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Original Research Article

Cadaveric Study of Dimensions of Human Adult Tricuspid Valve and the Attachment of Chordae Tendinae

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Abstract

Background and Objective: The right atrioventricular valve is the largest of all the heart valve. From a functional standpoint the term 'atrioventricular valve apparatus/complex' is more appropriate. The tricuspid valve is often called the "forgotten valve" or "lost valve" because it is relatively understudied compared to the other cardiac valves. The normal data of the tricuspid valve complex is of great clinical importance in the light of progress in cardiosurgery. The right atrium communicates with the right ventricle through right atrioventricular orifice, which is guarded by right atrioventricular valve. The objectives of the present study are to measure frontal, sagittal dimensions, circumference, right atrioventricular orifice area, height of anterior, posterior & septal leaflet, average number of chordae tendinae attached to anterior leaflet and average length of chordae tendinae attached to anterior leaflet of the Tricuspid valve.

Methods: The study sample consists of 50 formalin fixed adult human heart available in the Department of Anatomy & Forensic department of NMCH Patna. The parameters were noted meticulously and the data processed.

Conclusion: The results of the present study show that the morphometric measurement of Tricuspid Valve will serve as reference data for further studies, clinical use in patients with various cardiac abnormalities and construction of bioprosthetic valves for tricuspid repair.

Keywords: Chordae tendinae, Tricuspid valve, Atrioventricular orifice, Tricuspid valve leaflets.

Introduction

The anatomy of the tricuspid valve complex is highly sophisticated. The normal data of the tricuspid valve complex is of great clinical importance in the light of progress in cardiosurgery and the development of novel operating technique [1,2,3] The heart consists of four chambers—right atrium and right ventricle, and left atrium and left ventricle. The right atrium communicates with the right ventricle through right atrioventricular orifice, which is guarded by right atrioventricular valve (also known as tricuspid valve): As the name indicates it has three cusps—anterior, posterior and septal, which lie against the three walls of the ventricle. The tricuspid valve can admit the tips of three fingers. [4] The right atrioventricular valve is the largest of all the heart valve. From a functional standpoint the term 'atrioventricular valve apparatus/complex' is more appropriate. The tricuspid valve is often called the "forgotten valve" or "lost valve" because it is relatively understudied compared to the other cardiac valves. [5,6] The annulus of tricuspid valve is a ring of collagenous tissue, which gives attachment to the cusps of the valve. The anterior cusp is attached to the supraventricular crest, the posterior cusp to the posterior wall and the septal cusp to the membranous interventricular septum. Each cusp has two surfaces (atrial and ventricular). The chordae tendinae arising from the anterior papillary muscle are attached to the anterior and posterior cusps; those from posterior papillary muscle to the posterior and septal cusps; and those from the septal muscles or directly from the septum to the anterior and septal cusps. During ventricular diastole (when the intraventricular pressure is low), the papillary muscles are relaxed and the chordae tendinae are slack. At this stage, valves open and the apices of the cusps project into the ventricle. The blood flows freely from the right atrium to the right ventricle. During ventricular systole (when the intraventricular pressure is high), the cusps are driven upward, the papillary muscles contract and tighten the chordae tendinae. This action is responsible for the closure of the valve by apposition of the atrial or smooth surfaces of the cusps [7,8] However, because of the position of the TV in the

far field in relation to probe, transesophageal two-dimensional echocardiography can still only provide limited information and can also not visualize all TV cusps simultaneously. [9] Studies of the morphometry and normal anatomy of the tricuspid valve are in constant demand in the context of the transfer of a leaflet of the tricuspid valve for repair or insufficiency of the mitral valve. This demands great anatomical knowledge. [10] The high degree of thrombogenicity of artificial valves implanted into the tricuspid ostium argues a superiority of repair techniques over the supply of artificial Valves[10] The impetus given to tricuspid valve surgery in the course of the last few years has prompted revision of our knowledge concerning the anatomy of the normal. [11]

Objectives

- Right Atrioventricular orifice area
- Height of Anterior, Posterior & Septal leaflet of Tricuspid Valve
- Average number of Chordae Tendinae attached to Anterior leaflet
- Average length of Chordae Tendinae attached to Anterior leaflet

Material and Method

The study sample consists of 50 formalin fixed adult human heart available in the Department of Anatomy & Forensic department of Nalanda medical college and Hospital, Patna. The parameters were noted meticulously and the data processed. The study was carried out on 50 formalin fixed adult human hearts who had died of non-vascular causes & without any gross abnormality of the tricuspid valves. Tricuspid valve complex was studied in Hearts of embalmed human cadaver. The cadavers were from South Indian adult population. The dissection was done by following the guidelines of Cunninghans manual. The hearts were dissected with least destruction of valves after cleaning thoroughly under the tap water. The first incision was given from right aspect of inferior vena cava to the superior vena cava and the right atrium was opened. The second incision was given along the inferior border of the heart to the inferior margin of anterior interventricular groove i.e. along the acute margin of the heart. The third incision was made just right to the anterior interventricular groove. The walls were carefully retracted and the interior was thoroughly washed under running tap water to remove the clots. The shape of the tricuspid valve was observed.

1. Frontal & sagittal dimensions of Tricuspid valve attachment orifice
2. Circumference of the tricuspid valve attachment orifice
3. Right atrioventricular orifice area
4. Height of anterior, posterior & septal leaflet of tricuspid valve
5. Average number of chordae tendinae attached to anterior leaflet

- Vernier caliper
- Surgical silk thread
- Copper wire
- Gum to stick the thread.

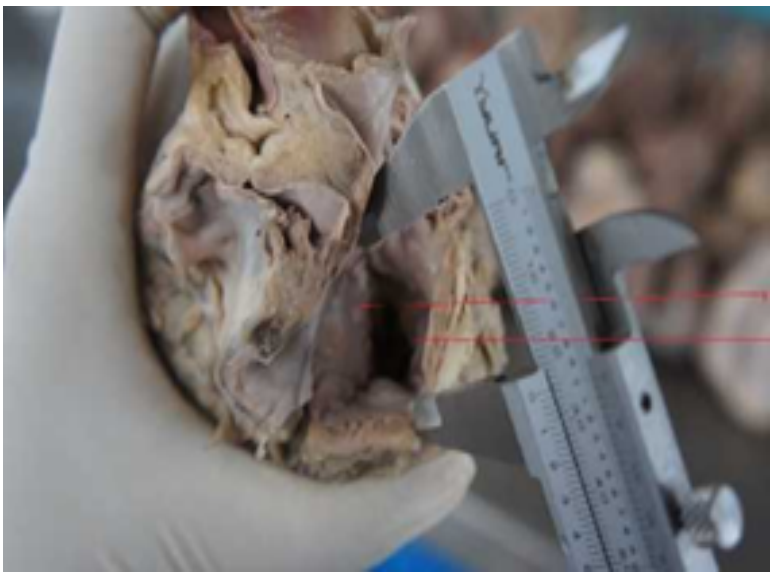

Figure 1: Showing the measurement of frontal dimension

Figure 2: Showing the measurement of Circumference of Tricuspid Valve

Conclusion Criteria

- Adult human cadaveric heart
- Patients who died of non-vascular causes
- Study will be done without any grouping of specimens on the basis of sex and age.
- Hearts with no developmental anomalies and pathological changes

Exclusion Criteria

- Malformations or pathological changes of heart
- Died from vascular diseases.
- Deaths of unnatural origin or from alcohol and overdose of drugs will be excluded from the study.
- Pediatric (less than 18) & Geriatric (above 65 years) hearts

Results

The observations, findings and analyzed data of the undertaken study have been represented in tables.

Statistical Methods: Normality tests were used to determine if a data set is well-modelled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed.

Table 1: Frontal dimension of Tricuspid Valve

Range of measurement	Frequency	Percentage(%)
15.6-20.5	6	6
20.6-25.5	9	9
25.6-30.5	18	18
30.6-35.5	14	14
35.6-40.5	2	2
40.6-45.5	1	1

The **Frontal dimension** of the tricuspid valve was measured from the commissure between the anterior and septal leaflet of the tricuspid valve along the axis of the right atrioventricular orifice to the sharp margin of the right ventricle.

Table 2: Statistical Summary of measurement of Frontal Dimension

	Statistic	Std. Error
Mean	28.0338	0.5082
Median	28.04	
Std. Deviation	5.08203	
Minimum	16.28	
Maximum	41.24	

Table 3: Sagittal dimension of Tricuspid Valve

Range of measurements	Frequency	Percentage (%)
10.6-15.5	1	1
15.6-20.5	8	8
20.6-25.5	22	22
25.6-30.5	13	13
30.6-35.5	4	4
35.6-40.5	2	2

The Sagittal dimension was measured perpendicularly to the frontal dimension at the midpoint of its length using non-stretchable surgical silk thread Measurement of sagittal dimensions were tabulated and represented as range. Majority of the Heart specimen ie 22 hearts (22%)have the sagittal dimension ranges from 20.6-25.5 mm, 13% of hearts with measurement ranges from 25.6-30.5mm, 8% between 15.6-20.5mm, 4% hearts with 30.6-35.5 mm, 2% between 35.6-40.5mm and 1 % heart specimens with sagittal dimension ranges from 10.6-15.5 mm.

Table 4: Circumference of Tricuspid Valve

Range of measurements	**Frequency**	**Percentage (%)**
70.6-80.5	1	1
80.6-90.5	7	7
90.6-100.5	18	18
100.6-110.5	10	10
110.6-120.5	6	6
120.6-130.5	6	6
130.6-140.5	2	2

Circumference of annulus was measured using surgical silk thread and the length was measured using Vernier calliper. Measurement of circumference were tabulated and represented as range. 18% of Heart specimens have circumference ranges from 90.6-100.5 mm, 10% between 100.6-110.5 mm, 7 % between 80.6-90.5 mm, 6% between 110.6-120.5mm, 6 % between 120.6- 130.5mm, 2% between 130.6-140.5 mm and 1% of heart specimen with circumference ranges from 70.6-80.5 mm.

Number of leaflets were noted. Those specimens with 3 leaflets were considered as normal. Those with additional leaflets were counted and maximum up to 7 leaflets were found in one specimen. Accessory leaflets 1, 2 and 3 were present between anterior and posterior leaflet and accessory leaflet 4 was present between septal and posterior leaflet.

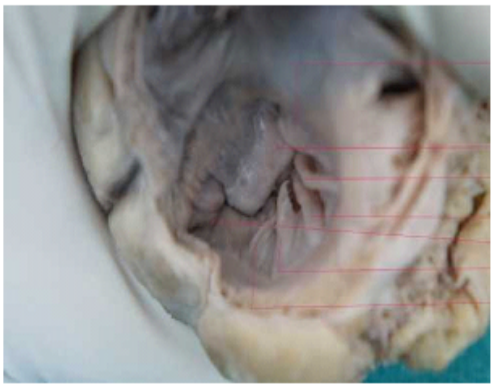

Table 5: Number of Leaflets of Tricuspid Valve

No of leaflet	**Frequency**	**Percentage (%)**
3	21	21.0
4	21	21.0
5	6	6.0
6	1	1.0
7	1	1.0
Total	100	100.0

In 21% Heart specimens have typical 3 leaflets but in another 21% cases 4 leaflets were present. 6% of

heart specimens with 5 leaflets, 1 % heart specimens with 6 leaflets and one heart with 7 leaflets.

Height of anterior leaflets were measured as the maximum vertical distance between the free edge of the anterior leaflet and its attachment to the annulus.

Table 6: Height of Septal Leaflet

Range of measurement	Frequency	Percentage(%)
5.6-10.5	12	12
10.6-15.5	27	27
15.6-20.5	10	10
20.6-25.5	1	1

Height of septal leaflets were measured as the maximum vertical distance between the free edge of the septal leaflet and its attachment to the annulus. Measurement of height of septal leaflets were tabulated and represented as range. Majority of heart specimen (27%) have the septal leaflet with height ranges from 10.6-15.5 mm.12% of septal leaflet with height ranges between 5.6-10.5mm, 10% between 15.6-20.5 mm and one heart specimen with septal leaflet above 20.6 mm.

The results of the present study was compared and correlated with that of earlier studies anddiscussed later in the discussion.

Discussion

The morphology of the atrioventricular orifice is still an open question. One of the oldest pictures of atrioventricular valve is found in De Humani Corpori Fabrica written by Vesalius in 16th century. The classic description of right atrioventricular valve found in the majority of available literature as having only three leaflets (Anterior, Septal and Posterior). The structure and function of heart was studied in situ only by dissection and by non invasive imaging techniques like echocardiography, tomography. Tricuspid valve has a complex three- dimensional structure which differs from the saddle shaped mitral valve annulus [12]. The distinct shape of tricuspid valve has clinical implications of the designing and application of currently available annuloplasty rings [13]. The present study is undertaken in order to construct a normal range for the different dimensions of the tricuspid valve orifice, which may be helpful for cardiosurgeons and invasive cardiologists, who use direct dimensions of this region for various surgeries. Also, the distinct shape of tricuspid valve has clinical implications for the designing and application of currently available annuloplasty rings. Skwarek et al studied 96 heart specimens and grouped into three cohorts corresponding to age. In men frontal dimension was 26.33 ± 4.25 in age group18 to 40 years, 29.42 ± 5.11 in age 41-65 years and 31.1 ± 3.49 in age above 65 years. Where as in women it was 24.89 ± 3.95, 26.31 ± 4.74 and 29.13 ± 1.84 according to age group mentioned above[1]. Kalyani et al studied 100 adult normal heart specimens. The hearts were grouped into three cohorts corresponding to age. According to this study frontal dimension in male was 27.34 ± 3.97 in age group between 8 to 40 years, 31.93 ± 4.52 in age between 41-64 years and 32.5 ± 2.12 in age above 64 years above. In females dimensions was 24.72 ± 2.69, 29.8 ± 4.15 and 31 ± 4.24 according to age group mentioned above. Kishore et al reported a study on 40 dead and spontaneously aborted foetal hearts of 16wks-4full term of gestational age of both sexes. In this study frontal dimension in male foetus was 4.79 ± 1.94 in age group 17-30 wks and 8.21± 2.27 in age group 31wks - full term and in female foetus it was 5.19 ±1.9 and 9.92± 3.93 according to age groups. N. Wafae et al reported that no relationship was observed between the perimeter of the right atrioventricular fibrous ring and the number of habitual cusps or the presence of commissural cusps in the tricuspid valve. Kishore et al studied heart specimens in foetal cadaveric heart and found the circumference in male was 16.77 ±11.75 mm between age 17 weeks to 30 weeks and 39.72 ±13.37 between age 31 weeks to 43 weeks. In females it was 18.01 ±12.83 and 55.6 ±30.04mm. Ashraf M. Anwar et al studied real-time three-dimensional echocardiography and reported Tricuspid valve has major and minor diameter and it changes during systole and diastole. Major Tricuspid annulus diameter during diastole was 38.6 ±9.3 mm and minor was 30.7± 9.2 mm. The major and minor Tricuspid annulus diameter during systole was 25.4 ±5.3 mm and 25.4 ±5.3mm.[9] Chuwa tei et al studied adult human heart by two dimensional echocardiography and found that the maximum tricuspid annular circumference was 11.9 + 0.9 cm and minimum was 9.6 + 0.9 cm. The author also studied the mean tricuspid valve annular circumference in the fresh and fixed state and found to be 13.5 ± 0.8 cm and 12.2 + 0.8 cm respectively. The author opined that the values measured in the fixed hearts were more similar to measurements obtained by echocardiography in a group of normal subjects. The choice of surgical management of "secondary" Tricuspid Regurgitation appears to be controversial, and several kinds of reconstruction methods are used. Preoperative evaluation of the Tricuspid valve may be helpful in planning the reconstruction procedure or the use of a prosthetic device. The results of tricuspid annuloplasty for correction of significant tricuspid regurgitation have usually been

successful. No technique is available to measure tricuspid annular size and assess annular function and no reports have described the tricuspid annular size and motion in man. Plastic repair of the tricuspid valve is increasingly being performed in children with complicated defects of the heart. 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. Surgical repair of the mitral and tricuspid valves are performed simultaneously using the Vega method (by decreasing the circuit of the right atrioventricular ostium with a ring) or, in the event of stenosis, with the balloon-plastic method. This demands great anatomical knowledge. [14]

Conclusion

A study was done on Tricuspid Valve to know the morphometric dimensions of the Valve and the attachment of chordae tendinae in cadaveric human adult hearts. A detailed study was done to note the following parameters:

- Frontal & Sagittal dimensions of Tricuspid Valve attachment orifice
- Circumference of the tricuspid valve attachment orifice
- Right Atrioventricular orifice area
- Height of Anterior, Posterior & Septal leaflet of Tricuspid Valve
- Average number of Chordae Tendinae attached to Anterior leaflet

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