



Morphological Study of Chorda Tendinae of Right Ventricle

¹Dr. S Satish Kumar, ²Dr. Dhanalakshmi V, ³Dr. Suresh Kumar T, ⁴Dr. Arun Kumar K

^{1,2,3,4}Associate Professor,

Department of Anatomy,

¹Government Dharmapuri Medical College, Dharmapuri, Tamilnadu, India

²Government Medical College, Thoothukudi, Tamilnadu, India

³Government Medical College, Vellore, Tamilnadu, India

⁴Dhanalakshmi Srinivasan Medical College, Perambalur, Tamilnadu, India

*Corresponding Author:

Dr. S Satish Kumar

Associate Professor, Department of Anatomy, Government Dharmapuri Medical College,
Dharmapuri, Tamilnadu, India

Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Introduction: Normal tricuspid valve function depends upon the anatomical and mechanical integrity of the AV ring, the valve leaflets, chordae tendinae and papillary muscles. The chordae tendinae are fibrous collagenous structures supporting the cusps of the atrioventricular valves. They transmit the force of the contracting papillary muscles during ventricular systole to the cusps of the valves to prevent the valves from prolapsing into the atria due to the higher pressures generated in the ventricles.

Materials and Methods: The study was conducted in 45 adult human heart obtained from embalmed cadavers in Institute of Anatomy, Madras Medical College, Chennai, Tamilnadu by conventional dissection method. Chordae Tendinae is observed for its Types, Number of Chordae Tendinae at Origin and at its insertion.

Results: All 5 types of chordae namely Rough Zone Chordae, Commissural chordae, Free edge chordae, Deep and Basal chordae were present in the present study. The number of chordae tendinae originated from anterior papillary muscle ranged from 3 to 10 (mean 5.7) and from septal papillary muscle ranged from 0 to 8 (mean 3.71). The number of chordae tendinae originated from posterior papillary muscle ranged from 1 to 8 (mean 3.75). In 10 hearts there were no septal papillary muscle and in these 10 hearts the chordae tendinae directly arose from ventricular wall. The number of chordae tendinae inserted into anterior leaflet ranged from 9 to 21 (mean 14.2) and in septal leaflet the number ranged from 7 to 18 (mean 11.95). The number of chordae tendinae inserted into posterior leaflet ranged from 8 to 16 (mean 9). 3 to 6 chordae tendinae were inserted into the commissures and clefts.

Conclusion: Advances in echocardiography, invasive cardiology and surgical reconstruction of Tricuspid valves necessitate an appreciation of the many variations in the anatomy of the Tricuspid valve for Interventional Cardiologists and Cardiac Surgeons. This study will also be of much help in Tricuspid valve procedure such as Artificial chordae tendinae replacement.

Keywords: Chordae tendinae, Commisure, Leaflet, Rough zone, Tricuspid valve

Introduction

Chordae tendinae are fibrous collagenous structure supporting the cusps of the atrioventricular valves. They can be false or true. False chordae

connect papillary muscles to each other or to the ventricular wall including the septum or pass directly between points on the wall. They are irregular in numbers and dimensions in the right

ventricle. True chordae usually arise from small projections on the tips or margins of the apical one-third of papillary muscles, but sometimes arise from the bases of papillary muscles or directly from the ventricular aspects or the free margins of the cusps. Chordae tendineae have been classified into first, second and third order chordae according to the distance of the attachment from the margins of cusps[1].

The function of chordae tendineae is to prevent the cusps from being everted when the ventricle contracts[2].

Chordae of the tricuspid valve are of various lengths and may originate from a papillary muscle either directly from the apex of the muscle or from small nipples which are usually on its upper third. Alternatively, the chordae may arise directly from the muscle of the posterior or septal walls of the right ventricle. Five different types of chordae tendinae are attached to the tricuspid valve. They are Fan-shaped, rough zone, basal, free edge and deep chordae[3].

Fan shaped chordae form precise landmarks for the commissures and distinguish clefts from the genuine commissures of the leaflets. Free Edge Chordae are characteristic of tricuspid valve. They are single and may originate in the apex of papillary muscle from its base and inserted into the leaflets free edge. Deep and Rough Chordae can be as long as 2.2cm. The deep chordae not present in the mitral valve, appears to provide a second arcade for leaflet attachment to the larger tricuspid valve annulus and leaflets. Basal Chordae are the shortest and measures an average of 0.6cm[3].

Number of chordae tendineae may vary in number at its site of origin and insertion.

Materials And Methods

The study was conducted in 45 adult human heart obtained from embalmed cadavers in Institute of Anatomy, Madras Medical College, Chennai, Tamilnadu by conventional dissection method. Heart is sectioned with an incision from the right atrium to the apex of the right ventricle. The section passed near the antero posterior commissure of the right atrioventricular valve. After opening, the heart is washed under running tap

water to remove blood clots. Dissection of myocardium was carried out from the right AV fibrous ring to the origin of papillary muscles, preserving the integrity of the valve apparatus. Ventricular aspect of the tricuspid leaflet was inspected to observe the types of chordae tendineae and its pattern of insertion. Tendinous chords attached to each papillary muscle were counted at their origin in situ and after removal of the right atrioventricular valve. The same was photographed for its documentation.

Results

On observation:

Types of Chordae Tendineae:

Rough zone chordae were observed in all 45 hearts. Commissural chordae were inserted into the free margin of the commissural area in a fan shaped manner in all 45 hearts. Fan shaped chordae [Figure 1] were observed to insert in the clefts between the scallops of the posterior leaflet. These are called cleft chordae and was seen in all the 45 hearts. Free edge chordae were found attached to anterior leaflet in 41 hearts, to posterior leaflet in 38 hearts and to septal leaflets in 22 hearts. Deep chordae were attached to anterior leaflet in 40 hearts, to posterior in 32 and septal leaflet in 24 hearts. Basal chordae were mostly single, arose directly from the myocardium (ventricular wall) or from trabeculae carneae and inserted into the basal zone of leaflet. These chordae were found attached to anterior leaflet in 22 hearts, to posterior leaflet in 20 hearts and to septal leaflet in 24 hearts.

In one heart, chordae had fenestrated appearance before attaching to septal leaflet[Figure 2].

Number Of Chordae Tendineae at Origin[Table 1]

The number of chordae tendinae originating from anterior papillary muscle ranged from 3 to 10 (mean 5.73), from septal papillary muscle ranged from 0 to 8 (mean 3.71) and from posterior papillary muscle ranged from 1 to 8 (mean 3.75). In 10 hearts there were no septal papillary muscle and in these 10 hearts chordae tendineae directly arose from ventricular wall.

Number Of Chordae Tendineae at Insertion[Table 2]

Chordae tendinae of anterior leaflet arose from anterior and septal papillary muscles and its number ranged from 9 to 21(mean 14.2). The septal leaflet received chordae tendineae from posterior and anterior papillary muscles and its number ranged from 8 to 14(mean 10.82). The posterior leaflet received chordae tendineae from posterior and septal papillary muscles and its number ranged from 7 to 18 (mean 11.95). 3 to 6 chordae tendineae inserted into the commissures and clefts.

Discussion

Chordae tendineae are fine tendinous cords which pass to the cusps from conical muscular projections on the wall of the ventricle called the papillary muscles[4].

Types of Chordae Tendineae:

Silver MD et al stated that the chordae of the tricuspid valve are fibrous cords of various lengths. According to their observation, fan shaped chordae were present at the anteroposterior commissure in 47 hearts, at the posteroseptal commissure in 50 and at the anteroseptal in 41 hearts. Rough zone chordae were attached to the anterior leaflet in all 50 hearts, to the posterior leaflet in 41 and to the septal leaflet in 49. Free edge chordae were found attached to 32 in anterior, 24 in posterior and 25 in septal leaflets. Deep chordae were attached to the anterior leaflet in 38 hearts, to the posterior in 29 and to the septal leaflet in 33. One inserted into an anteroposterior commissural area. Basal chordae were found attached to 23 in anterior, 23 in posterior and 45 septal leaflets[4].

The findings regarding the types of chordae tendineae in our study were similar to the study of above author.

Number of Chordae Tendineae At Origin

G.R. Nigri et al reported that Tendinous chords (TC) varied from 1 to 11 originated in the anterior papillary muscle (mean 4.74), from 1 to 8 TC originated in the posterior papillary muscle (mean 2.67) and from 1 to 5 TC originated in the septal papillary muscle (mean 1.77)[5]. The number

of chordae tendineae at origin in the present study was nearer with the study of the G.R. Nigri et al .

Number of Chordae Tendineae at Insertion

B.N Vijaya Ragawa Rao stated that on average, 25 chordae tendineae insert into the tricuspid valve, 7 to the anterior leaflet, 6 to the posterior leaflet, 9 into the septal leaflet and 3 into the commissural area[6].

Ankara studied 27 normal hearts, on the average 27 chordae tendineae in valva atrioventricularis sinistra, 30 in valva atrioventricularis dextra and 57 in the whole heart were detected[7].

Seccombe J.F et al stated that the tricuspid valve was served by an average of 170 ± 36 chordae tendineae, 49% inserted on the free edge of the valve, 44% undersurface and 7% on the basal region. Chordal density (number of chordae/cm²) was greater in women than men (9.9 ± 0.5 vs 7.3 ± 0.7 chordae/cm²). The septal leaflet had the greatest chordal density and the anterior leaflet the least (12.7 ± 0.9 vs 5.9 ± 0.7 chordae/cm²)[8].

M .Skwarek et al stated that the total average number of chords was 72.71 ± 13.38 . The anterior leaflet was provided by chords which originated in the anterior and posterior papillary muscles (Anterior papillary muscles $86.19 \pm 11.66\%$, posterior $13.09 \pm 1.74\%$). The posterior leaflet was provided by chords coming from the posterior and septal papillary muscles (posterior $85.67 \pm 11.48\%$, septal 1.83%). The septal cusp was provided by chords from the septal and anterior papillary muscles (septal $19 \pm 2.55\%$, anterior $80.99 \pm 10.85\%$)[9].

The number of chordae tendineae at insertion in the present study varies from the study of above mentioned authors.

Calcification of tricuspid valve chordae tendineae on echocardiography and computed tomography was reported in a 75 year old female[10] and no such calcification was observed in the present study

While doing pulmonary arteriography catheter may be entrapped by the chordae tendineae of the tricuspid valve, two such cases have been reported in a study [11] and so it is important to know in detail about the attachments of chordae tendineae.

Platypnea-orthodeoxia syndrome induced by spontaneous tricuspid valve chordal rupture, which

was caused by blunt chest trauma has been reported and rupture can also occur due to infective endocarditis, myocardial infarction, congenital disorders, iatrogenic complication of endomyocardial biopsy[12].

Conclusion

Chordae tendineae , a major bonding between papillary muscles and the valve leaflets are an important structure in the atrio ventricular valvular complex of heart. Knowledge of these variations in the chordae tendineae will be of immense help to the cardiologist while doing echocardiography, cardiothoracic surgeons while repairing the valvular apparatus of heart. Still more histopathological studies of these chordae tendineae are necessary to account for spontaneous rupture.

Acknowledgement

We acknowledge Dr. Christilda Felicia Jebakani, Former Director, Institute of Anatomy, Madras Medical College for encouraging and guiding us in the study.

References

1. Susan Standring : Gray's Anatomy 39th Edition, 2005;1002-1007.
2. Chummy S . Sinnathamby : Last’s Anatomy Regional and Applied ; Eleventh Edition , 2006 : 207-209.
3. Paulo A. Ribeiro, Muayed al Zaibag, Vijay Rajendran, Abdullah Ashmeg, Saad al Kasab, Yahya al Faraidi, Murtada Halim, Mohamed Idris, Mohamed R.al Fagih, Mechanism of mitral valve area increase by in vitro single and double balloon mitral valvotomy, The American Journal of Cardiology, Volume 62, Issue 4, 1988, Pages 264-269.
4. Silver MD, Lam JHC ,Ranganathan N .Morphology of the human tricuspid valve .Circulation 1971; 43:333-348.

5. Nigri GR, Di Dio LJA, Baptista CAC. Papillary muscles and tendinous cords of the right ventricle of the human heart: Morphological characteristics. Surg Radiol Anat 2001 ;23:45-49.
6. B.N Vijay Raghawa Rao: Clinical Examination in Cardiology; 1st Edition , 2000:20-27.
7. Ankara. The types and distribution of chordae tendineae attached to each leaflet of valve atrioventricularis sinistra and dextra. Turk J Med Res 1992;10(3):126-9.
8. Seccombe JF, Cahill DR, Edwards WD. Quantitative morphology of the normal human tricuspid valve autopsy study of 24 cases. Clin Anat 1993; 6: 203-212.
9. Skwarek M, Dudziak M, Hreczecha J, J.Jerzemowski , Grzybiak M .The morphology and distribution of the tendinous chords and their relation to the papillary muscle in the tricuspid valve of the human heart. Folia Morphol, 2007; 66: 314-322.
10. Song, M. W., Maldjian, P., & Waller, A. (2019). Calcification of tricuspid valve chordae tendineae on echocardiography and computed tomography. Radiology case reports, 15(3), 214–217.
11. Winrow, D., Beckmann, C.F., Lacomis, J.M. et al. Entanglement of a pigtail catheter by the chordae tendineae of the tricuspid valve during pulmonary angiography. Cardiovasc Intervent Radiol 19, 275–277
12. Motoki Uchihashi, MD, PhD, Masahiro Makino, MD, Satoshi Kaimoto, MD, PhD, Yuta Imai, MD, Mitsuyoshi Hadase, MD, PhD, Hiroyuki Kurata, MD, PhD, and Takashi Nakamura, MD, PhD, Shiga, Platypnea-Orthodeoxia Syndrome Associated with Spontaneously Ruptured Chordae Tendineae of Tricuspid Valve, Japan

Table 1 : Number of Chordae Tendineae at Origin from Papillary Muscle

No of Chordae Tendineae at	APM	SPM	PPM

origin			
0	-	10	-
1-2	-	7	15
3-5	20	13	21
6-8	21	15	7
9-10	4	-	-

Table 2 : Number of Chordae Tendineae at Insertion in Leaflets

No of Chordae Tendineae at Insertion	Anterior Leaflet	Septal Leaflet	Posterior Leaflet	Commissure
3-6	-	8	-	45
7-9	6	28	6	-
10-12	12	7	26	-
13-15	24	2	10	-
16-18	8	0	3	-
19-21	5	0	-	-

Figure 1 : Fan-Shaped Chordae

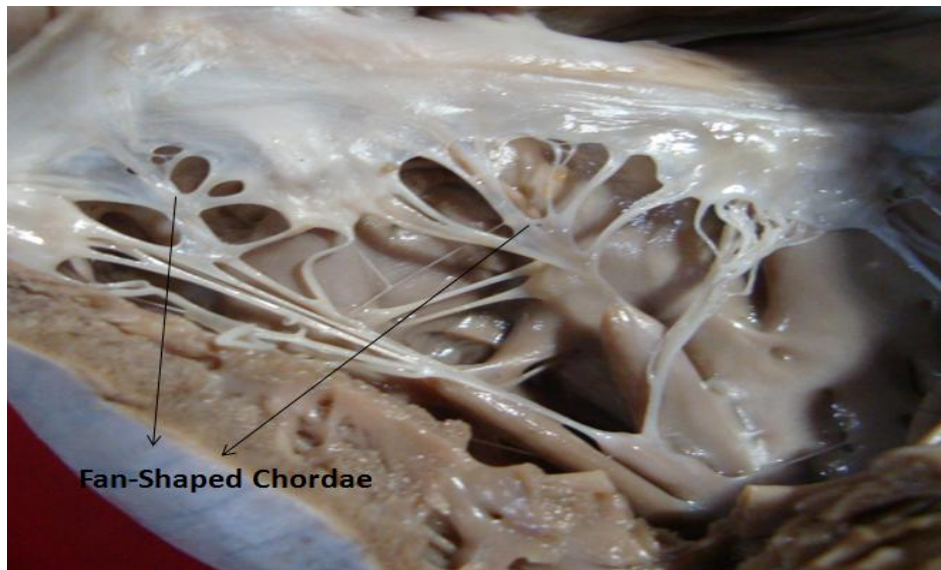


Figure 2 : Chordae forming net like pattern before attaching to Septal Leaflet.

