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Original Article

MORPHOMETRY OF TRICUSPID VALVE IN HUMAN FOETAL CADAVERS

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ABSTRACT

Introduction: Anatomy of tricuspid valve complex is highly sophisticated and is altered by various disease states. Anatomic and morphological studies on the tricuspid valve are comparatively less in adults and there were no studies on foetal tricuspid valve. Hence the present study was under taken.

Materials and methods: Parameters of the tricuspid valve of heart were defined and measured individually by using paquimeter. The morphometric parameters of basal width and depth of three cusps, attachment lengths of leaflets, frontal and sagittal dimensions of atrioventricular orifice and atrial circumference of valve attachment were recorded.

Results: All the parameters of tricuspid valve increased with gestational age and were statistically significant in males. The widths of all the three cusps were greater in male. The frontal and sagittal dimensions and tricuspid valve circumference were higher in female foetuses when compared to male foetuses. Tricuspid valve area is expressed as triangle only. Gestational age is negatively correlating with depth of posterior cusp while other parameters correlated positively as a whole as and in less than 30 weeks age group. In more than 30 weeks age group age has negative correlation with depth of anterior and posterior cusps; tricuspid valve circumference is negatively correlating with frontal and sagittal dimensions; frontal and sagittal dimensions positively correlated with age and tricuspid circumference.

Conclusion: Understanding tricuspid valve morphology and morphometry has great clinical importance in the practice of cardiac surgery, especially in partial transfer of leaflets of tricuspid valve for mitral valve repairs and in severe cardiac malformations. The present study forms a database for right atrioventricular orifice dimensions in human fetuses of different gestational ages.

KEY WORDS: Morphology, morphometry, tricuspid valve.

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INTRODUCTION

Though there are greatest advances in the diagnosis and treatment of valvular diseases of heart knowledge on tricuspid valve is lacking. Published works on normal anatomical dimensions of adult tricuspid valve are very limited [1]. There is only one report on measurements of right atrioventricular orifice in children and no reports on foetal tricuspid valve complex.

Normal data on morphological and morphomet-

ric parameters of tricuspid valve is of great clinical importance for performing cardiac surgical procedures and for the development of novel operating techniques. A range of measurements for the right atrioventricular orifice were reported in adults and children [1, 2] based on anatomical dissection, inspection, examination and statistical analysis.This is the only reported work on right atrioventricular orifice morphometry.

Skwarek et.al. [1] studied the tricuspid valve and classified it into different types and subtypes depending on the number of leaflets. Based on this classification of tricuspid valve reported in literature in adult hearts the present study on foetal hearts was conducted as there were no studies on foetal tricuspid valve in in literature.

MATERIALS AND METHODS

A total of 40 dead and spontaneously aborted fetuses of 16wks -4full term of gestational age and both sexes were utilized for the present study. For observations on morphological and morphometric parameters of tricuspid valve the specimens were assigned to Group I (17-30wks) and Group II (31wks -full term) according to their gestational ages.

After opening the thoracic cavity the heart was removed. Using scissors, the initial cut was made from the inferior vena cava to the right atrial appendage and the tricuspid valve was exposed [3]. A deep cut 2 cm to the left of anterior interventricular groove which is parallel to the left of interventricular septum was taken for measurement of atrioventricular parameters(Fig.1).

The following morphometric parameters of tricuspid valves were measured using Paquimeter following the method of Skwarek et.al.,[4].

1. Basal Width of the cusps: The greatest distance between the commissures (Fig.2).

2. Depth of the cusps: The greatest distance between the fibrous ring and the free edge of the cusps (Fig.3). Depth of the cusps was considered as the greatest distance between the fibrous ring and the free edge of the cusps.

For the localization of the cusps, the atrioventricular fibrous ring was divided in to three regions for tricuspid valve.

A. Anterior region: Distance between the anterior and septal commissures and the projection of the right margin in the fibrous ring.

B. Posterior region: Distance of the last points from the interventricular septum.

C. Septal region: Related totally to the inter ventricular septum.

3. Attachment length of anterior, posterior and septal leaflets of Tricuspid valve.

4. Frontal dimension: 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 right margin (Fig. 4).

5. Sagittal dimension: Measured perpendicular to the frontal dimension at the midpoint of its length (Fig. 4).

6. Atrial circumference of the tricuspid valve attachment (Fig.5).

Fig. 1: Measurement of atrioventricular orifice.

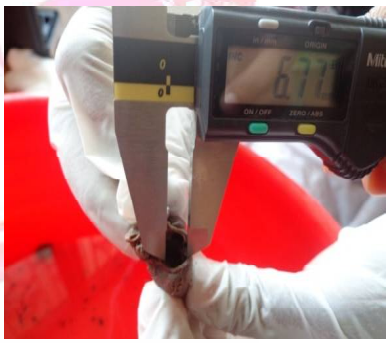


Fig. 2: Measurement of width of cusp.

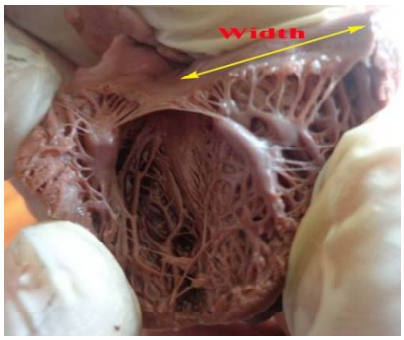


Fig. 3: Measurement of depth of cusp.

Fig. 4: Measurement of anterior and septal cusp in tricuspid valve.

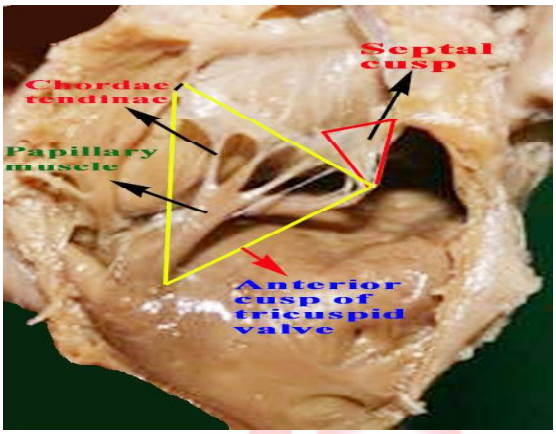
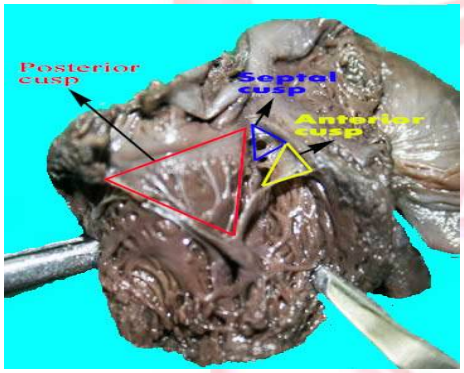


Fig. 5: Figure showing anterior, posterior and septal cusps in tricuspid valve.



On the basis of above measurements geometric figures of triangle and an ellipse were constructed to determine the shape of atrioventricular orifice. The triangle was marked using dimensions 2-4 and an ellipse using dimensions 5 and 6 stated above to determine the shape of the tricuspid valve.

The areas of these geometric figures were calculated according to the formulae

· For the triangle: 1/2 ×base × height

· For the ellipse: 3.14×a×b.

The data was analyzed with Med Calc R Version 12.2. All results are shown as Mean ± Standard Deviation. Comparison of continuous variables in distances of cusps of both valves was performed by Analysis of Variance (ANOVA) and Kruskals Wallis Test and significant differences were specified. Width and the depth of the corresponding cusps were compared by paired *t* test. Pearson's correlation coefficient and simple regression were used to analyze the relationship between the Mean distance and the Annular diameter

RESULTS

In the present study a total of 40 heart specimens of both sexes were categorized into two gestational age groups for observing morphology and morphometry of tricuspid valve (Table.1)

Table 1: Sex and Gestational age - wise distribution of specimens.

GESTATIONAL AGE	MALE	FEMALE	TOTAL
GROUP I (17-30 wks)	15	16	31 (77.5%)
GROUP II (31wks - full term)	6	3	9 (22.5%)
TOTAL	21 (52.5%)	19 (47.5%)	40

On gross examination the tricuspid orifice was triangular bounded by free margins of leaflets, chordae tendinae and papillary muscles. It presented three cusps and the number of chordae tendinae and papillary muscles were normal in all the specimen.

In the present study width and depth of cusps along with frontal and sagittal dimensions of atrioventricular orifice of fetal heart at different gestational ages were recorded in millimetres using paquimeter and the atrioventricular tricuspid valve circumference is calculated by formula as mentioned in materials and methods. Correlation coefficients between fetal Tricuspid valve parameters were analyzed.

Morphometric parameters of Tricuspid valve:

The mean± SD values of width of anterior cusp (4.65±1.04) is > posterior cusp (3.66±1.23) > septal (2.92±0.61) cusp. The mean± SD values of depth of posterior cusp (3.66±1.23) > anterior cusp (3.43±0.99) > septal (2.44±0.54) cusp. The width and depth of cusps, frontal and sagittal dimensions in the two different gestational age groups and sexes reveals (Table.2) that width of all the three cusps, frontal and sagittal dimensions and circumference of tricuspid valve increased with increase in gestational age. The widths of all the three cusps in both group I and II were greater in male foetuses when compared to female foetuses. Whereas the frontal and sagittal dimensions and tricuspid valve circumference were higher in female foetuses when compared to male foetuses in both gestational age groups(Table.2)

Table 2: Morphometric Parameters Of Tricuspid Valve In Mm In Male And Female Foetuses.

Measurements (mm)	Sex	Age Group				p-values
		I (17-30)		II (31-43)		
		MEAN	SD	MEAN	SD	
Width of anterior cusp (WA)	M	4.65	1.04	5.72	1.08	0.05*
	F	4.35	0.95	5.34	1.07	0.12
Width of septal cusp (WS)	M	2.92	0.61	3.81	0.21	0.00**
	F	2.93	0.46	3.21	0.86	0.41
Width of posterior cusp (WP)	M	3.85	1.25	5.07	0.71	0.04*
	F	3.46	0.71	3.93	1.77	0.42
Sagittal	M	6.17	2.41	9.53	1.04	0.00**
	F	6.29	2.09	10	3.17	0.02*
Frontal	M	4.79	1.94	8.21	2.27	0.00**
	F	5.19	1.9	9.92	3.93	0.00**
AV tricuspid valve circumference (dimensions)	M	16.77	11.75	39.72	13.37	0.00**
	F	18.01	12.83	55.6	30.04	0.00**

SD: standard deviation;
M: male; F: female;
AV: atrioventricular.

The p values for different dimensions of width of three cusps individually and frontal, sagittal and atrioventricular valve circumference of tricuspid valve in male and female fetuses (table.2) reveals that there was a significant increase in width of septal cusp (p=0.00), anterior cusp (0.05) and posterior cusp (p=0.04) in male foetuses and this increase was statistically significant. Sagittal, frontal and AV tricuspid valve circumference dimension are increased significantly in both male and female foetuses and this increase was statistically significant.

The mean and SD values for depth of three cusps showed significant increase from group I to group II but they were not statistically significant (Table.3).

Measurements (mm)	Sex	Age group				
		I (17-30)		II (31-43)		
		Mean	SD	Mean	SD	p-values
Depth of anterior cusp (DA)	M	3.43	0.99	4.2	0.45	0.09
	F	3.09	0.71	3.75	0.58	0.15
Depth of septal cusp (DS)	M	2.44	0.54	2.8	0.36	0.15
	F	2.17	0.43	2.53	0.59	0.23
Depth of posterior cusp (DP)	M	3.66	1.23	4.1	0.91	0.45
	F	3.4	0.66	3.5	1.06	0.84

Table: 3: Mean and SD values of depth of anterior, septal and posterior cusps of tricuspid valve with age wise and sex wise distribution in group I and group II.

Correlation coefficients for fetal tricuspid valve parameters in group I (Table.4) presented a negative correlation of age to depth of posterior cusp. Remaining all parameters were positively correlated with each other. p values shows that depth of anterior,posterior, septal cusps of tricuspid valve has increased significantly but was not statistically significant.

Correlation coefficients of foetal tricuspid valve parameters in group II (table.5) reveals that

i. Age is negatively correlated to depth of anterior cusp and posterior cusp.

ii. Circumference is negatively correlated to depths of all cusps

iii. Depth of posterior cusps is negatively correlated to frontal and sagittal dimensions

iv Frontal and sagittal dimensions are positively correlated to age and AV tricuspid valve circumference.

Table 4: Correlation coefficient of fetal tricuspid valve parameters in Group 1.

		AGE	AV tv Circumference	DA	DP	DS	Frontal	Sagittal	WA	WP	WS
AGE	*r		0.338	0.251	-0.236	0.023	0.355	0.363	0.445	-0.353	0.239
	P		0.0625	0.1732	0.2009	0.9019	0.0498	0.0449	0.012	0.0514	0.1952
AV tv Circumferen	*r	0.338		0.507	0.348	0.493	0.955**	0.972**	0.760**	0.278	0.48
	P	0.0625		0.0036	0.0549	0.0049	<0.0001	<0.0001	<0.0001	0.13	0.0063
DA	*r	0.251	0.507*		0.247	0.075	0.488	0.499*	0.329	0.226	0.486
	P	0.1732	0.0036		0.18	0.6872	0.0053	0.0042	0.0704	0.2206	0.0055
DP	*r	-0.236	0.348	0.247		0.516	0.338	0.372	0.289	0.944	0.178
	P	0.2009	0.0549	0.18		0.0029	0.0631	0.0395	0.1145	<0.0001	0.3372
DS	*r	0.023	0.493	0.075	0.516		0.44	0.515	0.540*	0.456	0.447
	P	0.9019	0.0049	0.6872	0.0029		0.0132	0.003	0.0017	0.0099	0.0117
Frontal	*r	0.355	0.955**	0.488	0.338	0.44		0.904**	0.695**	0.287	0.418
	P	0.0498	<0.0001	0.0053	0.0631	0.0132		<0.0001	<0.0001	0.1181	0.0193
Sagittal	*r	0.363	0.972**	0.499*	0.372	0.515*	0.904**		0.729**	0.275	0.455
	P	0.0449	<0.0001	0.0042	0.0395	0.003	<0.0001		<0.0001	0.1348	0.01
WA	*r	0.445	0.760**	0.329	0.289	0.540*	0.695**	0.729**		0.233	0.474
	P	0.012	<0.0001	0.0704	0.1145	0.0017	<0.0001	<0.0001		0.2067	0.0071
WP	*r	-0.353	0.278	0.226	0.944	0.456	0.287	0.275	0.233		0.16
	P	0.0514	0.13	0.2206	<0.0001	0.0099	0.1181	0.1348	0.2067		0.3885
WS	*r	0.239	0.48	0.486*	0.178	0.447	0.418	0.455	0.474	0.16	
	P	0.1952	0.0063	0.0055	0.3372	0.0117	0.0193	0.01	0.0071	0.3885	

r: Pearson's correlation coefficient; P: p-value.**0.01Correlation Coefficient at Significance Level *0.05 Correlation Coefficient at Significance Level

Table 5: **Coefficient of fetal tricuspid valve parameters in Group II.**

		AGE	AV tv-circumfere	DA	DP	DS	Frontal	Sagittal	WA	WP	WS
AGE	*r		0.242	-0.338	-0.634	0.138	0.22	0.297	0.135	0.372	0.24
	P		0.53	0.3734	0.0665	0.7231	0.5689	0.4375	0.7285	0.3249	0.5339
AV tv-circumfere	*r	0.242		-0.751	-0.726	-0.875	0.937*	0.915	0.078	-0.554	-0.642
	P	0.53		0.0197	0.0267	0.002	0.0002	0.0006	0.8411	0.1216	0.0622
DA	*r	-0.338	-0.751		0.928*	0.461	-0.805	-0.504	0.485	0.58	0.333
	P	0.3734	0.0197		0.0003	0.2111	0.0088	0.1669	0.1853	0.1019	0.3807
DP	*r	-0.634	-0.726	0.928*		0.342	-0.722	-0.578	0.264	0.392	0.262
	P	0.0665	0.0267	0.0003		0.367	0.0281	0.103	0.492	0.2969	0.4951
DS	*r	0.138	-0.875	0.461	0.342		-0.801	-0.821	-0.214	0.513	0.756
	P	0.7231	0.002	0.2111	0.367		0.0094	0.0067	0.5799	0.1575	0.0183
Frontal	*r	0.22	0.937*	-0.805	-0.722	-0.801		0.734	-0.201	-0.516	-0.408
	P	0.5689	0.0002	0.0088	0.0281	0.0094		0.0242	0.6032	0.155	0.2751
Sagittal	*r	0.297	0.915	-0.504	-0.578	-0.821	0.734		0.435	-0.434	-0.7
	P	0.4375	0.0006	0.1669	0.103	0.0067	0.0242		0.2415	0.2436	0.0358
WA	*r	0.135	0.078	0.485	0.264	-0.214	-0.201	0.435		0.317	-0.4
	P	0.7285	0.8411	0.1853	0.492	0.5799	0.6032	0.2415		0.4059	0.2867
WP	*r	0.372	-0.554	0.58	0.392	0.513	-0.516	-0.434	0.317		0.522
	P	0.3249	0.1216	0.1019	0.2969	0.1575	0.155	0.2436	0.4059		0.1498
WS	*r	0.24	-0.642	0.333	0.262	0.756	-0.408	-0.7	-0.4	0.522	
	P	0.5339	0.0622	0.3807	0.4951	0.0183	0.2751	0.0358	0.2867	0.1498	

r: Pearson's correlation coefficient; P: p-value. **0.01:Correlation Coefficient at Significance Level *0.05 Correlation Coefficient at Significance Level

Kruskal-Wallis test and one-way analysis of variance (ANOVA) was conducted to find out whether samples originate from the same distribution or not. The test was done for all parameters, for total sample and also group wise. The Kruskal-Wallis test is significant for similar distribution of samples in both the groups and in the total sample. The Kruskal-Wallis values are not statistically significant.

DISCUSSION

In the literature no study was reported on the tricuspid valve morphology and morphometry in developing fetuses. Those that were reported were either in children [2] or in adults [1.4]. Silver et.al., [5] made a comparative study in different species including human beings. Motabagani [6] studied on morphometric parameters of tricuspid valve in adult hearts. Those studies that reported on morphometric parameters of adult hearts were on shape of right A-V orifice using a special formula by Skwarek et.al., [1] which was followed later by Gunnal et.al.,[7] on left A-V orifice. Hence only morphological parameters of the present study could be compared.

In our study the right atrioventricular valve in fetus was formed by three cusps. The right atrioventricular valve is described with three cusps anterior, posterior and septal. Jatene et.al., [8] studying 101 adult human hearts, found three cusps in 73%,two in 26% and four in 1%.They related this variation in percentage incidence to ethnic variation. In the present study all the samples presented three cusps only for right atrioventricular orifice. The observations in the present study could be interpreted as the pattern in the south Indian population as no other reports were available.

Other parameters studied were the number of papillary muscles, number of tendineous cords. The observations on tendineous cords were divided in to three regions, anterior, posterior and septal for localization of cusps. Present study is in agreement with that of Gerola et.al., (2001)[2].

Skwarek et al.,[4] reported the tricuspid valve area expressed as a triangle and as an ellipse that increases with age. In our study tricuspid valve area is expressed as triangle only with no incidence of ellipse. Singh et al.,[9] found that in healthy Indian subjects aged from 2months to 50 years the tricuspid valve orifice area reaching a value of 4.07 ± 1.5 cm^2 and ranging from 0.62 to 7.2 cm^2 .In our study on 40 subjects aged from17 wks to full term gestational age the tricuspid orifice reached a value of 5.561.34 cm^2. The present study cannot be compared with the study of Singh et.al.,[9] due to the difference in age groups. No other study was available on the fetal heart in literature for comparison.

Skwarek et.al.,[10] observed the attachment length of the anterior leaflet increasing with age both in men and women and was statistically significant. The attachment length of the septal leaflet was stable in men and women. The observation in the present study on all the fetal heart morphometric parameter are in agreement to that of Skwarek et.al.,[10]as they were increasing with age and statistically significant.

The mean values of morphometric parameters observed in the present study when compared with those in the literature are closer to the values of Kalyani et.al., [11] who reported in Indian children but not fetuses. The individual parameters when compared with those of Kalyani et.al., [11] by gestational age wise showed difference though they are positively correlated when correlation coefficient was compared.

Motabagani et.al [6] conducted comparative study of same parameters as in the present study. i.e., morphometric assessment of the different elements of Tricuspid-valve complex in camel, sheep, monkey and man .They reported that human and animal tricuspid leaflets were similar in structure and they compared the similarities and dissimilarities between human tricuspid valves and some mammals.

The frontal and sagittal dimensions of the tricuspid valve increased both in male and female fetuses with age which corresponds to data of Skwarek et.al., [4] in adults.

CONCLUSION

Present study indicated that tricuspid annular diameter and dimension of the valve orifice positively correlated with age, depth of all three cusps and width of anterior and posterior cusps

in both groups.Tricuspid morphology gained importance as there is increase in the incidence of cardiac surgeries for the treatment of congenital heart diseases and most of these operations being undertaken through the right atrium. As there were no reported studies on foetal tricuspid valve parameters this will form a base line data on gestational age related normal tricuspid valve complex in Indian foetal population.

Conflicts of Interests: None

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