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Tricuspid Valve Morphometry: A New Learning from Cadavers

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Abstract

One hundred cadaveric human hearts were studied by dissection method for the correlation among various morphometric parameters of the heart and tricuspid valve. From the total hearts only 86 hearts were studied and 14 hearts have been excluded because of the one or the other anatomical variation in the structure of leaflets. The parameters studied were weight of heart (g), circumference of tricuspid valve (mm), attachment length of leaflets and commissures (mm), and height of the three leaflets (mm). A strong and direct correlation was observed between the circumference of tricuspid valve with the weight of heart, attachment length of leaflets and the three commissures and height of leaflets. Thus the present study tried to provide the normal data on morphometric parameters of heart and tricuspid valve which will help the cardiac surgeons and forensic experts. Possibly, it can also be used as an important tool in the anthropological studies, for better understanding of surgical anatomy of heart and designing of tissue-engineered cardiac valves.

Keywords: Tricuspid valve; Human heart; Leaflet attachment length

Introduction

The right atrioventricular valve is the largest of all the heart valve orifices. From a functional standpoint the term 'atrioventricular valve apparatus/complex' is more apt [1]. Tricuspid valve diseases can be either congenital or acquired and common in persons with pulmonary hypertension and in i.v. drug abusers. Ebstein's anomaly is the commonest anomaly of the tricuspid valve [2]. The trans-catheter therapies for mitral regurgitation are in common use, but in rare cases parallel percutaneous approaches for tricuspid regurgitation may be needed [3]. Accordingly, the accurate knowledge of the morphology and morphometry of the tricuspid valve is of importance for differentiating between functional and organic tricuspid diseases. The tricuspid valve does not lie in a single plane. Its position and structural complexity adds to the challenges in its assessment by radiological techniques in living human beings [4,5]. The task of cardio-surgeons is to regain the original mechanics of the valvular complex in order to maintain the natural circulation after repair of the diseased valve. With the rapid progress in the field of interventional cardiology and new valvuloplasty methods, study of morphometric measures of tricuspid valve complex on cadavers is the crucial need of time.

Material and Methods

The present study was conducted on 100 adult human hearts; age ranging from 20 to 65 years, during medico-legal postmortem examination which had been performed within eighteen hours of death, as the morphology and morphometry of the heart is not altered because of decomposition or putrefaction by that time [6]. The hearts which were injured before or during autopsy, having evidence of any disease, burnt or decomposed were not included in the study. From the total hearts only 86 hearts were studied and 14 hearts have been excluded because of the one or the other anatomical variation in the structure of leaflets. In the 14 excluded hearts, there was presence of accessory leaflets and scallops in tricuspid valve. After studying the desired parameters, the hearts were placed back in the dead body.

Steps of Dissection of Heart

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 inter-ventricular 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. The tricuspid valve was then opened by cutting through the annulus at the junction of anterior and posterior leaflet. Then again the heart was thoroughly washed. Excessive water was soaked with a clean cotton cloth.

Morphometric Parameters Measured Were

1. Weight of heart.
2. Circumference of tricuspid valve.
3. Attachment length of leaflets.

a) Anterior Leaflet

b) Septal Leaflet

c) Posterior Leaflet

4. Attachment length of commissures: Commissures are defined as junctional tissue present in the deep indentations between the leaflets of the valve.

a) Anteroseptal Commissure: It extends between anterior leaflet and septal leaflet.

b) Septoposterior Commissure: It extends between septal leaflet and posterior.

c) Posteroanterior Commissure: It extends between posterior leaflet and anterior leaflet.

5. Height of leaflets: Defined as the Maximum vertical distance between the free edge of the leaflet and its attachment to the annulus.

a) Anterior Leaflet

b) Septal Leaflet

c) Posterior Leaflet

Then weight of heart was recorded by using Electronic Weighing Balance of "SARTORIUS-AZ3102 M-Power Series" with minimal sensitivity of 0.1g. The number of cusps of tricuspid valve and their position was noted. The lengths of above said parameters were measured by using non-stretchable surgical silk thread (Figure1). That was subsequently straightened and the length was measured by the metric ruler with least readability of 0.5 mm. As per Rusted et al. this measurement technique has a measurement error of no more than 0.2-0.3 mm [7]. Each reading was taken thrice, by the same investigator and the mean of all the three was taken to rule out any inadvertent error. The results were computed and statistically analyzed with SPSS Software 16. Pearson's Correlation Coefficient was calculated to study the correlation between the parameters. P-value was calculated and analyzed [8] as: >0.05- Statistically Insignificant, <0.05- Statistically Significant, <0.01- Statistically Highly Significant, <0.001- Statistically Extremely Significant.

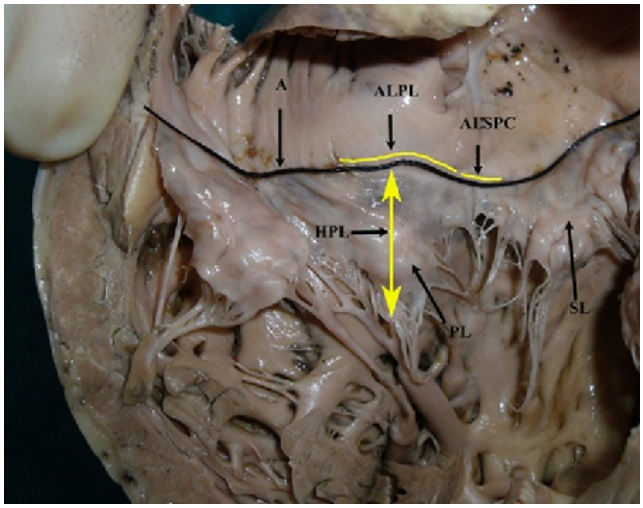

Figure 1: Showing the method of measurements of circumference and attachment length of tricuspid valve leaflets with surgical silk thread (A), Septal Leaflet (SL), Posterior Leaflet (PL), Attachment Length of Posterior Leaflet (ALPL), Height of Posterior Leaflet (HPL), Septo-posterior Commissure (SPC), Attachment Length of Septo-posterior Commissure (ALSPC).

Observations and Results

It is observed that amongst the three leaflets, the septal leaflet was found to be the largest. Its average attachment length was 28.74 mm. The septoposterior commissure was the largest commissure with the average attachment length of 8 mm. The Anterior leaflet bears the maximum height measuring 19.22 mm when compared with the other leaflets (Table 1). It was also found that a statistically high significant correlation exists between the weight of heart and the circumference of tricuspid valve; as well as between the attachment length of leaflets and commissures with the circumference of tricuspid valve. The anterior leaflet was the only exception in that. When the correlation between the height of leaflets and the circumference of tricuspid valve was calculated, statistically significant correlation was again observed in anterior and posterior leaflet with the exception of septal leaflet (Table 2). Results of correlation between height of leaflets and the attachment length of corresponding leaflets were statistically insignificant.

Sr. No.	Morphometric parameters	Present study
1	Average Weight (gm)	258.39 ± 32.20
2	Circumference (mm)	94.96 ± 10.59
3	Ratio C/Wt	0.367 ± 0.03
4	Average Attachment length (mm)	
a)	Anterior Leaflet	27.28 ± 5.43
b)	Septal Leaflet	28.74 ± 4.89
c)	Posterior Leaflet	22.02 ± 4.35
d)	ASC	5.20 ± 3.11
e)	SPC	8 ± 4.02
f)	PAC	4.14 ± 4.02
g)	Average (ASC+SPC+PAC)	7.1 ± 3.8

Table 1: Showing morphometric parameters of heart and tricuspid valve.

Discussion

The problem of morphology of the atrioventricular ostia 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 cusps (leaflets), Anterior, Septal and Posterior [1]. The structure and function of heart was studied in situ only by dissection and by noninvasive imaging techniques like echocardiography, tomography [9-13]. The standard text books [1] and dissection manuals [14] of anatomy give only the average of morphometric parameters of heart and valve measurements. Tricuspid valve has a complex three-dimensional structure which differs from the saddle shaped mitral valve annulus. This distinct shape of tricuspid valve has clinical implications of the designing and application of currently available annuloplasty rings [15].

The results of present study have been compared with previous studies in Table 3. The average weight of heart in the present study (mean value 258.39 ± 32.2) is lower than as reported by Antoniali [9]. It is observed that the mean circumference of tricuspid valve of heart as 94.96 mm and was lower than the values reported by Skwarek et al. [12] and Antoniali [9], probably due to racial differences in BMI and stature.

Sr. No.	Correlation Parameters	Pearson's Correlation Coefficient	P- value	Statistical Significance
1	Weight of Heart and Circumference of Tricuspid Valve(C)	0.638	<0.001	Extremely Significant
2	Attachment Length of Leaflet and Circumference of Tricuspid Valve(C)			
a)	Anterior Leaflet	0.1763	>0.05	Insignificant
b)	Septal Leaflet	0.5095	<0.001	Extremely Significant
c)	Posterior Leaflet	0.457	<0.001	Extremely Significant
3	Attachment Length of Commissure and Circumference of Tricuspid Valve(C)			
a)	ASC	0.438	<0.01	Highly Significant
b)	SPC	0.512	<0.001	Extremely Significant
c)	PAC	0.370	<0.01	Highly Significant
4	Height of Leaflet and Circumference of tricuspid Valve(C)			
a)	Anterior Leaflet	0.331	<0.05	Significant
b)	Septal Leaflet	-0.037	>0.05	Insignificant
c)	Posterior Leaflet	0.508	<0.001	Extremely Significant

Table 2: Showing Pearson's correlation coefficient between various parameters and their p-value with significance.

The mean ratio of circumference to weight of heart was 0.37 and it was slightly higher than the value reported by Antoniali (0.303) [9] but both of them showed a high degree of correlation. The average attachment length of all leaflets in our study was lower than the values reported by Skwarek et al. [12] and Motabagani [11] respectively. The difference could be due to different morphometric method followed as we have measured the commissures separately while the Skwarek et al. [12] and Motabagani [11] have not done the same. Average attachment length of anteroseptal, septoposterior, posteroanterior commissure was 5.20 mm, 8 mm, 4.14 mm respectively which were higher than those reported by Anwar et al. [4,5] for septoposterior commissure but lower for the posteroanterior commissure. Results are comparable but disparity may be due to radiological measurement done by Anwar et al. while we studied cadaveric hearts by manual dissection. The mean height of all leaflets was considerably lower than the value reported by Skwarek et al. [13] indicating that the size of the tricuspid valve among Indians is comparatively smaller than the reported data (Table 3).

Sr. No.	Morphometric parameters	Present study	Motabagani	Skwarek et al.	Antoniali	Anwar et al.
1	Average Weight (g)	258.39 ± 32.20			355.55 ± 65.30	
2	Circumference(mm)	94.96 ± 10.59		105.67 ± 16.76	105 ± 12.7	
3	Ratio C/Wt	0.367 ± 0.03			0.303 ± 0.05	
4	Average Attachment length (mm)					
a)	Anterior Leaflet	27.28 ± 5.43	43.60 ± 3.40	31.98 ± 8.74		
b)	Septal Leaflet	28.74 ± 4.89	33.20 ± 3.30	32.16 ± 8.79	30.6 ± 3.7	
c)	Posterior Leaflet	22.02 ± 4.35	29.20 ± 2.80	24.10 ± 9.08		
d)	ASC	5.20 ± 3.11				5.4 ± 1.5
e)	SPC	8 ± 4.02				5.2 ± 1.5
f)	PAC	4.14 ± 4.02				5.1 ± 1.1
g)	Average (ASC+SPC+PAC)	7.1 ± 3.8		6.42 ± 2.23		
5	Height of leaflet (mm)					

a)	Anterior Leaflet	19.22 ± 2.42		23.88 ± 0.85		
b)	Septal Leaflet	15.30 ± 2.99		18.33 ± 0.98		
c)	Posterior Leaflet	16.22 ± 2.88		21.35 ± 0.90		

Table 3: Comparison of morphometric data of tricuspid valve of heart from present study and some previous studies.

Sairanen and Louhimo [16] and Anwar et al. [5] have reported that tricuspid annular diameter and dimensions of the valve orifice closely correlated with age, body weight, and height and body surface area but did not find the correlation among the parameters of heart. However, we observed a statistically high significant correlation of the weight of heart, the attachment length of leaflets and the height of leaflets with the circumference of tricuspid valve except attachment length of the anterior leaflet and the height of posterior leaflet.

Conclusion

Our analysis of morphometric parameters of tricuspid valve and correlation among various parameters will try to help in better understanding of the anatomy of the tricuspid valve complex and appropriate designing of valvular complex for transplantation. Thus, this study may turn out to be a potential source of database to fulfill the deficiency in the basic data on morphometric parameters of tricuspid valve. However, it is pertinent to say that these findings are to be extended in individuals with valvular disease and need to be replicated in large population by other investigators in India. Further, Correlation with weight and Body Surface area and BMI needs to be studied along with other studied parameters and also include the investigations regarding disease states of pulmonary hypertension, diastolic heart failure, mitral valve disease, pacemaker mediated tricuspid regurgitation. Our hope has been to bridge the gap between the surgical and anatomical understanding of morphology of tricuspid valve.

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