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Original Research Article

Variations in the Number and Morphology of Cusps of the Tricuspid Valve: A cadaveric study

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Abstract

Background: Valvular heart diseases are one of the most common pathologies of heart. Modalities of treatment available for valvular disease are balloon valvuloplasty, valvotomy and replacement by prosthetic valve. Hence the morphometry of tricuspid valve is important.
Materials and methods: For this study we dissected 120 formalin fixed hearts and studied tricuspid valvular complex. We found that there were a lot of variations in the number and dimensions of cusps in tricuspid valve.
Results: Normal tricuspid valve with three cusps was found only in 51.66% of hearts. Bicuspid, tricuspid valve was present in seven hearts. The number of accessory cusps ranged from one to four. Most of the anterior cusp, posterior cusp and septal cusp was found to be triangular in shape. The anterior cusp was found to be largest in length, followed by septal cusp. The average height of all anterior, posterior and septal cusps was almost same.
Conclusion: This data will be of immense value to cardiothoracic surgeons and also for manufacture of modern type of prosthesis of tricuspid valve.
Keywords: Tricuspid valve, cusps, shape, accessory cusp, prosthesis.

1. Introduction

Diseases of tricuspid valve though less as compared to mitral valve, the incidence of organic impairment of the tricuspid valve reported is 10–15% of rheumatic valve diseases [1]. However, clinically significant tricuspid valve disease in association with mitral or aortic valve disease is reported to be 10–20% of cases [2]. Tricuspid valve regurgitation (TR) after mitral valve replacement in rheumatic heart disease is a serious clinical problem. If it occurs or progresses late after mitral valve surgery, tricuspid valve annuloplasty or replacement may be performed with satisfactory results.

Tricuspid valve regurgitation can also result from severe annular dilatation of the valve without any organic or congenital disease affecting the valve leaflets [3]. Thus tricuspid valvular disease either repaired by valvuloplasty or replacement it requires anatomical knowledge of morphometry of tricuspid valve. Further more knowledge of normal anatomical details of various cusp of tricuspid valve is highly significant for preparation of prosthesis.

The normal data on tricuspid valve complex is of great clinical importance but published works on the normal dimensions are surprisingly scant [4,5]. Detailed morphometric study of tricuspid valve in significant number of hearts was deemed relevant in view of paucity of such a study. The aim of this study is to establish the normal dimensions of the cusps of tricuspid valves utilizing the cadaveric hearts from Indian population.

2. Materials & Methods

The study was conducted in the Department of Anatomy, Dr. D. Y. Patil Medical College, Pimpri, Pune & IIMS&R, Integral University, Lucknow (UP). A total of one hundred and twenty formalin fixed hearts were dissected and data was collected. Normal adult human hearts without any malformations or pathology were included in the study. Heart specimens so obtained were preserved in 10% formalin. Specimens were numbered and valves were dissected out.

2.1 Removal 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. A second incision was taken around the outer margin of annulus.

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 to left to expose the right ventricular ventricular chamber. All the attachments of tricuspid valve from ventricular wall were cut and thus tricuspid valve with annulus was removed (Figure 1).

The following observations were made regarding tricuspid valve.

1. Number of cusps: number of the cusps in tricuspid valve was noted. Observation was made for accessory cusps or a missing cusp (Figure 3 & 4)
2. Shape of cusp: Appearance of cusp, e.g. triangular, rectangular, D shaped.
3. Length of the cusp: measurement of distance of attachment of the cusp to the annulus. 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 and fixed by pins. Thread was then straightened out, fixed on thermacol sheet and length was measured using vernier calipers. (Figure 1 & 2)
4. Height of the cusp: measured with the help of vernier calipers. (Figure 2)

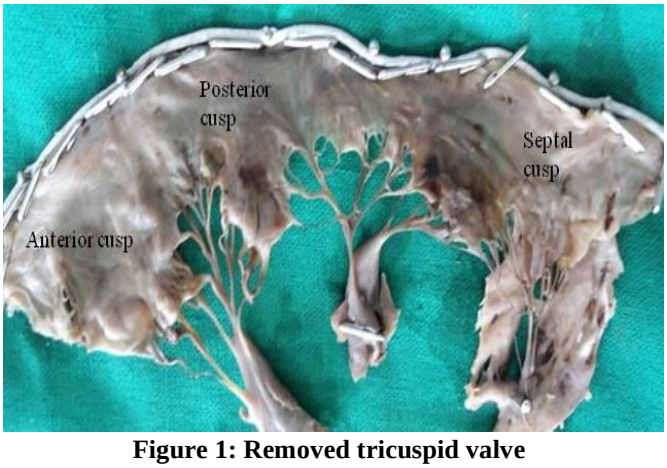

Figure 1: Removed tricuspid valve

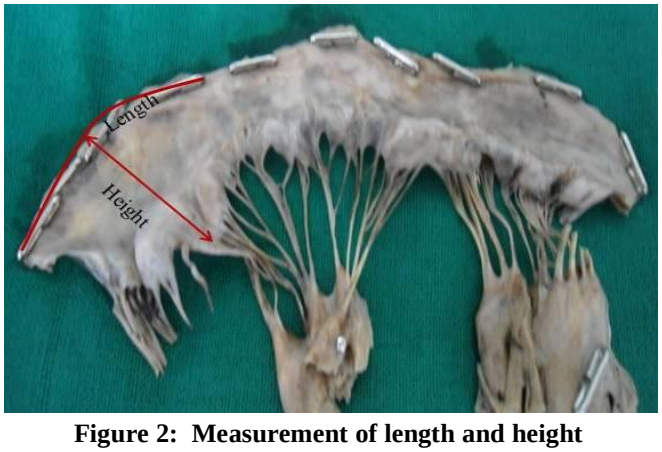

Figure 2: Measurement of length and height

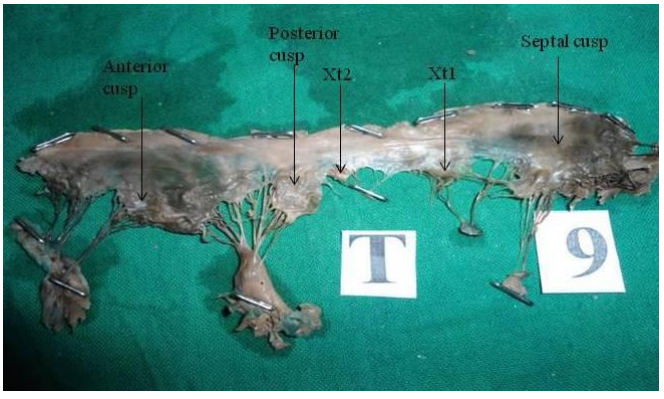

Figure 3: Showing Accessory cusp

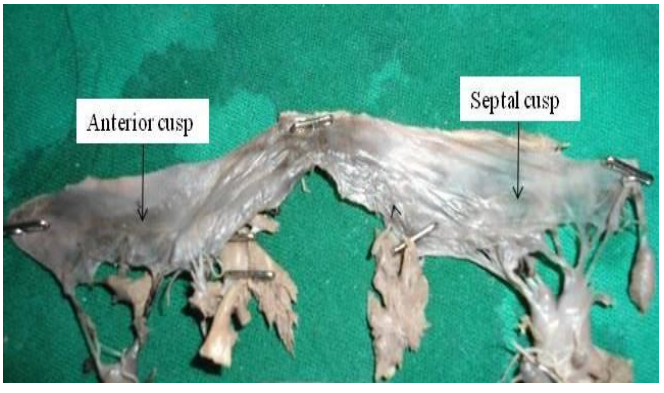

Figure 4: Missing posterior cusp

3. Observations and Results

3.1 Number of the cusps

We observed that the number of the cusps in tricuspid valve was quite variable. The tricuspid valve was found to be bicuspid to septacuspid valve in the present study. The normal tricuspid valve was present only in 51.66% of the heart, while the bicuspid tricuspid valve was present in 5.83% of heart. The accessory cusp was present in 42.5% of hearts and maximum number of accessory cusps found was four (Figure 3). The findings regarding number of cusps of tricuspid valve is tabulated in Table 1.

3.2 Shape of cusps

Shape: The types of shape of cusps observed were triangular, rectangular and D-shape. Maximum number (95%) of anterior cusps 92.5% posterior cusp and 97.5% of septal cusp were triangular in shape. Few of them were rectangular in shape. Finding regarding shape of cusps is tabulated in Table 2.

3.2 Dimensions of cusps of tricuspid valve

Anterior cusp

Length: Length of anterior cusp showed a great variation and was ranged between 1.58 and to 9.28cm. Arithmetic mean of length of anterior cusp was 5.0 cm. and standard deviation was ±1.32.Coefficient of variation 0.2621. The categorization of length of anterior cusp was tabulated and shown in table 3.

Height: Minimum height of anterior cusp was 1.08 cm and maximum height was 3.12 cm. Arithmetic mean of height of anterior cusp 2.86 cm with SD ± 1.01. Coefficient of variation

calculated was 0.3534. The height of anterior cusps is tabulated in Table 4.

Posterior cusp: Out of 120 tricuspid valves in 7, the posterior cusp was missing (Figure 3).

Length: Minimum length of posterior cusp was 0.55cm and maximum length was 3.43cm. 81.67% of cusps were found to be less than 2.5 cm in length. Arithmetic mean of posterior cusp was 1.7 cm and standard deviation was ±0.67. Coefficient of variation was 0.2621. The range of length of posterior cusp is tabulated in table 3.

Height: Minimum height of posterior cusp was 0.61 cm and maximum was 2.55cm. Arithmetic mean was 1.5 and standard deviation was ±0.84 15 with a coefficient of variation of 0.4624. The range of length is tabulated in table 4.

Septal cusp:

Length: Length of maximum number (76.67%) of septal cusp was ranged between 2.5- 5 cm. But minimum length of septal cusp was 1.09 cm and maximum length was 5.44cm.

Arithmetic mean of length of septal cusp was 3.2 cm and standard deviation was 0.932. Coefficient of variation was 0.3883. The observations regarding length of septal cusp are tabulated in Table 3.

Height: 95.83% of septal cusp had height < 2.5 cm. However minimum height of septal cusp was 0.82cm and maximum height was2.65 cm. Arithmetic mean of height of septal cusp was 2.57 cm with SD ±1.01. Coefficient of variation was 0.40. Range of height of cusp and its percentage are given in Table 4.

Table 1: Number of cusps in tricuspid valve

Type of valve	Number of accessory cusp	Number of hearts (n=120)	Percentage
Bicuspid	0	7	5.83%
Tricuspid	**0**	**62**	**51.66%**
Quadricuspid	1	35	31.66%
Pentacuspid	2	10	8.33%
Hexacuspid	3	5	4.16%
Septacuspid	4	1	0.83%

Table 2: Shape of anterior, posterior and septal Cusps

Shape of cusp	Anterior cusp(leaflet) (n=120)	Posterior cusp (leaflet) (n=120)	Septal cusp(leaflet) (n=120)
Triangular	114 (95%)	111 (92.5 %)	117 (97.5%)
Rectangular	06 (05%)	02 (1.67 %)	01 (0.83%)
D shape	nil	Nil	01 (0.83%)
Missing cusp	nil	07 (5.83 %)	01 (0.83%)

Table 3: Range of Length of anterior, posterior and septal Cusp

Range of length (in cm)	Number of anterior cusp (n=120)	Number of posterior cusp (n=120)	Number of cusp septal (n=120)
0.5-2.5	1 (0.83%)	98 (81.67%)	23 (19.17%)
2.6 – 5	60 (50%)	11 (09.16%)	92 (76.67%)
5.1 - 7.5	54 (45%)	3 (2.49%)	4 (3.33%)
7.6-9.5	5 (4.17%)	nil	nil
missing	nil	7	1 (0.83%)

Table 4: Height of Anterior posterior and septal Cusp

Range of length (in cm)	Number of anterior cusp (n=120)	Number of posterior cusp (n=120)	Number of septal cusp (n=120)
0.5- 2.5	96 (80%)	120 (100%)	115 (95.83%)
2.6-5.0	24 (20%)	nil	05 (4.17%)

4. Discussion

Knowledge of the morphology of the normal tricuspid valve may be useful, in the context of the transfer of a leaflet of the tricuspid valve for repair or insufficiency of the mitral valve [6]. Surgical repair of the mitral valve using tissue of the tricuspid valve is becoming ever more frequent as a result of the reduced rate of complications in comparison with repair using synthetic materials. Furthermore plastic repair of the tricuspid valve is increasingly being performed in children with complicated defects of the heart [7]. Primary valve replacement of the tricuspid valve is preferred to valve repair in extensive tricuspid valve destruction as a result of acute endocarditis [8]. Frequent infectious complications of the tricuspid valve are sometimes indications for surgical treatment, including severing the infected part of leaflet or replacement with a biological prosthesis [9,10]. Moreover post-traumatic damage of the tricuspid valve is more frequent than damage of the mitral valve because the tricuspid valve is

located anteriorly to the mitral valve and closer to the chest wall [6,11]. Hence knowledge of the morphology and morphometry of the tricuspid valve helps to differentiate between functional and organic tricuspid pathology [11]. Such data may also be helpful to cardiac surgeons for planning the treatment of patients with tricuspid valve abnormality. Also the knowledge of normal anatomical data and variation in the number of the cusp, their variant shape & length is also important for the formation of a good quality of prosthesis of tricuspid valve.

Skwarek *et al* studied, 75 formalin–fixed human hearts and found that the normal tricuspid valve having three leaflets was present only in 9.3% of hearts. Most commonly 40% of heart was having one accessory cusp other than three main cusps. They also found quadricuspid, hexacuspid and septacuspid tricuspid valve in their study [12].

In another study Sutton *et al* reported that the majority of human tricuspid valves (62%) are reported to possess three well demarcated leaflets, some (30%) have two leaflet, and others (8%) are formed of four leaflets [13]. Georla *et al* found that the cusps in the right AV valve were 2-4 in number and finding 3 cups was commonest [14]. Similarly in present study we found that tricuspid valve with three leaflets was the most common pattern but other patterns were also frequently found.

In present study we found that most of the anterior cusp, posterior cusp and septal cusp were triangular in shape. This finding is similar to Skwarek *et al* as they found that all the anterior cusps and posterior cusp and septal were triangular in their study [6]. However Motabagani *et al* found that the most common shape of septal cusp was semicircular [15].

All the measurements of cusps of tricuspid valve are compared with results of different studies in table 5.

Table 5: Comparison of variables of anterior, posterior and septal cusp of present study with different studies

	Anterior cusp			Posterior cusp			Septal cusp		
	Shape	**Length**	**Height**	**Shape**	**Length**	**Height**	**Shape**	**Length**	**Height**
Skwarek [6]	triangular	31.98±8.74mm	20.71±5.23mm	triangular	24.1 ± 9.08 mm	18.88±4.66mm	triangular	32.16±8.79 mm	17.22±4.71mm
Motabagani [15]	Triangular	43.6±0.34 mm in men 30.8±0.33 mm in women	24.6±0.21 mm in men 20.2±0.13 mm in women	triangular	29.2±0.28mm in men, 23.4±0.46mm in women	25.2±0.33 mm in men, 19.2±0.33mm in women	semicircular	33.2±0.33 mm in men, 29.4±0.30 mm in women	15.8±0.18mm in men, 15.2±0.13 mm in women
Skwarek *et al* [5]		33.56±6.32 – 34.68±6.41 in men 31.17±7.1 – 34.72±6.08 in women			28.56±7.1 – 38.4±11.28 in men, 27.61±6.61 – 36.22±9.8 in women			29.14±4.59 - 29.98±5.29mm.in men, 28.97 ± 5.34 – 29.75±6.5 in women	
Present study	Triangular	50.2±1.32 mm.	20.6±0.49 mm	triangular	17 ±0.66 mm	13.9 ± 0.44 mm.	triangular	32.5 ± 0.91 mm.	25.7 ±1.01 mm

Most of the studies in the literature mention that anterior cusp is largest in length. The anterior leaflet is the largest component of the valve as reported by shwarek *et al* [5]. In a cadaveric study Skwarek *et al* found that average length of anterior cusp was 31.98±8.74mm [6]. In another study Motabagani *et al* mention average length of anterior cusp 3.9-4.7cm in male and 2.7-3.5cm in female [15]. In this study we found average length of anterior cusp was 5.02±1.32 cm which was comparatively higher. In present study we also found that posterior cusp is smallest in length out of the three cusps, in contrary to that quoted by Motabagani in posterior leaflet as the second largest cusp [15]. However the finding is similar to skwarek who mentioned the average length of posterior cusp less than average length of septal cusp [6]. The average length of posterior cusp in our study was found to be 1.74±0.66 cm. This finding was less as observed by Skwarek *et al* and Motabagani [6,15]. Septal cusp is second largest cusp in length found in this study which is similar to that found by the Skewarek *et al* [6].

Maximum average height measured in present study is for the septal cusp which is different from Skwarek who found maximum average height for anterior cusp though the measurements for anterior cusp was almost similar anterior cusp in both studies. Average height of posterior cusp in present study is similar to Skwarek but less than what mentioned by Motabagani [6,15].

5. Conclusion

There was quite range of variation of different variables of cusps of tricuspid valve. Variability of the measurements of cusps is likely to play important role in hemo-dynamics of circulation. These data may be of immense value for determining the normal dimensions and in manufacturing of tricuspid valve prosthesis.

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