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Original Research Article

MORPHOLOGICAL ANALYSIS OF TRICUSPID VALVE COMPLEX IN CADAVERIC HUMAN HEARTS IN SOUTH INDIAN POPULATION

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ABSTRACT

Introduction: The tricuspid valve complex is present between the right atrium and right ventricle which consists of i) Tricuspid orifice and its associated annulus ii) 3 Leaflets (anterior, septal, posterior); iii) 3 Commissures (anteroposterior, posteroseptal, anteroseptal); iv) 2 Papillary muscles (anterior, posterior, occasionally septal); v)Chordae tendinae of various types. Awareness of tricuspid valve complex is of great clinical importance in cardiosurgery and is considered a prerequisite for successful, uncomplicated cardiac surgeries and interventional radiology.

Materials and Methods: 45 cadaveric human hearts have been utilized in this study. Conventional dissection technique was performed and the detailed morphology of the tricuspid valve complex was studied. The following observations were taken a)Number of commissures b) Position of commissures c) Shape of orifice d) Number & shape of leaflets e) Presence or absence of accessory leaflets f) Position of normal and accessory leaflets, if present, g) No. of scallops in posterior leaflet.

Observations and results: The tricuspid orifice was elliptical in 34 hearts (75.6%) and triangular in 11 hearts (24.4%).The number of leaflets or cusps in the tricuspid valve complex showed variation. There were typical 3 leaflets in 41 hearts (91.1%) with anterior, posterior and septal leaflets. In 4 hearts (8.9%) 4-cuspidal form was noticed with an accessory cusp. Three Commissures were identified between the leaflets in the 3-cuspidal form. They are anteroposterior, posteroseptal and anteroseptal.

Conclusion: This knowledge of anatomical variation in the morphology of the tricuspid valve may help cardiac surgeons during surgical procedures conducted for correction of valve defects.

KEY WORDS: Human Heart, Right Ventricle, Tricuspid Valve, Commisure, Variation.

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INTRODUCTION

When heart valves become diseased, it forms an important cause of morbidity and mortality across the world. Prolapse and stenosis mainly affects the mitral valve as well as the tricuspid valve. Heart valve diseases are classified into incompetence and stenosis. Valvular incompetence (regurgitation) is due to chronic heart disease (eg. rheumatic heart disease) or congenital anomalies. Valvular stenosis may be due to inflammation of valve, which later on undergoes fibrous thickening and shrinks thereby narrowing the valvular orifice. Organic tricuspid and mitral valve diseases are more common in India, Pakistan and other developing countries. Autopsy findings in the Indian subcontinent show organic tricuspid valve diseases occurring in more than 1/3rd of the patients with rheumatic heart diseases [1]. Hence the normal data of tricuspid valve complex is of great importance to cardiovascular specialist and clinicians, but a very few Indian studies were available in the literature. Hence in the present study, the morphological analysis of Tricuspid valve complex were done in human adult cadaveric hearts of South Indian population and then compared and analyzed with the works of many eminent scientists in this field.

MATERIALS AND METHODS

The 45 hearts were collected from the cadavers, which were routinely dissected for teaching purpose for first t year MBBS students. Of the 45 hearts, 30 hearts were obtained from the Department of Anatomy, SRM Medical College Hospital & Research center, Potheri.15 hearts were obtained from the Department of Anatomy, Sri Ramachandra Medical College & Research Institute, Porur. The hearts were preserved in 10% formaldehyde and Glycerin.

Conventional dissection method is used to study the morphology of the tricuspid valve complex. In each heart, the right atrium and ventricle were incised along their right lateral wall, the walls were carefully retracted, and the interior was thoroughly washed with saline. The tricuspid valve was then opened by cutting through the annulus fibrosus between the anterior and posterior leaflets. The tricuspid valve complex was examined morphologically and photographed in situ [2].

RESULTS

Tricuspid Annulus: The tricuspid orifice was elliptical in 34 hearts (75.6%) and triangular in 11 hearts (24.4%) and has a clear line of transition from the atrial wall or septum to the bases of valvular cusps. It faced anterolaterally (on its ventricular aspect) to the left and somewhat inferiorly. In roughly triangular orifice, the orifice margin is described as anterior, posterior and septal corresponding to the attachment of bases of the three leaflets.

Tricuspid Valve Leaflets: The number of leaflets or cusps in the tricuspid valve complex showed variation. There were typical 3 leaflets in 41 hearts (91.1%) with anterior, posterior and septal leaflets. And in 4 hearts (8.9%) 4-cuspidal form was noticed with an accessory cusp.[Fig.1] Of the 4 hearts with accessory cusp, in 3 hearts the accessory cusp was present between the posterior and septal cusp and in 1 heart the accessory cusp was situated between the anterior and posterior cusp.

Each leaflet presents a rough zone, clear zone and a basal zone. The clear zone of the leaflet is identified towards the annular side as a smooth and membranous area without any chordal attachment on the ventricular surface.

The rough zone is visualized towards the apex of the leaflet as a crescentric area, which is thicker on palpation and presents attachments of chordae tendineae on the ventricular surface.

The basal zone was thick close to the attachment of base of leaflets and it received chordae from the ventricular wall in its ventricular aspect.

Natural Foramen (true and spurious) was observed in 5 hearts (11.1%). True foramina are surrounded by valve tissue from each side and Spurious foramina are a part of musculo-fibrous arcade. In 3 hearts, true foramen was observed in posterior leaflet (2 hearts) and septal leaflet (1 heart).The true foramen in septal leaflet was two in number. In 2 hearts, spurious foramen was observed in posterior leaflet in one heart and in septal leaflet in the second heart.[Fig. 2(a) & 2 (b)]. There was no duplication, parachute deformity, double orifice of the leaflets or frenula in the leaflets.

Anterior Leaflet: The anterior leaflet was triangular and largest in 37 hearts (82.2%). A single notch was observed along the edge of the anterior leaflet in 3 hearts (6.7%). A notch is differentiated from the cleft by a reduced area of rough zone and attachment of fan shaped chordae. The anterior leaflet received chordae

Fig. 1: Photograph showing the presence of accessory Leaflet (subtype 2c).

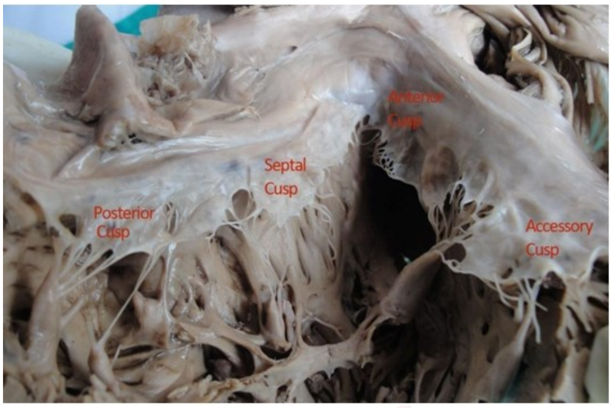

Fig. 2 (a): Photograph Showing The Presence Of Natural Foramina (Tf- In The Posterior Lealfet; Sf- Between The Posterior And Septal Leaflet.

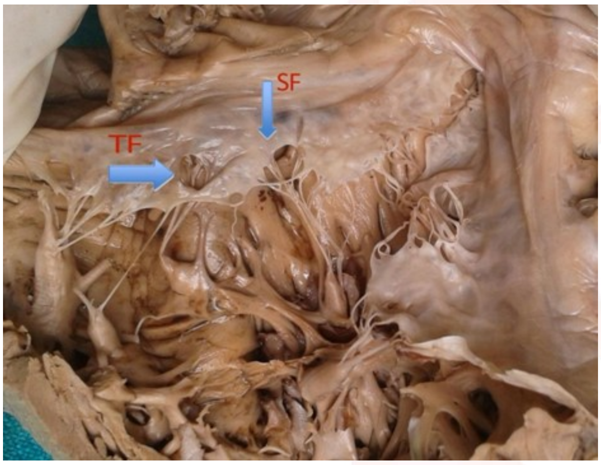

Fig. 2 (b): Photograph showing the presence of trueForamina in the septal leaflet.

from both the anterior and posterior papillary muscles.

The annular length and height of anterior leaflet were measured using thread, divider and a millimeter scale. The annular length is measured along the annulus between the points of attachment of the anterior leaflet. The height is measured as a perpendicular line from the base of attachment of the leaflet to the centre of free edge of leaflet.

Posterior Leaflet: The posterior leaflet was quadrangular and largest in 8 hearts (17.8%). Cleft was observed along the free edge of posterior leaflet in 38 hearts (84.4%), with a single cleft in 9 hearts (23.6%) and two clefts in 29 hearts (76.4%). The clefts were identified by the presence of prominent rough zone and attachment of fan shaped cleft chordae in the indentations of the free margin of the leaflet. The posterior leaflet received chordae from the anterior and posterior papillary muscles. The clefts divided the posterior leaflet into scallops. In 9 hearts they were bi-scalloped with a large Anteroposterior scallop and a small posteroseptal scallop. In 29 hearts they were tri-scalloped with a large middle scallop and two small lateral scallops.

Septal Leaflet: The septal leaflet was semicircular in shape and the smallest of the three leaflets. There was no cleft or notch observed in the free margin of the septal leaflet. The septal leaflet received chordae from the ventricular wall and the septal papillary muscle.

Accessory Leaflet: Accessory leaflet was observed in 4 hearts (8.9%). In 3 hearts, the accessory leaflet was observed in between the posterior and septal leaflet (subtype 2A) and in 1 heart it was found between the anterior and posterior leaflet (subtype 2C). The accessory leaflets in subtype 2A received chordae from the ventricular wall and the septal papillary muscle. The accessory leaflet in subtype 2C received chordae from the ventricular wall and the anterior papillary muscle.

Commissures: The commissures are junctional regions between the leaflets which are deep indentations in the free margin of the valve curtain. The commissures were identified by the following features: 1) Presence of a prominent (primary) indentation 2) Attachment of fan-shaped commissural chordae 3) Absence of rough zone and 4) Evidence of clear zone extending to the margin of indented area. Three Commissures were identified between the leaflets in the 3-cuspidal form. They are Antero-posterior, Posteroseptal and Anteroseptal. The Anteroposterior commissure received chordae from Anterior papillary muscle in 33 hearts, Posterior papillary muscle in 8 hearts and septal papillary muscle in 4 hearts. The Posteroseptal commissure received chordae from Posterior papillary muscle in 20 hearts, Anterior papillary muscle in 15 hearts and from the ventricular wall in 10 hearts. The Anteroseptal commissure received chordae from the ventricular wall in 30 hearts, Septal papillary muscle in 10 hearts and Posterior papillary muscle in 5 hearts. (Table I) (Fig.3)

In hearts with 4-cuspidal Rt. atrioventricular valve , in addition to the three commissures there exists commissures between the accessory leaflet and the normal leaflets. The commissure between the posterior and accessory leaflet received chordae from the posterior papillary muscle in 2 hearts and from the septal papillary muscle in 1 heart. The commissure between the accessory and septal leaflet received chordae from the septal papillary muscle. The commissure between the anterior and accessory leaflet received chordae from the anterior papillary muscle. The commissure between the accessory and posterior leaflet received from the anterior papillary muscle.

Fig. 3: Photograph showing the attachment of commissural chordate.

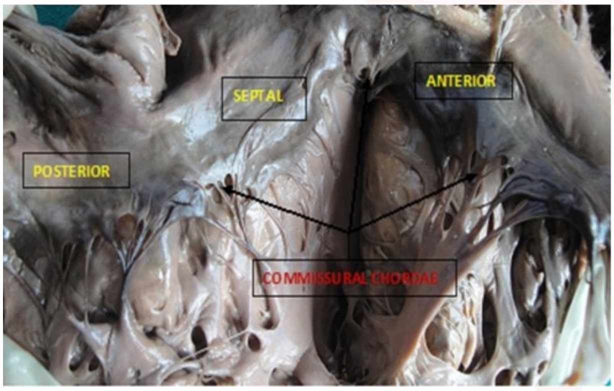

Table 1: Site of origin of commissural chordate.

Commissures	Commissural chordae
Anteroposterior	33 from APM; 8 from PPM; 4 from SPM
Posteroseptal	20 from PPM; 15 from APM; 10 from ventricular wall.
Anteroseptal	30 from ventricular wall; 10 from SPM;3 from PPM.

DISCUSSION

According to Mohamed A.B. Motabagani [3], the human tricuspid orifice was triangular bounded by three leaflets. In 2012 Kalyani [4] demonstrated that the shape of the right atrioventricular orifice evolves during life, from a triangular shape in young hearts to a more elliptical shape in older hearts. According to Gray's Anatomy (37th edition) [5], the shape of the orifice varies from circular (mostly), oval or roughly triangular with rounded angles.According to A.K.Datta [6], the right atrio-ventricular orifice is somewhat oval or circular in outline (depending upon the phase of the cycle). In the present study, the tricuspid orifice was elliptical in 34 hearts (75.6%) and triangular in 9 hearts (24.4%) which coincided with Kalyani et al., [4] who demonstrated that, the shape of orifice evolves from a triangular to elliptical shape during life. Since the age of the hearts included in this study is not known, classifying them according to age group could not be done.The number of leaflets in the present study does not coincide with the findings of other foreign authors. This could be attributed to the racial difference and there is no Indian study available regarding the number of leaflets to compare with the findings in this study. (Table 2).

Magdalena K. Skwarek [9] classified the tricuspid valves with accessory cusp into 3 subtypes on the basis of their localization: 1) Subtype 2A- the accessory cusp localized between the posterior cusp (CP) ant the septal cusp (CS) - most common (25.3%); 2) Subtype 2B- the accessory cusp localized between the anterior cusp (CA) and the CS - occurred in 9.3%; 3) Subtype 2C- the accessory cusp is localized between CA and CP-occurred in 5.3%.In present study, Of the 4 hearts with accessory cusp, in 3 hearts (75%) (6.6%) the accessory cusp was of subtype 2A and in 1 heart (25%)(2.2%) the accessory cusp was of subtype 2C, supporting the fact that sub type 2A is the most common type. (Table III).The observation of number of foramina (both true and spurious foramens) in the leaflets revealed that there were foramina in 11.1% of cases bearing a close relationship with study done by Magdalena Skwarek et al.,[10] who observed it in 11.21% cases. (Table 4).

The anterior leaflet was largest in most of the studies (Mohamed A.B. Motabagani [3]; Ashraf M. Anwar et al., (2007) [11]. In the present study, the anterior leaflet was largest in 37 hearts (82.2%). The shape of the anterior leaflet varied in different studies. It was quadrangular (Khan A.A. et al., 1999)[12], semicircular (Ashraf M.Anwar et al., 2007)[11] and triangular (Mohamed A.B. Motabagani 2006)[3]. The present study coincided with Motabagani 2006[3] study where the anterior leaflet was triangular in shape

The posterior leaflet was second largest in the present study which coincided with studies conducted by Khan A.A.et al.,(1999)[12] & Mohamed A.B. Motabagani (2006)[3]. The shape of the leaflet was semicircular in Khan A.A et al., [12] and triangular in Mohamed A.B. Motabagan [3] study, whereas it was quadrangular in the present study. In present study, all the posterior leaflets presented clefts and scallops in its free margin, whereas Khan A.A. et al., [12] mentioned that in5 hearts the posterior leaflet was scallopless and 20% of hearts of Mohamed A.B. Motabagani [3] study were scallopless.

The free margin of posterior leaflet presented a single cleft in 9 hearts (23.6%) in the present study, whereas it was in 11 hearts in Khan A.A. et al., (1999)[12] and in 80% of hearts in Mohamed A.B. Motabagani (2006)[3] study.Two clefts in the free margin were observed in 29 hearts (76.4%) in the present study, and A.K.Datta (1986) [6]says that two clefts is the usual type. Whereas Khan A.A. et al.,(1999)[12] reported it to be present in 9 hearts and Mohamed A.B. Motabagani (2006)[3] did not observe two clefts in his study.

In the present study, the septal leaflet was the smallest of the three leaflets which coincided with findings of A.K.Datta (1986)[6] and Mohamed A.B. Motabagani (2006)[3], whereas L.-R. Gerola et al.,(2001)[13]observed that the septal and anterior leaflet were of same size. In this study, there was no cleft or notch observed in the free margin of the septal leaflet, as observed by Mohamed A.B. Motabagani (2006)[3]. The shape of the septal leaflet was semicircular which was similar to studies by Khan et al.,(1999)[12] and Mohamed A.B. Motabagani (2006)[3], whereas according to Ashraf M.Anwar et al., (2007)[11]it was semi-oval in shape.

The origin of commissural chordae to each commissure in 3-cuspidal form is compared with the study conducted by Khan A.A.et al., (1999)[12]. The AP commissure received maximum number of commissural chordae from APM in 33 hearts in the present study, whereas it was from APM in 16 hearts in Khan A.A. et al.,[12] study. The PS commissure received maximum number of commissural chordae from the PPM in 20 hearts according to present study, whereas it was from SMPM in 8 hearts and from ventricular wall, PPM and SPM in 5 hearts in Khan A.A. et al.[12] study. The AS commissure received maximum number of commissural chordae from ventricular wall in 30 hearts in the present study, whereas it was from ventricular wall in 16 hearts in Khan A.A. et al., [12] study. (Table V). Whereas, in hearts with four leaflets (1 accessory cusp), the commissure between the anterior and accessory leaflet received chordae from the anterior papillary muscle. The commissure between the accessory and posterior leaflet received chordae from the anterior papillary muscle. There was no literature available to compare the commissural chordae in presence of accessory leaflet.

Table 2: Comparison of number of leaflets and accessory leaflets.

Studies	2 Cusps	3 Cusps	4 Cusps	2-5 Cusps	6 Cusps	7 Cusps
Wafae et al, (1990) [7]	-	28%	-	72%	-	-
Sutton 3rd et al., (1995) [8]	30%	62%	8%	-	-	-
M.Skwarek et al., (2004)[9]	-	9.30%	36.15%	-	13.30%	4.10%
PRESENT STUDY	-	91.10%	8.90%	-	-	-

Table 3: Comparison of location of accessory leaflets.

Location Of Accessory Cusp	M. Skwarek Et Al.,[9]	Present Study
SUBTYPE 2A	25.30%	6.60%
SUBTYPE 2B	9.30%	-
SUBTYPE 2C	5.30%	2.20%

Table 4: Comparison of number of foramina in the leaflets and its distribution.

S.NO	Studies	No. of hearts with foramen with foramen	% of hearts	Distribution of foramen	
				Single	Multiple
1	Magdalena Skwarek et al.,(2005)[9]	12	11.21%	9 hearts	3 hearts
2	Present Study	5	11.10%	2 hearts	3hearts

Table 5: Comparison of site of origin of commissural chordate.

Commissures	Present study	Khan A.A. et al.,(1999)[12]
Anteroposterior Commissure	33 from APM; 8 from PPM; 4 from SPM.	16 from APM; 5 from PPM; 4 from APPM.
Posteroseptal Commissure	20 from PPM; 15 from APM; 10 from ventricular wall.	5 from ventricular wall; 5 from PPM; 2 from APPM; 5 from SPM; 8 from SMPM.
Anteroseptal Commissure	30 from ventricular wall; 10 from SPM; 3 from PPM.	16 from ventricular wall;5 from Papillary muscle of conus.

CONCLUSION

The knowledge of the annulus of the tricuspid valve is important for the cardiac surgeons in tricuspid valve diseases like stenosis and regurgitation as it will help them to plan palliative or corrective surgery in the congenital or acquired heart diseases. This study gives an overview about the normal anatomy and variations related to tricuspid valves complexes in the South Indian population, and can be used as a data-base. Accurate knowledge of the morphology and all possible variations is of utmost important in a successful and uncomplicated cardiothoracic surgery and other invasive procedures.

Conflicts of Interests: None

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