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Original research article

Morphometric Study and Clinical Significance of Tricuspid Valve Complex in Heart of Human Cadavers

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Abstract

Background: Tricuspid valve or right atrio-ventricular valve is present in human heart between right atrium and ventricles. It prevents back flow of blood from ventricle to atrium duringsystole. The Tricuspid valve is more complex than the mitral valve, because of its high variability. Traditionally it is described as containing three leaflets (anterior, posteriorand septal), the chordae tendinae, two discrete papillary muscles and the fibrous Tricuspid annulus. Gross morphology of Tricuspid valve complex is more important parameter to know during surgical intervention of valve complex. Errors during valve surgeries commonly result in failure of valvular graft, valve prolapse and improper correction**.**

Methodology: The study was taken on 96 adult human heart specimens, collected from the Department of Anatomy and Forensic Medicine, at Patna medical college and Hospital Patna. Study duration of three years. The specimens obtained were fixed in 10%formalin and were finely dissected.

Conclusion: The present study adds up to the existing knowledge regarding anatomy and variations in Tricuspid valve complex. Knowledge regarding the normal anatomy and variations of the Tricuspid valve complex is highly esteemed and it is considered a prerequisite for the entire clinical workflow including diagnosis, therapy-planning, surgery, or percutaneous interventions as well as patient monitoring and follow-up.

Keywords: Tricuspid valve complex; papillary muscles; chordae tendinae; fibrousannulus; rough zone chordae; free edge chordae; fan shaped chordae; deep chordate.

Introduction

An accurate knowledge of morphology of the cardiac valves in human heart is of prime importance for at least three very practical reasons. First is thatthe various anatomical peculiarities in the valve leaflets suggest an explanation forat least some of the mechanical components entering into the localization of inflammatory, as well as degenerative processes in these sites. Secondly, the insight into pathological processes thus obtained helps one to

differentiate these lesions from one another. Thirdly, one is better able to cope with long disputed question as to whether blood vessels of myocardium normally exist in valves.[1]The heart valves are an essential anatomical structure regulating the hemodynamics and the blood flow between the heart and human body.[2] The knowledge of normal anatomy of cardiac valves and variations causedby specific diseases is important in the clinical detection of abnormalities of the cardiac valves and in the development of specific therapeutic interventions thatprove to be helpful in patient care.[3] According to Hyrtl, the name valve was first used for the heart valves by Benedicts. The Greeks named them Hymenses, while Vesalius named them valve onthe basis of the papillary muscle tethering. They were a posterior bridging leaflet,a left lateral, right lateraland two anterior leaflets. The lateral leaflets showed various degrees of 'scalloping' which in some instances, was sufficiently obviousto suggest the presence of an additional leaflet. However, it was the variation in morphology of the two anterior leaflets which provided the basis for subdivisionof the heart.[12] In 1982, Donaldson RM et al. visualised the abnormal Tricuspid valve structure and motion resulting from the rupture of a right ventricular papillarymuscle by using 2D echocardiography and told that it occurs as a complication of right sided infective endocarditis after myocardial infarction, penetrating and non- penetrating chest trauma, external cardiac massage and in association with primary pulmonary hypertension.[13] In 1982, Tei C et al. reported that the Tricuspid valve annulus is larger than the mitral valve annulus by confirming it with the help of two dimensional echocardiographic and the autopsy measurements. He also reported that valve annulus measurement in the fixed hearts is smaller compared in the fresh hearts.[14]

Material and methods

The present study was performed on 96 human heart specimens, collected from the cadavers Department of Anatomy and Forensic Medicine, at Patna medical college and Hospital Patna. Study duration of three years. The specimens obtained were fixed in 10%formalin and were finely dissected.

Inclusion criteria

Human hearts from cadavers of individuals whose death was caused bynon-cardiac disease.

Exclusion criteria

Any gross evidence of congenital heart disease, Any macroscopic features of rheumatic heart disease or any other pathologicalconditions, Injured or lacerated hear, Heart specimens from the decomposed bodies.

METHOD OF COLLECTION OF DATA

After exploring the pericardial cavity, the heart was detached from the major venous channels (superior vena cava and inferior vena cava) and the aortawas cut 3 centimetres above the level of the coronary sinus and then the heart was extracted with intact pericardium. The specimens were stored in 10% formalin solution. The Tricuspid valve was opened by a scalpel knife cut passing from theright atrium to the apex of the right ventricle through the lateral or acute margin of the ventricle. The interior of the heart was washed and all the blood clots were removed. Annular circumference and diameter of the Tricuspid valve was

Figure 1: Measurement of circumference of the tricuspid valve annulus with vernier callipers

MEASUREMENT OF CIRCUMFERENCE OF THE TRICUSPID VALVE ANNULUS WITH VERNIER CALLIPERS measured using slide callipers and findings were recorded and photographs were taken. The second cut was made along the anterior surface of the heart just left tothe intra-ventricular groove from apex of the ventricle to annulus, care was taken not to damage the papillary muscles. After opening the valve from ventricularside, blood clots were removed completely, incidence and measurements of valve leaflets, papillary muscles, chordae tendinae and commissures were noted and photographs were taken Out of all the valves in human heart, C. M. G. Duran defined Tricuspidvalve as the "Cinderella" of cardiac valves because of its unique characteristics,like,it is difficult to evaluate its preoperative importance and assess the value of different surgical techniques. These characteristics of Tricuspid valve cause cardiologists and surgeons to often ignore it with apparent impunity.[5] However, recent developments in diagnostic tools and in two-dimensional colour Doppler echocardiography in particular have increased the awareness ofthis valve. An accurate knowledge of the morphometry of the Tricuspid valvecomplex is essential for cardiac surgeons to replace diseased or damaged valves with use of prosthetic valves.[2] A surgical correction of the heart valves has given a new lease of life to patients. The incidence of prosthetic valve dehiscence has decreased over the past30 years, primarilbecause of improvements in the technical conduct of valve procedures.[4]

Figure 2: Measurement of diameter of the tricuspid valveannulus in two planes with the divider

Results

Table 1:CIRCUMFERENCE OF TRICUSPID VALVE ANNULUS

MEASUREMENTS	ANNULAR CIRCUMFERENCE (cm)
Mean	8.92
SD	1.09
C.I. (95%)	8.7-9.14
Range	5.6-11
Median	9
N	96

Table 2: DIAMETER OF TRICUSPID VALVE ANNULUS IN TWODIFFERENT PLANES

MEASUREMENTS	HORIZONTAL DIAMETER (cm)	VERTICAL DIAMETER (cm)
Mean	3.18	2.52
SD	0.56	0.53
C.I. (95%)	3.06-3.29	2.41-2.63
Range	2.00-4.6	1.2-4.3
Median	3.2	2.5
N	96	96

Table 3: TOTAL NUMBER OF LEAFLETS

NUMBER OFLEAFLETS	NUMBER OF HEARTS	PERCENTAGE
2.00	4	4.2
3.00	92	95.8
TOTAL	**96**	**100.0**

Table 4: NUMBER OF FAN SHAPED CHORDAE TENDINAE IN PPM

TOTAL NO. OF CHORDAE TENDINAE	NUMBER OF PPM	PERCENTAGE
Zero	189	89.5
One	21	9.9
Three	1	0.4
TOTAL	**211**	**100.0**

Table 5: NUMBER OF FREE EDGE CHORDAE TENDINAE IN SPM

NUMBER OF CHORDAE TENDINAE	NUMBER OF SPM	PERCENTAGE
Zero	37	48.0
One	34	44.1
Two	6	7.7
TOTAL	**77**	**100.0**

Table 6: NUMBER OF ROUGH ZONE CHORDAE TENDINAE IN SPM

NUMBER OF CHORDAE TENDINAE	NUMBER OF SPM	PERCENTAGE
Zero	67	87.0
One	10	12.9
TOTAL	**77**	**100.0**

Table 7: NUMBER OF BASAL CHORDAE TENDINAE IN SPM

NUMBER OF CHORDAE TENDINAE	NUMBER OF SPM	PERCENTAGE
Zero	65	84.4
One	10	12.9
Two	2	2.5
TOTAL	**77**	**100.0**

Table 8: NUMBER OF DEEP CHORDAE TENDINAE IN SPM

NUMBER OF CHORDAE TENDINAE	NUMBER OF SPM	PERCENTAGE
Zero	60	77.9
One	15	19.4
Two	2	2.5
TOTAL	**77**	**100.0**

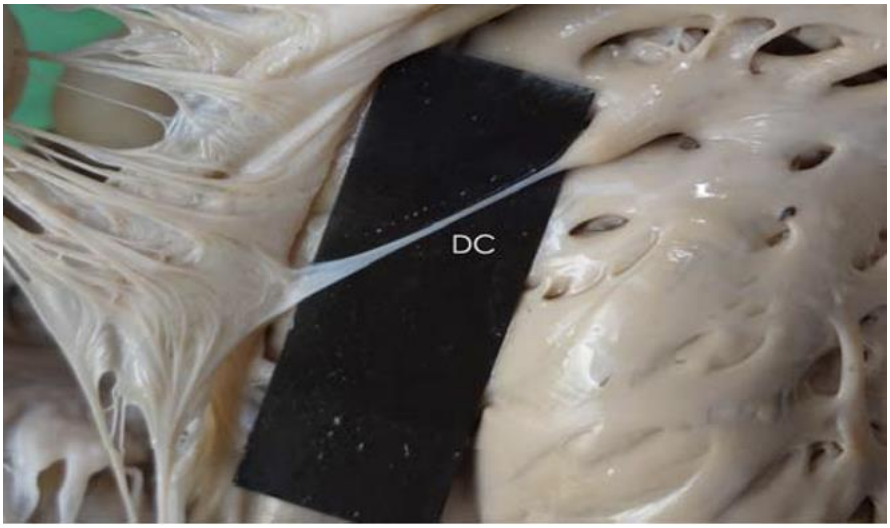

Figure 3: HEART SHOWING DEEP CHORDAE TENDINAE

Discussion

The internal morphology of two ventricles of heart is extremely complicated and remarkably variable. Atrioventricular valves of both right and left are compared to the finger print of human being to explain the concept of their extreme variability from one individual to another.[15] Morphological and functional assessment of the complete Tricuspid valve apparatus is crucial for clinical decision making during diagnosis and severity assessment as well as treatment selection and planning.[16] Knowledge of the Tricuspid valves has always lagged behind when compared to mitral valve, because of the paucity of clinical signs whendiseasedand the imprecision of available diagnostic tools. Hence Tricuspid valvehas been generally ignored by cardiologists and surgeons, by limiting Tricuspid surgery to valve replacement or simple annuloplasty. But advances in echocardiography awoken new interest in the Tricuspid valve surgeries.[5] Understanding of the Tricuspid valve remains important because ofprogress in cardiac surgery, including the partial transfer of the posterior leaflet of the Tricuspid valve for repair of the mitral valve, Tricuspid valve replacement, complication after heart transplantation, invasive cardiology and valvuloplasty.[17] Accurate knowledge of the morphology of the Tricuspid valve is mandatory for differentiation between functional and organic regurgitation.[18] Anwar AM et al. respectively. Difference in the measurement between the present study and above mentioned authors might be because of the difference between the number of specimens, type of method and age groups of human beings. Knowledge regarding the normal measurements of Tricuspid valve annulusis mandatory in diagnosis and accurate treatment of Tricuspid valve stenosis and regurgitation. The last step in a Tricuspid valve repair procedure is the implantation of an annuloplasty ring on the native annulus. It helps to restore the shape and size of the annulus to its physiological dimensions, enabling adequate leaflet coaptation to prevent regurgitation, as well as helping to stabilize any additional repair work by taking tension off suture lines. The absence of an encircling fibrotic structure explains the large changes in the Tricuspid orifice during the cardiac cycle and its easy dilatation in disease. The mobility and size of the Tricuspid orifice are dependent on the transversely oriented myocardial fibres, which surround the atrioventricular valves. The Tricuspid orifice narrowing was caused by shortening of the free wall portions of the annulus.[5] Measurement of diameter of two different planes of valve annulus is very important in knowing the amount of abnormality of Tricuspid valve orifice. In the present study an attempt was made to measure the mean diameter of Tricuspid valve annulus in two different planes namely, horizontal and vertical which was 3.18 cm and 2.52 cm respectively. There was minimal difference noted in the present study and work done by Gerola LR et al., where difference was observed in incidence of percentage ofboth posterior leaflet and septal leaflet. Possible reason for such difference is the number of specimens, geography and race of specimens studied. Improper coaptation of the leaflets leads to regurgitation. In Ebstein's anomaly there is a downward displacement of the valve, i.e.; basal insertion of elements of valve at a level below the annulus and the most common leafletsinvolved are septal and posterior. So, incidence, anatomy and morphology of leaflets will be necessary before undertaking any surgical treatment.[3] The fan-shaped chordae are very useful for the exact landmarks of the commissures and in few hearts where such chordae are not found other pointersmay be used to define them. Once the commissures are defined, all valvular tissue between them is part of the leaflets. Knowing anatomy of this would be useful for functional studies of chordae tendinae.[19] Although the number of Tricuspid leaflets varies according to different studies, it is generally accepted that the Tricuspid valve consists of three leaflets (septal, anterior and posterior), which are separated by three commissures or clefts-the anteroseptal, anteromedial and posteroseptal. These commissures do not reach the annulus but delineates small "commissural leaflets". This is an important surgical point because in cases offused commissures, their incision should not extend all the way to the annulus,

which destroys the commissural leaflets.[5] The flexibility of particular leaflets of the Tricuspid valve varies, as does the tension of the blood stream in particular cusps. The study of the distribution of tendinous chords of the Tricuspid valves is helpful in aspects of progress in cardio surgical techniques, including Tricuspid valve repair with chordal replacement after traumatic regurgitation, surgical repair of the mitral and Tricuspid valve simultaneously using the De Vega method and invasive procedure with balloon valvuloplasty in cases of stenosis.[20] Observation regarding the range of basal chordae tendinae in papillary muscles in the present study was in agreement with the work of Balachandra Net al. Observations are showing much difference between present study and work done by Kocak A et al. and Silver MD et al. Possible reason for such difference is the number of specimens studied. Free edge and deep chordae are unique to the Tricuspid valve.[21]

Conclusion

Rapid progress in the field of interventional cardiology and advance investigation techniques has awoken new interest in the anatomy of Tricuspid valve, which was largely ignored by clinicians and cardiac surgeons. In view of the importance of anatomy and its variations, it is logical to look detailed morphology and variations of Tricuspid valve during any surgical procedure. Knowing the measurements of Tricuspid valve annulus help in various cardiac procedures like ring annuloplasty, prosthetic valve implantation etc. in treatment of diseases like severe Tricuspid regurgitation and Tricuspid valve stenosis.

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