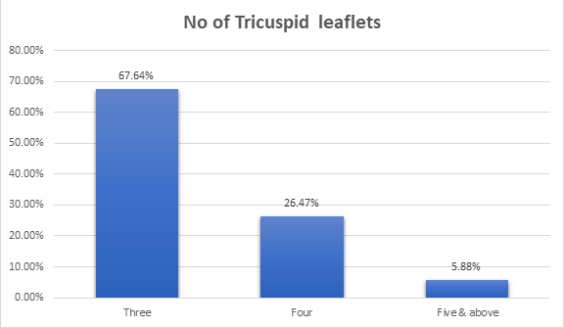
Parameters: Circumference of tricuspid valve, frontal and sagittal diameter of tricuspid valve, right atrioventricular orifice area, Height of anterior, posterior and septal leaflet of tricuspid valve, average number and average length of chordae tendinea attached to anterior leaflet.

Circumference of the tricuspid valve, frontal and sagittal diameters of the tricuspid valve, area of the right atrioventricular orifice. Dimensions of the anterior, posterior, and septal leaflets of the tricuspid valve, together with the mean quantity and average length of chordae tendineae connected to the anterior leaflet. We ascertain the circumference via a pliable metallic wire. The wire is positioned along the perimeter of the annulus, severed at the junction of its ends, and subsequently measured using a ruler after being straightened. The diameters of the tricuspid valve are assessed in two distinct dimensions within two orthogonally orientated planes at the sites of maximum separation using sliding Vernier callipers.

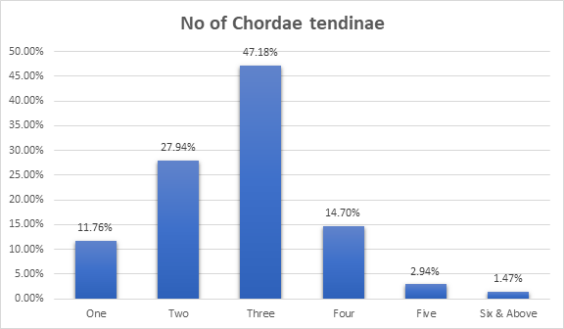
Instruments used for measurements: Sliding vernier calliper, Aluminium wire or surgical silk thread, scale, Magnifying lens.

Statistical analysis: The gathered data underwent analysis utilising SPSS version 32.0. The Kolmogorov-Smirnov Z test and the Shapiro-Wilk test have been employed to assess the adequacy of the normal distribution for the study parameters.

RESULTS



Graph 1: Details of total number of tricuspid leaflets observed in cadaveric hearts.



Graph 2: Details of number of chordae tendinae attached to anterior tricuspid leaflet.

Table 1: Morphometric details of tricuspid valve.

Tricuspid valve	Total no of specimens (n=68)				
	Frequency (%)	Mean ± SD	Minimum	Maximum	Std. Er
Frontal dimension (Range from 15.5 to 45.5mm)					
15.6-25.5	20 (29.41%)	27.84±4.36	16.14	42.08	0.610
25.6-35.5	39 (57.35%)				
35.6-45.5	09 (13.23%)				
Sagittal dimension (Range from 10.5 to 40.5mm)					
10.5-20	13 (19.11%)	25.88±4.87	12.92	38.60	0.451
21-30	48 (70.58%)				
31-40.5	07 (10.29%)				
Circumference (Range from 70.5 to 140.5mm)					
70.6-80.5	03 (4.41%)	104.52±10.43	73.48	140.2	0.993
80.6-90.5	06 (8.82%)				
90.6-100.5	29 (42.64%)				
100.6-110.5	14 (20.58%)				
110.6-120.5	08 (11.76%)				
120.6-130.5	06 (8.82%)				
130-6-140.5	02 (2.94%)				
Area of orifice (up to 1250.5mm2)					

Up to 250.5	03 (4.41%)	581.2±137.22	183.90	1222.76	18.957
250.6-500.5	26 (38.23%)				
500.6-750.5	31 (45.58%)				
750.5-1000.5	06 (8.82%)				
1000.6-1250.5	02 (2.94%)				

Table 2: Morphometric details of tricuspid valve leaflets.

Height of Leaflets	Total no of specimens (n=68)				
	Frequency (%)	Mean ± SD	Minimum	Maximum	Std. Er
Anterior leaflet					
10.6-15.5	41 (60.29%)	15.3±3.21	11.34	25.12	0.325
15.6-20.5	23 (33.82%)				
20.6-25.5	04 (5.88%)				
Posterior leaflet					
5.6-10.5	04 (5.88%)	15.12±2.78	6.98	24.87	0.541
10.6-15.5	42 (61.76%)				
15.6-20.5	17 (25%)				
20.6-25.5	05 (7.35%)				
Septal leaflet					
5.6-10.5	20 (29.41%)	13.67±1.98	6.12	23.40	0.238
10.6-15.5	31 (45.58%)				
15.6-20.5	15 (22.05%)				
20.6-25.5	02 (2.94%)				

Table 3: Details of chordae tendinae in cadaveric hearts.

Chordae tendinae	Total no of specimens (n=68)				
	Frequency (%)	Mean ± SD	Minimum	Maximum	Std. Er
Length					
5.6-10.5	32 (47.05%)	12.64±1.29	6.82	19.45	0.580
10.6-15.5	29 (42.64%)				
15.6-20.5	07 (10.29%)				

Figure 1: Circumference of tricuspid valve.

Figure 2: Height of tricuspid valve leaflet.

DISCUSSION

The predominant frontal dimension ranged from 25.6 to 35.5 mm in 57.35% of specimens, while 15.6 to 25.5 mm was observed in 29.41% of specimens. The mean sagittal dimension measured 25.88 mm. The tricuspid valve size ranged from 90.6 to 100.5 mm in 42.64% of the samples and from 100.6 to 110.6 mm in 20.58% of the samples, with an overall average of 104.52 mm. The tricuspid opening measured between 500.6 and 750.5 mm in 45.58% of the samples, while 38.23% of the samples ranged from 250.6 to 500.5 mm, yielding an average size of 581.2 mm [Table 1]. The measurements reveal a notable variation in the dimensions of the tricuspid valve among the examined specimens. This variability may significantly impact the comprehension of valve function and the development of customised surgical interventions.

In our study, we found that 67.64% of the samples had three leaflets in the tricuspid valve, 26.47% had four leaflets, and 5.88% had five or more leaflets [Graph 1].

The height of the anterior leaflet was recorded as 10.6–15.5 mm in 60.29% of specimens, 15.6–20.5 mm in 33.82%, and 20.6–25.5 mm in 5.88% of specimens, yielding a mean height of 15.3 mm. The height of the posterior leaflet was noted as 10.6-15.5 mm in 61.76%, 15.6-20.5 mm in 25%, 20.6-25.5 mm in 7.35%, and 5.6-10.5 mm in 5.88% of specimens, with a mean height of 15.12 mm. The septal leaflets exhibited heights of 10.6–15.5 mm in 45.58% of specimens, 5.6–10.5 mm in 29.41%, and 15.6-20.5

mm in 22.05% of specimens, resulting in a mean height of 13.67 mm in the septal leaflets [Table 2].

Three chordae tendinae are most prevalent, occurring in 47.18% of specimens, followed by two chordae tendinae in 27.94%, four chordae tendinae in 14.70%, one in 11.76%, five in 2.94%, and six or more in 1.47% of specimens [Graph 2]. The length of chordae tendinae ranged from 5.6 to 10.5 mm in 47.05% of specimens, 10.6 to 15.5 mm in 42.64%, and 15.6 to 20.5 mm in 10.29% of specimens, with a mean length of 12.64 mm [Table 3]. These findings underscore the variability in both the number and length of chordae tendinae across different specimens. Clinicians and researchers must recognise this anatomical diversity, as it may influence surgical methods and the management of valvular disease.

A study by Zeba Alam et al. on 50 adult human cadaveric hearts found a mean frontal dimension was 28.03±5.08. sagittal dimension was frequent between 20.6-25.5 mm in 44% of specimens, common tricuspid valve circumference was between 90.6-100.5 mm in 36%, followed by 100.6-110.5 mm in 20% of the hearts. Three and four tricuspid leaflets were commonly reported in 42% of specimens each.[6]

Harsha BR et al. examined 96 human cadaveric hearts and identified five categories of chordae tendineae based on their attachments: rough zone, free edge, fan-shaped, deep, and basal chordae. The anterior papillary muscle was observed attaching to 2 to 9; the posterior papillary muscles were noted with 1 to 6, and the septal papillary muscles supplied connection to 1 to 4 chordae tendineae.[7] Aytac Kocak et al. examined 400 human hearts obtained from deceased individuals, categorised into cardiac (n=200) and non-cardiac (n=200) causes of death. In the non-cardiac group, two leaflets were present in 20% of hearts, three in 70%, and four in 10%. In the cardiac group, two leaflets were found in 36 hearts (18%), three in 130 hearts (65%), and four in 34 hearts (17%). The annular circumference of the tricuspid valve associated with cardiac mortality was 11.2 ± 1.2 cm in males and 10.8 ± 1.1 cm in females (8). In typical individuals, the TA circumference measures 12±1 cm, whereas the area is 11±2 cm^2.[9,10] The diameters of the TA expand during atrial systole and again in late ventricular systole/early diastole by approximately 30%.[11] Rohilla A et al. examined 100 adult human cadaveric hearts and determined that the septal leaflet was the biggest of the three leaflets, with the anterior leaflet exhibiting the greatest height at 19.22 mm.[12] Skwarek et al. discovered No discrepancies were seen in the lengths of the anterior and septal leaflets. The posterior leaflet was the shortest, whilst the anterior leaflet was the broadest and possessed the biggest surface area. The posterior leaflet exhibited greater width than the septal leaflet and has the least surface area. No discrepancies were observed between the primary and accessory leaflets regarding the length of the commissures.[13]

In their study, Balachandra N et al. examined 96 cadaveric hearts and identified several common types of chordae: basal, fan-shaped, free edge, rough zone, and deep chordae. They noted that the number of chordae attached to the papillary muscles varies, with the anterior papillary muscles having 2-8 chordae, the posterior muscles having 1-6 chordae, and the septal muscles having 1-10 chordae.[14] Arumugam K et al. conducted a study on 20 human hearts, finding that the circumference of the tricuspid orifice varies between 79.10 and 121.27 mm, with an average measurement of 102.1005±13.461 mm. In 19 out of the 20 hearts examined, there were 3 cusps, while one heart exhibited only 2 cusps. The dimensions of the anterior cusp exhibit a range of 12.12mm to 24.84mm in length and 10.12mm to 43.83mm in width, with mean values calculated at 18.968±4.217mm and 29.1915±9.052mm, respectively. The dimensions of the posterior cusp exhibit a range of 11.02mm to 25.51mm in length and 11.63mm to 32.74mm in width, with mean values of 17.5±4.72mm and 23.005±6.07mm, respectively. The dimensions of the septal cusp exhibit a range from 11.18mm to 25.30mm in length and from 12.54mm to 26.40mm in width, with mean values of 17.571±3.724mm and 19.345±3.66mm, respectively.[15] The morphometric values from the aforementioned studies are relatively close to the findings of the current investigation.

CONCLUSION

The dimensions of the tricuspid orifice presented will serve as significant data for forthcoming investigations and for the management of patients with various cardiac conditions. This research has the potential to offer significant insights that may address the deficiencies in fundamental data regarding the dimensions and morphology of the tricuspid valve. Nonetheless, it is imperative that we reproduce these findings within a larger cohort and broaden their applicability to those afflicted with valvular disease. The results of this research may prove beneficial for cardiac surgeons who depend on direct morphological assessments of the right atrioventricular region. Moreover, precise measurements of the leaflets are instrumental in the development of bioprosthetic valves employed for the repair of the tricuspid valve. Moreover, a comprehensive grasp of the complex characteristics of the tricuspid valve's structure could advance the creation of tailored surgical methodologies and possibly lead to better patient outcomes. As research advances, it becomes crucial to incorporate these discoveries into clinical practice, guaranteeing that surgical interventions are not only effective but also customised to accommodate individual anatomical differences.

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