

Attachment of the Chordae to the Tricuspid Valve – A Study

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Abstract: The structures supporting the tricuspid valve leaflets are called chordae tendinae. They are collagenous. They are also known as tendinous cords. The tricuspid valve cusps are attached into the atria, during ventricular contraction, by the chordae. Tension in the chordae tendinae is regulated by specialized muscles called papillary muscles which contract along with the ventricular muscle. The chordae tendinae are attached to the papillary muscles. The chordae tendinae have been found to be involved in causing valve dysfunction and have shown variations in their number and attachment causing tricuspid valve dysfunction. Hence, the study was undertaken to describe their morphology and report any variations. 96 hearts were studied, which were collected from cadavers allotted to undergraduate students for dissection, over a period of time. Hearts were removed by dissection method. Window dissection of the anterior ventricular wall and the posterior right ventricular wall exposes both the papillary muscles & the chordae tendinae. The following types of Chordae tendinae were observed. They were 5 in number and were as follows: Basal chordae, Fan shaped chordae, free edge chordae, rough zone chordae and Deep chordae. No abnormal deviations were observed.

Keywords: Chordae tendinae, papillary muscles, Tricuspid valve muscles.

INTRODUCTION

There tricuspid valve has 3 three tissue flaps which separate the right atria and the right ventricle. The ventricular surface of the valve is roughened by the attachments of the chordae [1]. Tendons known as Chordae tendinae are found in the tissue flaps of the AV valves (often called Cusps). The tricuspid valve cusps are attached into the atria by the chordae during ventricular contraction.

Tension in the chordae tendinae is regulated by specialized muscles called papillary muscles which contract along with the ventricular muscle [2].

The right ventricle has 3 papillary muscles, 2 major and 1 minor. The major papillary muscles are situated in the anterior and posterior positions while the minor papillary muscle is medial. In addition, several smaller and variable muscles attached to the ventricular septum. The fibrous collagenous structures supporting the valve leaflets are chordae.

Two types of cords are seen in the ventricles: True and False Cords

True cords: from margins of the apical thirds of the papillary muscles or from small projections on the tips of the papillary muscles, the true cords arise. The bases of the papillary muscles or the ventricular walls or the septum directly give origin to the true cords. The free margins of the leaflets provide attachments to the true cords.

False cords: These act as bridges between the papillary muscles. They also connect the muscles to the ventricular wall, including the septum or may pass directly between points on the wall (and/or septum). They vary in number and dimensions in the right ventricle.

Tandler first classified the true cords into 1st, 2nd & 3rd order chordae but various other morphological types have also been described. They are: Fan shaped, Rough zone, Free edge, Deep & Basal chordae.

Fan shaped chordae

Their branches radiate from a short stem to attach to the tip (margin), other zones of apposition

between leaflets and to the ends of adjacent leaflets, on their ventricular aspect.

Rough zone chordae

Usually splits, into 3 components after arising from a single stem & is attached on the ventricular aspect, to the free margin and to some intermediate point on the leaflet.

Free edge chordae

Often long, threadlike, single and, passing from either the base or apex of a papillary muscle to a point close to the midpoint of a leaflet or one of its scallops.

Deep chordae

Long, branching to various extents, passing beyond its margins, reaches the more peripheral rough zone or the intermediate clear zone.

Basal chordae

Short and muscular or long and slender, round or flat ribbons. They take origin from the smooth or trabeculated ventricular wall and attach to the basal component of a leaflet [3].

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MATERIALS & METHODS

96 hearts were studied. They were collected from cadavers allotted to undergraduate students for dissection, over a period of time, in Dr B R Ambedkar Medical College, K G halli, Bengaluru 560045. Hearts were removed by dissection method.

Methods

Window dissection of both the anterior and posterior right ventricular walls exposes the papillary muscles and the chordae. A transverse incision is made about 1cm below the tricuspid valve starting from the left to the inter-ventricular septum and from here a vertical incision is made up to about 1cm above the apex. The papillary muscles and the chordae are found on the anterior wall as well as the septum. The posterior papillary muscles and the chordae are seen by a similar procedure.

The chordae arising from each papillary muscle are identified; their types, number and any variations are noted and tabulated. The same is done for the papillary muscles.

RESULTS AND DISCUSSION

Results

Three papillary muscles were observed in the ventricle & named according to their situation in the walls of the ventricle. The chordal attachments to the leaflets were observed for any variations in their numbers, types or absence.

- The types of chordae observed were; Basal, Fan shaped, free edge, rough zone and Deep chordae. No abnormal deviations were observed.
- The number of chordae attached to the papillary muscles is as follows:
 - a) Anterior papillary muscles - 2 to 8 chordae.
 - b) Posterior papillary muscles -1 to 6 chordae.
 - c) Septal papillary muscles -1to10 chordae.
- Variation in the number of papillary muscles is as follows:
 - a) Anterior papillary muscle – 1-2
 - b) Posterior papillary muscle - 1-3 and
 - c) Septal papillary muscle - 01

Discussion

M.D Silver *et al.*, [4] dissected 50 normal tricuspid valves. Based on the chordal morphology and mode of insertion, they identified fan-shaped, rough zone, basal, free edge, and deep chordae. They observed that the free edge and the deep chordae are unique to the tricuspid valve as the fan-shaped chordae when present, can be used to define the commissures between the leaflets. In their absence, other landmarks may be used for commissural definition. They also observed that once the commissures are defined, the tissue between the commissures can be regarded as part of the anterior, posterior, or septal leaflet.

They also observed that a leaflet's components can be identified as follows: (a) recognition of notches in the free edges of the anterior and septal leaflets (b) insertion of rough zone chordae and (c) the presence of scallops in the posterior leaflet. They also opined that, structures formerly regarded as accessory leaflets were incorporated into one of the three leaflets [4].

Escando G Guillot *et al.*, [5] A new type of tendinous cord in the tricuspid valve was identified by them, which was different from the 4 types described earlier. They called it the 'Mixed cord'. The mixed cord was a cylindrical tendinous cord which always ramified into branches and these branches attached to the valve

by expansions, the orientation of which was perpendicular or parallel to the ring [5].

Sokolov VV and Litvinova [6] In 50 cardiac preparations of various ages (children, teenagers, adolescents, persons of mature and elderly age), described characteristics related to the valves of the human hearts, based on the distribution and attachment of chordae tendinae to the valves of the human hearts.

Their results were as follows:

- There is increase of in the number of the 1st order chordae in the mature age and a decrease in the elderly age At the same time there is an increase in the number of chordae of the 4th, 5th, and 6th orders.
- In the elderly single chordae of the, 8th and 9th order can be found.
- Attachment of various chordae to the cusps of the AV valves is age specific, which could be related to functional peculiarities of their different zones, which ensure air tightness of atrio-ventricular openings.

They reported numerical differences in the attachment of chordae to certain cusps of the right and left AV valves related to the mechanism of closure of the cusps [6].

Nigri GR *et al.*, [7] In 79 normal human hearts studied the following characteristics of the papillary muscles and tendinous cords of the right ventricle were studied (a) number, (b) incidence, (c) length and shape of the anterior, septal, and posterior papillary muscles and (d) the number of tendinous cords attached to each papillary muscle at their origin. In situ measurement of the papillary muscles and the tendinous cords as well as after removal of the right AV valve (tricuspid valve) was done.

Their results were as follows; [A] (i) Presence of Anterior papillary muscles- 100 %. (ii) Presence of Septal papillary muscles- 75 %. (iii) Presence of Posterior papillary muscles - 100 %. [B] Number of heads of papillary muscles: (i) Anterior papillary muscle - 1 head: 8.1 %, 2 heads: 16.5%, 3 heads: 12.7%; 4 heads: 7.6 %, (ii) Posterior papillary muscle - 1 head: 25.4%, 2 heads: 46.8%, 3 heads- 21.5%; 4 heads-

6.3% [C]. Length of the papillary muscle: 11.53mm in length [D]. Number of tendinous cords: (i) In the APM- 1-11(mean-4.74) (ii) In the PPM- 1-8(mean-2.67) (iii) In the SPM- 1-5(mean-1.77) [7].

Wafae N *et al.*, [8] conducted studies on 50 human hearts of both sexes on the; (i) Area of the cusp (ii) width of the cusp base (iii) relation between cusp depth and commissure depth and (iv) morphological criteria such as the presence of AV cusp node, number of tendinous cords, perimeter of the fibrous ring and properties of papillary muscles. They found that, in 65% of cases commissural cusps were found independent of the number of tricuspid cusps and that the tricuspid valve was not consistently tricuspid, but was observed to present, 2, 4, 5 or 6 cusps in 72% of cases [8].

Various authors 1990, 2004 observed variations in the distribution of chordae tendinae to the leaflets [9], the number of papillary muscles [10, 11], number of leaflets in the tricuspid valve [10] and the presence of supernumerary leaflets [8].

Victor S and Nayak studied 100 normal human hearts and reported that numerous variations were present in the arrangement of the cusp tissue and chordal/ papillary support of the ventricular wall and observed that these made the interior of the ventricles as unique to each individual as one's fingerprint [10].

The present study was confined to reporting various types of chordae and their attachments [1]. The types of chordae identified were: (a) Free edge chordae (b) Fan shaped chordae (c) Rough zone chordae (d) Deep chordae and (e) Basal chordae [2] the cusps were three in all cases. No accessory cusps or commissural cusps were found [3] No variations were found in any of the hearts [4]. In the present study: (i) Papillary muscles – 100% in all the 3 walls (anterior, posterior and septal walls). Heads of papillary muscles: (a) APM- 1 head – 90 hearts; 2 heads- 06 hearts, (b) PPM- 1 head- 62 hearts; 2 heads- 26 hearts; 3 heads- 08 hearts (c) SPM- 1 head- 95 hearts; 2 heads- 01 heart.

Tables showing the attachment of the chordae to the different parts of the leaflets

Table-1: Showing Number and Type of Chordae Attached To the Tip of Valve Leaflets

Number & type of chordae attached to the tip of the tricuspid valve leaflets						
Sl No	Leaflets	Free edge chordae	Fan shaped chordae	Rough zone chordae	Deep chordae	Basal chordae
01	Anterior	1-2 per leaflet(32/96)	1-6 per leaflet(88/96)	Nil per leaflet	Nil	Nil
02	Posterior	1-5 per leaflet(30/96)	1-5 per leaflet(116/96)	01 per leaflet	Nil	Nil
03	Septal	1-3 per leaflet(33/96)	1-6 per leaflet(85/96)	01 per leaflet	Nil	Nil

Table-2: Showing Number and Type of Chordae Attached To the Base of Valve Leaflets

Number & type of chordae attached to the base of the tricuspid valve leaflets						
Sl No	Leaflets	Free edge chordae	Fan shaped chordae	Rough zone chordae	Deep chordae	Basal chordae
01	Anterior	1-2 per leaflet(2/96)	1-2per leaflet(02/96)	01 per leaflet	13 per leaflet(13/96)	20 per leaflet (20/96)
02	Posterior	1-5 per leaflet(05/96)	1-2per leaflet(2/96)	02 per leaflet	06 per leaflet (06/96)	16 per leaflet 16/96)
03	Septal	1-3 per leaflet(03/96)	0 per leaflet(0/96)	02 per leaflet	01 per leaflet (01/96)	04 per leaflet 04/96)

Table-3: Showing Number and Type of Chordae Attached Between the Base and Tip of the Valve Leaflets

Number & type of Chordae tendinae attached between the base and the tip of the tricuspid valve leaflets						
Sl No	Leaflets	Free edge chordae	Fan shaped chordae	Rough zone chordae	Deep chordae	Basal chordae
01	Anterior	1-2 per leaflet(02/96)	Nil	54 per leaflet(54/96)	14 per leaflet(14/96)	Nil
02	Posterior	1-2 per leaflet(02/96)	Nil	43 per leaflet (43/96)	07 per leaflet (07/96)	Nil
03	Septal	Nil	Nil	49 per leaflet (49/96)	08 per leaflet (08/96)	NIL

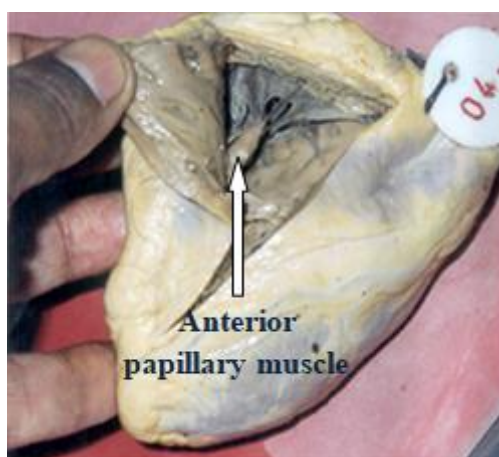


Fig-1: Anterior papillary muscle (arrow)

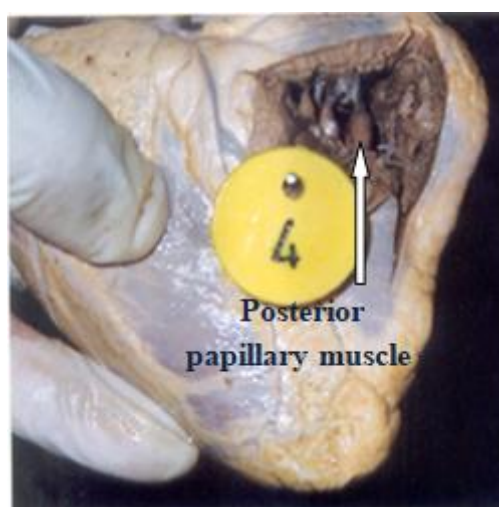


Fig-2: Posterior papillary muscle (arrow)

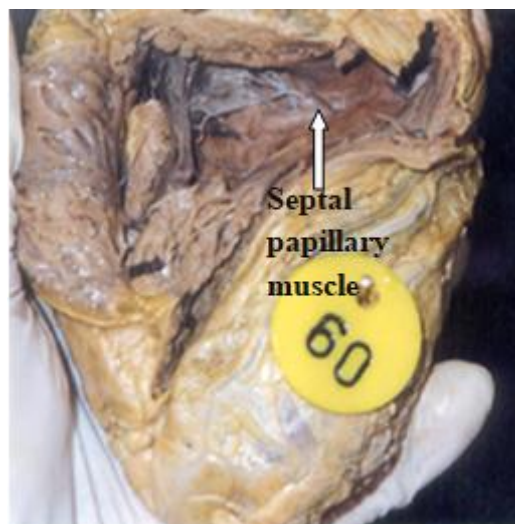


Fig-3: Septal papillary muscle (arrow)

CONCLUSIONS

The study of the attachments of the chordae tendinae is important for the simple reason that they support the tricuspid valve leaflets by attaching at various points on the latter's ventricular surface. Chordae vary in their attachment and number, resulting in defective closure of the valves. Variations in the attachment of the chordae or their absence may cause prolapse of the leaflets. Hence, this knowledge helps the cardiac surgeons in performing the corrective surgery.

The chordal attachment to the valve is age specific i.e. it differs in different age groups in the manner of distribution and attachment of chordae to the valves. There is variation in the density of the chordae in male and female and also in density in different leaflets.

SUMMARY

Chordal attachments of the leaflets, was observed, for any variations in their numbers, types or absence. The 5 types of chordae observed with no abnormal deviations were; Basal, Fan shaped, Free edge, Rough zone and Deep chordae.

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