



## MORPHOMETRIC MEASUREMENTS OF TRICUSPID VALVE IN CADAVERIC HEART IN MAHARASHTRA POPULATION

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### ABSTRACT

**Aim of study-** Knowledge of the morphometric measurements of the normal tricuspid valve may be useful in the context of the repair of annulus (circumference) of tricuspid valve prolapse or formation of prostheses for repair of annulus.

**Material & Method-** In this study 120 formalin-fixed adult human hearts were dissected. After opening & cleaning the interior of the chamber thoroughly, right atrio-ventricular valve complex was observed & removed from heart and observation was made for number of cusps in each valve. After that we measured the tricuspid valve annulus after making a flap. A thread was well fitted at margin and the thread length was measured by vernier callipers. The area of circumference was obtained by formula  $2\pi r^2$ .

**Result-** The 55.83 % of valves had circumference between 10.1-12.5 cm, Maximum number of tricuspid valve (42.5%) had cross sectional area in the range 7.6-10.0 cm<sup>2</sup>. The posterior leaflet was the shortest, while the anterior leaflet was the widest and had the largest surface area.

**Conclusion:** The study of morphometric measurements of tricuspid valve will be of immense value in designing prototype of tricuspid valve prosthesis.

**KEYWORDS :** Tricuspid valve, Leaflet (cusp), Circumference of tricuspid valve, Area of cusp, Accessory cusps, Prostheses.

### INTRODUCTION

Valvular morbidities are one of the common cardiac disease and the commonest cause of valvular heart diseases in India is chronic rheumatic heart disease. The prevalence of rheumatic heart disease in India was 0.06–0.46 % in the year 2008 as quoted by S. Ramakrishnan et al [1]. Hence the disease burden of valvular pathologies is high in society and it affects almost all the valves of heart. The incidence of organic impairment of the tricuspid valve reported is 10–15% of rheumatic valve diseases but in the Indian subcontinent, the organic tricuspid valve involvement is reported to occur in more than one-third of patients with rheumatic heart disease [2,3].

Modalities of treatment available for valvular disease are balloon valvuloplasty, valvotomy and replacement by prosthetic valve. Approximately eighty varieties of model prosthesis are available in the market, of which Ball-valves, St.Jude's medical bi-leaflet, Star – Edward ball case, Bijor Shely titing disk<sup>2</sup> are well known. Morphometric measurements of cardiac valves with their circumference and diameters, numbers and lengths of cusps are mandatory data for valvular heart surgeries and preparation of prostheses.

Tricuspid opening is a valvular communication present between right atrium and right ventricle, which is guarded by tricuspid valve. It has three cusps named as anterior, posterior, septal with reference to their position. Detailed morphometric study of tricuspid valve in significant number of hearts was deemed relevant in view of paucity such a study. Hence a study was undertaken in Department of Anatomy at Dr. D. Y. Patil Medical College Pune to measure the circumference, cross-sectional area, length of annular attachment of cusps. This baseline data will be of immense help to cardio thoracic surgeons and for manufacture of modern type of prosthesis of tricuspid valves.

### MATERIALS AND METHODS:

This study was conducted in Department of Anatomy, Padmashree Dr. D. Y. Patil Medical College, Pimpri, Pune. 120 adult human cadaveric hearts without any malformations or pathology were included in the study. Hearts were dissected from the cadaver and specimen obtained were numbered and preserved in 10% formalin. The data on gender and age of cadavers was not available as most of the heart specimens were removed from the cadaver during previous years.

### Dissection of Tricuspid valve:

The incision to expose tricuspid valve was taken from lower end of right border of heart, then along the upper margin of the coronary sulcus, curving upwards towards right auricle till root of superior vena cava. The flap so created was turned to right and right atrial chamber

was opened. After cleaning the interior of the chamber thoroughly & tricuspid valve, A-V valve annulus, cusps, chordae tendinae were examined {Figure No: 1}

A second incision was taken around the outer margin of annulus and tricuspid valve with annulus was removed. {Figure No: 1}

A third incision extended along the inferior border of heart till right margin of anterior inter-ventricular groove, then curved along right side of inter-ventricular septum till the anterior coronary sulcus. Flaps so obtained were turned left to expose the right ventricular chamber. {Figure No: 1}

### Measurement of tricuspid Circumference:

Tricuspid valve was divided between septal and anterior cusps. Valves were flattened out in single plane on a thermacol sheet and pinned. Thread was placed along the margin of circumference and fixed by pins. Thread was then straightened out, fixed on thermacol sheet and length was measured using vernier calipers. {Figure No: 2}

Applying formula used in geometrical calculations for Circumference,  $C = 2\pi r$ , radius was calculated by equation  $\text{radius } (r) = \text{Circumference}/2\pi$ . Substituting radius value in formula for area of circle,  $\pi r^2$ , area of the valvular opening was calculated. Though atrioventricular orifice is not exactly circular, but elliptical, area logically will not change. Elliptical shape is similar to a stretched circle, without change in its area. On this premise, valvular area is equated with cross sectional area in observations. Data was tabulated and arithmetic mean<sup>5</sup>, standard deviation (SD)<sup>6</sup> & co-efficient of variation (CV)<sup>7</sup> were applied.

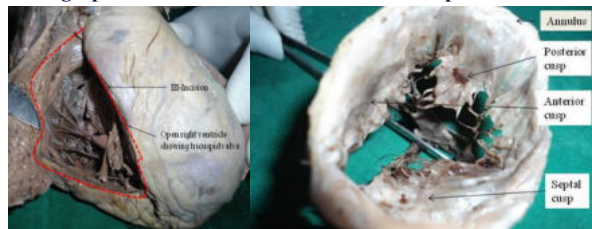
### Definitions:

- Length of the cusp: measurement of distance of attachment of the cusp to the annulus.
- Height of the cusp: measurement of distance between tip of cusp and annular attachment.
- Circumference: circumference of the annular ring.
- Cross sectional area: area of the annulus
- Annulus: Fibrous margin to which cusps are attached

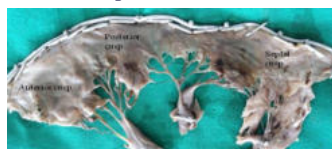


**Photograph 1: 1" Incision For Removal Of Tricuspid Valve**

**Photograph 2: 2<sup>nd</sup> Incision For Removal Of Tricuspid Valve**



**Photograph 3: 3<sup>rd</sup> Incision For Removal Of Tricuspid Valve**



**Photograph 5: Normal Tricuspid Valve With Dissected Annulus**

**Photograph 4: normal tricuspid Valve With Annulus**



**Photograph 6: Normal Tricuspid Valve Showing Length & Height Of Anterior Cusp**



**Photograph 7: Thread Along The Margin Of Tricuspid Valve For Measurement Of Circumference**



**Photograph 8: Vernier Scale With Pinned Two End Of The Thread**

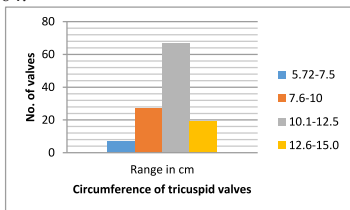
**Figure No 2 Results**

Morphometric data of the tricuspid valve was recorded as follows- circumference (in cm), Cross-sectional area of valve (in cm<sup>2</sup>), cusp length and height.

**Circumference:**

It was found that 55.83% Tricuspid valve had circumference between 10.1-12.5 cm, while 5.83% of tricuspid valves had circumference between 5.72-7.5 cm [Table 1 and Chart 1]

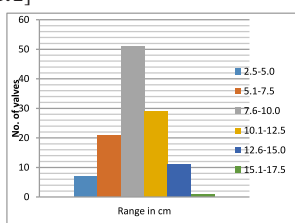
Arithmetic mean of circumference was 10.6 cm with a standard deviation was ± 1.64.



**Chart: 1 Bar diagram showing range of circumference of tricuspid valve**

**Cross sectional area:**

Circumference = 2πr, with the help of this equation r (radius) was calculated. The value of radius is used to calculate the cross-sectional area using the formula cross-sectional area = πr<sup>2</sup>. Maximum number of hearts (42.5%), cross sectional area was seen in range 7.6- 10 cm<sup>2</sup>. Arithmetic mean of area was 9.21 cm<sup>2</sup>, standard deviation was ± 2.75. [Table 1 and Chart 2]



**Chart 2: Bar diagram showing incidence range of cross-sectional area of tricuspid valve**

**Anterior cusp length:** Maximum no. (50%) of cusp had length in range 2.5-5 cm. Minimum length of cusp was 1.58 cm and maximum length was 9.28 cm. Arithmetic mean of length of anterior cusp was 5.0 cm and standard deviation was ± 1.32.

**Anterior cusp height-** Maximum no (80%) of cusps had height less than 2.5cm and 20% had height between 2.5 – 5 cm. Minimum height of anterior cusp was 1.08 cm and maximum height was 3.12 cm. Arithmetic mean of anterior cusp height was 2.86 cm with SD ± 1.01.

**Posterior cusp length-**Maximum no. (81.67%) of posterior cusps had length less than 2.5 cm. Minimum length of cusp was 0.55 cm and maximum length was 3.43 cm. Arithmetic mean of length of posterior cusp was 1.7 cm and standard deviation was ± 0.67.

**Posterior cusp height-** Height of all posterior cusps was less than 2.5 cm. Minimum height was 0.61 and maximum 2.55cm, Arithmetic mean was 1.5 and standard deviation was ± 0.84. In seven valves posterior cusp was missing.

**Septal cusp length -** Maximum no. (76.67%) of septal cusp had length in range between 2.5- 5 cm. Minimum length of cusp was 1.09 cm and maximum length was 5.44cm. Arithmetic mean of septal cusp was 3.2 cm and standard deviation was 0.932.

**Septal cusp height-** maximum no (95.83%) of septal cusp had height < 2.5 cm. Minimum height of cusp was 0.82cm and maximum height was 2.65 cm. Arithmetic mean of septal cusp height was 2.57 cm with SD ± 1.01.

**Table 1: Circumference and cross-sectional area of tricuspid valve**

Range of Circumference (cm)	Number of valves n=120 (%)	Range of Cross-sectional area (cm) <sup>2</sup>	Number of hearts n=120 (%)
5.72-7.5	07 (5.83%)	2.5-5.0	07(5.83%)
7.6-10.0	27 (25.80%)	5.1-7.5	21(17.50%)
10.1-12.5	67 (55.83%)	7.6-10.0	51(42.50%)
12.5-15	19 (10.83%)	10.1-12.5	29(24.17%)
		12.6-15.0	11(9.17%)
		15.1-17.5	01(0.83%)

**Table 2: Length & Height of Anterior Cusp**

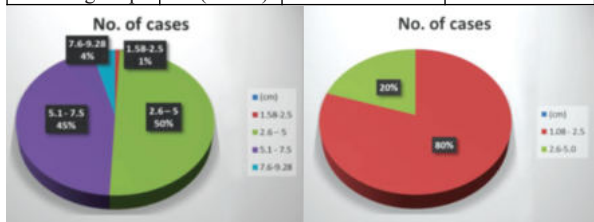
Range of Length (in cm)	No. of cusps (%)	Range of Height (in cm)	No. of cusps (%)
1.50 -2.5	1 (.83%)	1.0 – 2.5	96 (80%)
2.6 – 5.0	60 (50%)	2.6 – 5.0	24 (20%)
5.1 – 7.5	54 (45%)		
7.6 – 10.0	5 (4.17%)		

**Table 3: Length & Height of Posterior Cusp**

Range of Length (in cm)	No. of cusps (%)	Range of Height (in cm)	No. of cusps (%)
0.55-2.5	98 (81.67%)	0.5 – 2.5	120 (100%)
2.6 – 3.43	15 (12.5%)		
>5	07 (5.83%)		

**Table 4: Length & Height of septal Cusp**

Range of Length (in cm)	No. of cusps (%)	Range of Height (in cm)	No. of cusps (%)
1.09 – 2.5	23 (19.17%)	0 – 2.5	115 (95.83%)
2.6 – 5	92 (76.67%)	2.6 – 5	05 (4.17%)
5.1 - 5.44	04 (3.33%)		
Missing cusp	01 (0.83%)		



**Chart No. 3: Length of anterior cusps:**

**Chart No. 4: Height of anterior cusps**

**Chart No: 3 and 4 DISCUSSION**

The tricuspid valve has the largest orifice among all the cardiac valves and measured an average 114 mm in circumference in males and 108 mm in females [4]. Tricuspid valve regurgitation occurs mainly from annular dilation and right ventricular enlargement [2,5]. So the data on normal tricuspid valve circumference becomes important both for

diagnosing tricuspid regurgitation as well as preparation of prostheses. Similarly data regarding measurements of cups are also important to understand complex anatomy of right atrioventricular valve.

Studies of morphometric measurements of tricuspid valve are few and majority were reported in western population. Present study includes comprehensive morphometric evaluation of tricuspid valve in formalin fixed hearts using high number of specimens.

In present study, the circumference of tricuspid valve ranged from 5.72 cm to 15 cm but majority (55.83%) of the tricuspid valves had a circumference between 10.1 and 12.5 cm with a mean of  $10.6 \pm 1.64$  cm. Findings of this study is similar to a study done by Skwarek et al who reported mean circumference of tricuspid valve was  $105.67 \pm 16.76$  mm [6]. In a study done by Motabagani total leaflet annular length ranged in male 11.8 -13.9 cm and in female 11.3 -12.4 cm which is slightly higher than the findings of present study but variability quotient was 0.15, suggesting consistency in the findings [7].

In the present study the mean area tricuspid valve was  $9.21 \text{ cm}^2$  with standard deviation of  $\pm 2.75$ . it was found higher than a study done by Anwar et al where area of normal tricuspid annulus was  $10.0 \pm 2.9 \text{ cm}^2$  [8]. It is relevant to mention here that the measurements carried out in the study are on formalin fixed static hearts and they are manually taken. However, in real-time studies, the valves, annulus, cusps are in a dynamic state in a cardiac cycle. Hence, the measurements two-dimensional, three-dimensional echo findings may differ from the static valve studies.

According to Susan Standing et al in Gray's Anatomy anterior cusp of tricuspid valve is largest of the three, which is also a finding in present study [4]. According to our study anterior leaflet was largest followed by septal cusp. Similar finding was reported by Motabagani et al in their study [7]. Though Skwarek et al, A Rohilla et al and Nagarathanamma et al reported highest length of septal cusp followed by anterior cusp [6, 9, 10].

In present study maximum no. (50%) of anterior cusp had length in range of 2.5 - 5 cm. Minimum length of cusp was 1.58 cm and maximum length was 9.28 cm with an average of  $5.0 \pm 1.32$  cm. In a study done by Skwarek et al average length of anterior leaflet was  $31.98 \pm 8.74$  mm [6]. In a study done by Motabagani annular length of anterior leaflet in male range 3.9-4.7 cm and in female range 2.7-3.5 cm [7]. Average length of anterior leaflet is on higher side in present study due to higher length of anterior leaflets in few of the hearts. In present study mean of anterior cusp height was 2.06 cm with  $SD \pm .49$  which is almost similar in a study done by skwarek et al where mean height of anterior cusp was 23.88 mm with  $SD \pm 0.85$  [6]. Present study similar to Motabagani with a coefficient of variation of 0.38, suggesting lesser degree of variability [7]. A comparison of morphometric findings of different studies from results of present study is displayed in table 5.

**Table 5. Comparison of morphometric data of tricuspid valve from different studies**

	Morphometric parameter	Motabagani [7] 2006	Skwarek [6] 2008	A Rohilla [9] 2015	Nagarathanamma [10] 2018	Present study 2020
1	Circumference		$105.67 \pm 16.76$ mm	$94.96 \pm 10.59$ mm	$95.25 \pm 11.48$ mm	$10.6 \pm 1.64$ cm
2	Length of anterior cusp	$43.60 \pm 10.59$ mm	$31.98 \pm 8.74$ mm	$27.28 \pm 5.43$ mm	$26.87 \pm 6.88$ mm	$5.0 \pm 1.32$ cm
3	Length of septal cusp	$33.20 \pm 3.30$ mm	$32.16 \pm 8.79$ mm	$28.74 \pm 4.89$ mm	$29.44 \pm 5.26$ mm	$3.2 \pm 0.93$ cm
4	Length of posterior cusp	$29.20 \pm 2.80$ mm	$24.10 \pm 9.08$ mm	$22.02 \pm 4.25$ mm	$23.07 \pm 9.21$ mm	$1.7 \pm 0.67$ cm
5	Height of anterior cusp		$23.88 \pm 0.85$ mm	$19.22 \pm 2.42$ mm		$2.86 \pm 1.01$ cm
6	Height of septal cusp		$18.33 \pm 0.98$ mm	$15.30 \pm 2.99$ mm		$2.57 \pm 1.01$ cm
7	Height of posterior cusp		$21.35 \pm 0.90$ mm	$16.22 \pm 2.88$ mm		$1.5 \pm 0.84$ cm

In present study we found that average height of anterior cusp was highest followed by septal cusp similar to the findings of Skwarek et al

[6]. The finding of present study regarding to height of cusp is towards higher side as compared to the findings of A Rohilla et al [9].

## CONCLUSION:

In the view of paucity of data on circumference, cross-sectional area, length, height of cusps of tricuspid valve in Indian population, this baseline data will be of immense value in surgical procedure involving tricuspid valve and manufacturing valve prosthesis.

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