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A Morphometric Study of the Right Atrioventricular Valve in Cadavers

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Abstract

The right atrio-ventricular (tricuspid) valve is having three leaflets in majority of cases. However, in some cases it has shown only two leaflets or in few four leaflets. Accurate knowledge of morphometry and morphology is important in differentiating and treating various pathologies of the right atrio-ventricular (tricuspid) valve. Hence, the aim of the present study is to measure various dimensions of the right atrio-ventricular (tricuspid) valve and note any variations found. The dimensions were measured with the help of standard instruments. The data obtained was statistically analysed and compared with the available literature. The Mean results obtained were (in mm), circumference of right atrioventricular valve annulus: - 10.2, width of anterior leaflet: - 4.9, width of posterior leaflet: - 3.8, width of septal leaflet: - 4.4, height of anterior leaflet: - 3.3, height of posterior leaflet: - 3.4, height of septal leaflet: - 4.8

Keywords: Atrioventricular; Morphometric; Tricuspid; Valve.

Introduction

The right atrioventricular valve is also called as tricuspid valve since it has 3 leaflets as the most common occurrence (62%), two leaflets in 30% and four leaflets in 8% cases [1].

The anatomy of right atrioventricular valve complex is highly sophisticated but understanding of it may be helpful in the practice of cardiac surgery, especially in the partial transfer of leaflets of tricuspid valve for mitral valve repair. The right atrioventricular valve may be involved in severe cardiac malformations. Surgical techniques of tricuspid valve repair has been developed for correction of organic tricuspid regurgitation which is resistant to medical therapy.

The normal values of different dimensions are based on echocardiography or angiography. The appropriate knowledge of morphometry of tricuspid valve is essential for the success of prosthetic implants.

Aim

The present study was performed to estimate the various dimensions of the right atrioventricular valve in Indian population which may be helpful for cardiothoracic surgeons and invasive cardiologists.

Objectives

1. To measure the circumference of tricuspid valve annulus
2. To measure the width and height of anterior leaflet
3. To measure the width and height of posterior leaflet
4. To measure the width and height of septal leaflet
5. To note the presence or absence of cleft in posterior leaflet, to count its number if present

Materials and Methods

Fifty four specimens of hearts from cadavers embalmed using 10% formalin were used in this study. The study consisted of meticulous dissection using standard dissection kit and measurement of

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various parameters.

The cadavers used in this study were the ones used by the medical students for dissection in a medical teaching institute and tertiary care hospital. Pericardial cavity was explored and the heart was removed from the cavity.

An incision was made along the right border of right atrium across the opening of superior and inferior venae cavae and the cavity of right atrium was opened and cleared off clots that exposed the right atrioventricular orifice and atrial surface of tricuspid leaflets.

Second incision was made parallel to and just to the right of anterior interventricular groove extending from the root of pulmonary trunk to the inferior border of the heart. Same incision was extended along the inferior border until it reached the junction between right and inferior borders of the heart.

The wall of right ventricle was reflected and cavity of right ventricle cleared off clots with particular care not to damage the chordae tendineae. That exposed the ventricular aspect of tricuspid valve, chordae tendineae and papillary muscles. The measurements were taken in situ with the help of a divider, non elastic thread and measuring scale.

The circumference of tricuspid valve annulus was measured with the help of non elastic thread and a measuring scale (Figure 1). The width of anterior leaflet was measured as distance between two points i.e. Point a and b. Point a was marked at the junction of anterior leaflet with anteroposterior commissure and point b was marked at the junction of anterior leaflet with anteroseptal commissure (Figure 2).

The width of the posterior leaflet was measured as distance between two points' c and d. Point c was marked at the junction of posterior leaflet with anteroposterior commissure and point d was marked at the junction of posterior leaflet with posteroseptal commissure.

The width of septal leaflet was measured as distance between two points e and f. The point e was marked at the junction of septal leaflet with anteroseptal commissure and point f was marked at the junction of septal leaflet with posteroseptal commissure.

The height of anterior, posterior and septal leaflet was measured from base to apex in the middle of leaflet (Figure 3).

Presence or absence of cleft in posterior leaflet was noted, when present its number noted (Figure 4).

All the data was recorded and was statistically analysed for the purpose of calculating the

- Range
- Mean
- Standard deviation

Mean was calculated by the following formula

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$

Fig. 1: Illustration showing measurement of the circumference of right atrioventricular valve annulus.
AL = Anterior Leaflet, PL = Posterior Leaflet, SL = Septal Leaflet, S = Superior, I = Inferior, A = Anterior, P = Posterior

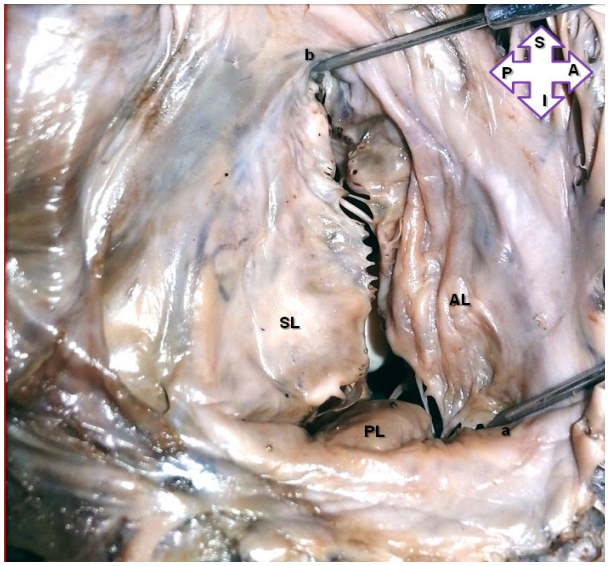

Fig. 2: Illustration showing measurement of the width of anterior leaflet of right atrioventricular valve. a = Junction of AL with anteroposterior commissure, b = Junction of AL with anteroseptal commissure
AL = Anterior Leaflet, PL = Posterior Leaflet, SL = Septal Leaflet, S = Superior, I = Inferior, A = Anterior, P = Posterior,

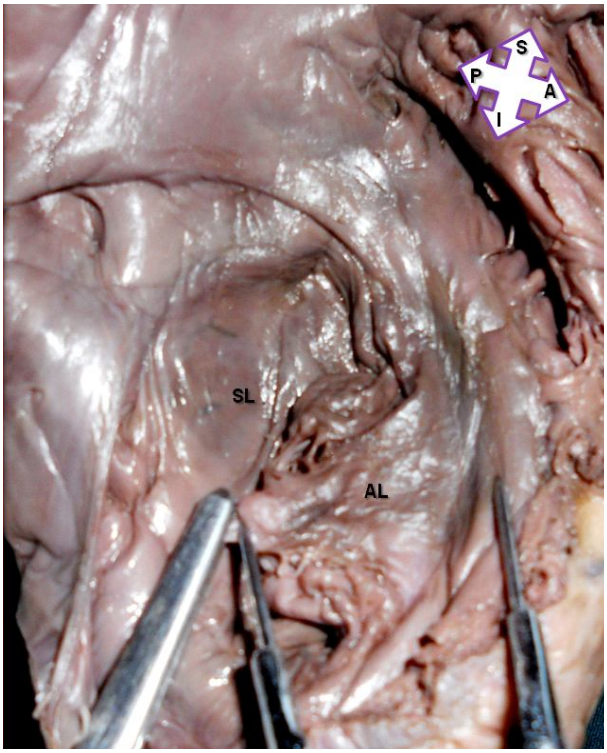

Fig. 3: Illustration showing measurement of the height of anterior leaflet of right atrioventricular valve.
AL = Anterior Leaflet, PL = Posterior Leaflet, SL = Septal Leaflet, S = Superior, I = Inferior, A = Anterior, P = Posterior,

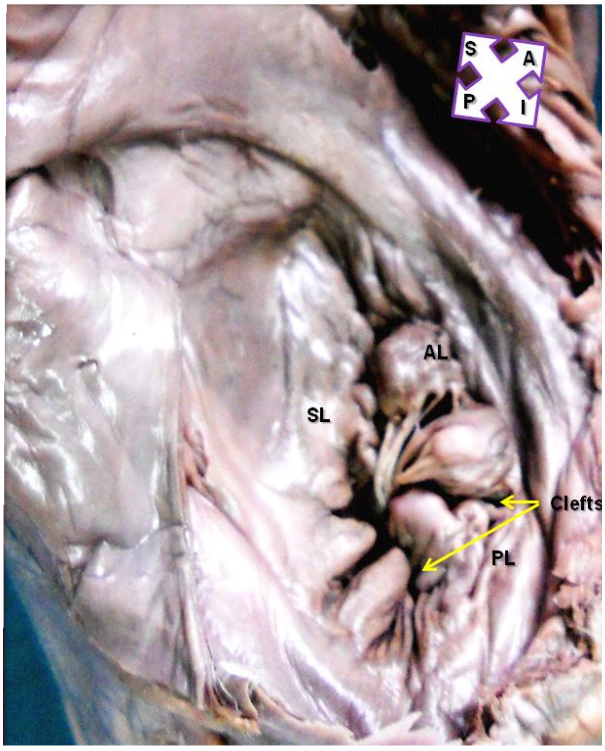

Fig. 4: Illustration showing clefts in the posterior leaflet of the right atrioventricular valve.
AL = Anterior Leaflet, PL = Posterior Leaflet, SL = Septal Leaflet, S = Superior, I = Inferior, A = Anterior, P = Posterior,

Table 1: Showing measurements of various parameters of tricuspid valve

Sr. No.	Parameter	Range (mm)	Mean (mm)	Standard Deviation
1	Circumference of right atrioventricular valve annulus	92 -140	117.1	10.2
2	Width of anterior leaflet	21-45	31.8	4.9
3	Width of posterior leaflet	20-35	27	3.8
4	Width of septal leaflet	16-38	25.2	4.4
5	Height of anterior leaflet	14-29	21.1	3.3
6	Height of posterior leaflet	11-24	16.6	3.4
7	Height of septal leaflet	8-29	16.7	4.8

Table 2: Showing comparison of various parameters of present study with previous studies.

Sr. No	Parameter	Mohammed AB Motabagani [1]	MD Silver et al [2]	Skwarek et al [3]	Skwarek et al [5]	R. Kalyani et al [8]	Fernando Antoniali et al [6]	Natalia Andrade et al [7]	Present study
1	Circumference of right atrioventricular valve annulus	M -129.6 F- 118.2	M -114 F –108	-	M-107.28 F-104.04	M-107.5 F -104	117.5	96.1	117.1
2	Width of anterior leaflet	M - 43.6 F- 30.8	M – 39 F – 35	-	M - 33.56 F - 31.17	M - 36.40 F - 36.4	46.3	44.2	31.8
3	Width of posterior leaflet	M – 29.2 F- 23.4	M – 19.2 F – 18.2	-	M -28.56 F – 27.61	M -25.81 F – 24.2	39.1	22.8	27
4	Width of septal leaflet	M – 33.2 F- 29	M -37 F -35	-	M -29.14 F – 29.5	M -30.12 F – 28	32	30	25.2

5	Height of anterior leaflet	M – 24.6 F- 20.2	M -24 F -21	23.88	-	-	-	-	21.1
6	Height of posterior leaflet	M – 25.2 F- 19.2	M – 17.8 F – 16.5	21.35	-	-	-	-	16.6
7	Height of septal leaflet	M – 15.8 F- 15.2	M -17 F -15	18.33	-	-	-	-	16.7

Table 3: Comparison of average number of clefts in posterior leaflet of the right atrioventricular valve with previous studies

Authors/study	Single cleft	Two cleft	Three cleft	Four cleft	Absent cleft
Mohammed AB Motabagani	80%	-	-	-	20%
Present study	43%	32.75%	8.62%	3.44%	12.06%

Results

Dimensions of various components of the right atrioventricular valve were studied in 54 heart specimens obtained from embalmed cadavers. The following observations were noted:

Table 1 showing results obtained

Discussion

The right atrioventricular (tricuspid) valve is a multi-component complex structure. Right atrioventricular valve although described as having three leaflets, review of literature suggests that the number of leaflets may vary or accessory leaflets may be found between the main leaflets [2]. Magdalena Skwarek et al performed a study on 75/ formalin-fixed adult human hearts, between 27 – 79 years of age and of both sex without any macroscopic pathological changes. They classified the right atrioventricular valve in five types depending upon the number of cusps(3 cusps-Type1, 4 cusps-Type2, 5 cusps-Type3, 6 cusps-Type4, 7 cusps-Type5) [3]. M. Skwarek et al studied the distribution of tendinous chords with respect to their position in the main and accessory leaflets, whether in the margin, ventricular surface or commissural area [4]. M. Skwarek et al performed a study on 96 formalin-fixed hearts and made the following measurements [5]:

1. The attachment length of anterior, posterior and septal leaflets
2. The frontal and sagittal dimensions of the tricuspid valve attachment
3. The right atrioventricular orifice area
4. The circumference of the tricuspid valve attachment orifice
5. The evolution of dimensions of the right atrioventricular orifice with ageing

Mohamed A.B. Motabagani performed comparative anatomical, morphometric and histological studies of the tricuspid valve complex in human and some mammalian hearts (ten hearts of each species). The author made the following measurements [1]:

1. The total annular length of the valve
2. The annular length of each leaflet
3. The height of each leaflet, being measured from the middle of its base at the annulus fibrosus to the middle of its free edge. When scallops were identified in a leaflet, the sum and mean of their heights were considered.
4. The annular length and height of each commissure
5. The length and number of different types of the chordae tendineae

The author observed that the anterior leaflet was the largest, triangular and devoid of clefts.

Fernando Antoniali et al performed a descriptive autopsy study on thirty human hearts without fixation Digital images of the tricuspid ring in its anatomical position and after flattening were analysed by specific software. The mean measurements and ratios were compared in the two different situations [6]. Natalia et al performed a study on digital photographs of 41 hearts obtained from autopsies performed in coroner's office. The photographs were processed using MATLAB software specially developed for the study which provided following measurements [7]:

1. Total perimeter of the annuli of the tricuspid and mitral valves
2. Area of each valvula and the total area that it occupied

3. Intercommissural distance of the heart valves
4. Circular area of the left ventricle at its midpoint
5. Size of the greatest axis of the left ventricle
6. Perimeter and area of the valvar lascinias
7. Volume of the left ventricle

R. Kalyani et al studied 100 formalin-fixed hearts obtained from patients who had died of non-vascular causes and whose age ranged from 8 to 85 years. The authors measured following dimensions [8]:

1. The attachment lengths of anterior, posterior and septal leaflets
2. The circumference of valve along with frontal and sagittal dimensions
3. Area of valve expressed as a triangle and as an eclipse

M. Skwarek et al performed a study on four cuspidal model of right atrioventricular valve on 107 formalin-fixed heart samples which were taken from adult humans. The authors used the four-cuspidal form of the tricuspid valve as the simplest model to show the appearance of accessory leaflets for anatomical and statistical examination. A group of 45 tricuspid valves, classified according to an earlier scheme as Type 2 was identified.

The authors identified subtypes of Type 2 on the basis of the location of the accessory leaflets as follow:

1. Subtype 2A: an accessory leaflet (Cac) between the posterior cusp (CP) and the septal cusp (CS) was found in a group of 24 hearts;
2. Subtype 2B: Cac between the anterior cusp (CA) and the CS, was found in a group of 10 hearts;
3. Subtype 2C: Cac the CA and the CP, a group of 11 hearts.

Afterwards, using a flexible millimetre ruler, the authors made following measurements:

1. The attachment length of the main leaflets: anterior, posterior and septal
2. The attachment length of the accessory leaflets in particular subtypes: 2A, 2B, and 2C
3. The length of the tricuspid attachment in particular walls of the right ventricle: anterior, posterior and septal.

The results obtained were statistically analysed by Pearson's analysis and one way analysis of variance (ANOVA; $p < 0.05$).

On the basis of the results of their study the authors concluded that the separation of accessory leaflets is a complex process [9].

Ashraf M. Anwar et al performed a study on assessment of normal tricuspid valve anatomy in 100 normal adults by real-time three-dimensional echocardiography. The following points were checked for visualization:

1. Tricuspid annulus diameter and area
2. Tricuspid valve leaflets (number, mobility, thickness and relation to each other)
3. Tricuspid valve area
4. Tricuspid valve commissures (anteroseptal, anteroposterior and posteroseptal) including the position of their closure line

All these structures were classified according to a subjective 4- point scale for image quality (1 = not visualised, 2 = inadequate, 3 = sufficient and 4 = good). The tricuspid annulus diameter and area could be measured in 63 patients (70%); normal values were 4.0 ± 0.7 cm and 10.0 ± 2.9 cm^2. Tricuspid valve area could be measured in 77 patients (86%) and mean was 4.8 ± 1.6cm^2.

Tricuspid valve commissural width could be obtained in 63 patients (70%) mean commissural width in these patients was 5.4 ± 1.5 mm for the anteroseptal commissure, 5.2 ± 1.5 mm for posteroseptal commissure and 5.1 ± 1.1 mm for anteroposterior commissure respectively [10].

C. Tei et al performed a two dimensional echocardiographic study on five normal hearts. The authors recorded valve leaflets and their annular attachments from a view of the right ventricular inflow tract obtained by placing the transducer at an intermediate position between the left ventricular apex and the left lower sternal border. The transducer was rotated, and recordings were made at 30 degrees rotational intervals around the circumference of the tricuspid valve annulus. The authors studied cyclical pattern of variations in tricuspid annular size using 12 measurements made during the cardiac cycle. The authors measured annular areas and circumferences, the maximum and minimum tricuspid annular sizes and their percent reduction in 16 normal subjects and 18 patients with tricuspid regurgitation. The authors observed that the mean maximum annular circumference and area were 11.9 ± 0.9 cm and 11.3 ± 1.8 cm^2 in normal subjects. They were significantly greater in tricuspid regurgitation (14.0 ± 0.7 cm and 15.8 ± 1.8 cm^2, respectively). The mean minimum annular sizes were much larger in tricuspid regurgitation (12.5 ± 0.6 cm and 13.0 ± 1.4 cm^2) than in normal subjects (9.6 ± 0.9 cm, 7.6 ± 1.4 cm^2). Thus, the percent reduction of annular circumference and area were significantly decreased in tricuspid regurgitation. For anatomic correlations, authors

measured the tricuspid annular circumference in 18 hearts without underlying valvular disease obtained from autopsy cases. The annular circumference was measured in the fresh and fixed states, which was 13.5 ± 0.8 cm in fresh state and 12.0 ± 0.8 cm fixed state. They observed that the values measured in the fixed hearts were more similar to measurements obtained by echocardiography in a group of normal subjects. They concluded that tricuspid annular reconstruction by the new two-dimensional echocardiographic method provides additional information about normal and abnormal size and function of the tricuspid valve annulus[11].

Gerola LR et al performed an anatomic study of the right atrioventricular valve in children under one year of age using a conservative method of dissection of the heart valve. The main aspects studied were the number of cusps and their morphometric characteristics, such as the width of the base and the depth of the cusps, the number of papillary muscles, number of tendinous cords, and diameter of the fibrous ring and the last one were divided in three regions, anterior, posterior and septal for localization of cusps. They observed that the number of cusps varied from two to four with three cusps as the commonest finding. The fourth cusp, if present, was classified as anterolateral in location. The anterior and septal cusps had bases bigger than those of the posterior and anterolateral cusps; the septal cusp was deeper than the others; and the number of tendinous cords was greater for the anterior and septal cusps than for the posterior and anterolateral cusps [12]. Inflammation induces angiogenesis in the valve and vascularisation in the normally avascular layers of valve [13].

Inflammation of a valve can cause the valve cusps to stick together. Later, fibrous thickening occurs followed by loss of flexibility and shrinkage producing either stenosis or insufficiency [14].

Ebstein anomaly is a congenital malformation of the heart that is characterized by apical displacement of the septal and posterior tricuspid valve leaflets, leading to atrialization of the right ventricle with a variable degree of malformation and displacement of the anterior leaflet [15].

Tricuspid valve annuloplasty performed with either mitral and/or aortic valve operations is accomplished either through a full or partial lower sternotomy approach or less invasive right mini thoracotomy exposure [16].

The treatment of functional insufficiency of the tricuspid valve by valvuloplasty is currently the most accepted technique. It is known that dilatation of the anterior and posterior segments correspond to 5/6 of the total dilatation of tricuspid annulus. Thus, treatment of the dilatation of these segments by annuloplasty restores most of the normal anatomy of the tricuspid valve ring because the septal segment is affected very little [6].

Accurate anatomical knowledge is of great clinical importance for diagnosing valvular lesions, surgical intervention and for development of novel operating techniques. Apart from this, it has potential application for studying functioning of tricuspid valve by echocardiography.

In clinical practice, the size of prosthesis to be inserted is usually determined by the size of native valve annulus. It demands accurate knowledge of annular dimensions.

Partial transfer of tricuspid valve to the mitral valve is an effective procedure for the treatment of mitral valve insufficiency secondary to ruptured chordae tendineae of the anterior leaflet.

The treatment of functional insufficiency of the tricuspid valve by the valvuloplasty is currently the most accepted technique. Tricuspid valve disease is frequently associated with diseases of mitral valve, therefore these two valves are repaired simultaneously using de vega technique or in the case of stenosis, balloon valvuloplasty.

Conclusion

This study will help cardiac surgeons to use the morphometric data while doing surgeries on the right atrioventricular valve.

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