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Original Research Paper

Anatomy

MORPHOLOGICAL AND MORHOMETRIC STUDY OF SEPTOMARGINAL TRABECULAE (MODERATOR BAND)

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ABSTRACT

BACKGROUND AND OBJECTIVES:

Septomariginal trabeculae or Moderator band is a specialized bridge connecting interventricular septum to the base of the anterior papillary muscle. It contains Right Bundle branch of HIS, it is also Known to prevent the over distension of the rightventricle. The literature review shows the paucity of articles related to morphological and morphometric evaluation. Since it has a great clinical importance its, further studies become Mandatory. Here we have measured the Length, the thickness, the Height from the tricuspid orifice, the angle of the Moderator band to its origin from theinterventricular septum and the anterior papillary muscle is measured. The superficial marking of Moderator band on the sternocostal surface of the right ventricle is marked. The morphological variations are noted. The results are compared with gender, with the previous results.

METHODS:

50 Formalin soaked cadaveric Hearts were taken from the department of Anatomy of KSHEMA. 36 Males and 14 Female Hearts were tagged according to ascending order of the age. Moderator band length, thickness, height, the angle with the anterior papillary Muscle ect are Noted.

RESULT:

The average Length of the moderator band is found to be 15.06 mm. The average thickness of the Moderator band is found to be 4.70 mm. viiThe average Height of the Moderator band is found to be 23.64 mm The average angle between the anterior papillary muscle and moderator band is found to be 910 The average angle between the interventricular septum to the moderator band is found to be 550. The average Length of the junction of the anterior papillary muscle and moderator band to the right border is found to be 3.13 cm on the sternocostal surface. The average Length of the junction of the anterior papillary muscle and moderator band to the apex of the Heart is found to be 5.06 cm on the sternocostal surface. The average Length of the junction of the interventricular septum and moderator band to the right border is found to be 4.71 cm The average Length of the junction of the interventricular septum and moderator band to the apex of Heart is found to be 5.40 cm. The average Length of Moderator Band on the sternocostal surface is found to be 17.00 mm, directed to the right and downwards, occupying the centre portion on the sternocostal surface of the right ventricle.

CONCLUSION:

There is a difference in upper border and lower border length as well difference in thickness measured in septal, papillary and at the midpoint of the moderator band, both in male and in females. The height measured from the viiisupraventricular crest may be more precise when compared to the same measured from the tricuspid valve. Difference in depth, morphological variations is noted in male and female heart specimens.

KEYWORDS : Septomarginaltrabeculae, Moderator Band, Anterior Papillary Muscle, False chordae tendenae, Right ventricle.

1. INTRODUCTION

The Heart is a muscular organ about the size of a closed fist that functions as the body's circulatory pump. It takes in deoxygenated blood through the veins and delivers it to the lungs for oxygenation before pumping it into the various arteries.

The heart sits within a fluid-filled cavity called the pericardial cavity. The walls and lining of the pericardial cavity are a special membrane known as the pericardium. Pericardium is a type of serous membrane that produces serous fluid to lubricate the heart and prevent friction between the ever beating heart and its surrounding organs. Besides lubrication, the pericardium serves to hold the heart in position and maintain a hollow space for the heart to expand into when it is full. The pericardium has 2 layers—a visceral layer that covers the outside of the heart and a parietal layer that forms a sac around the outside of the pericardial cavity.

The right ventricle extends from the right atrium to near the apex of the heart, triangular in shape. The sternocostal surface of the heart is convex and rounded and forms major portion of anterosuperior surface. Under surface of right ventricle forms part of diaphragmatic surface and rest on diaphragm. The cavity of the right ventricle forms a semi lunar shape due to the bulging of the interventricular septum. The pulmonary artery originates from the conus arteriosus, which is located left upper angle of the right ventricle. The Aorta is connected by a tendinous band which extends upward from the right atrioventricular fibrous ring and connects the posterior surface of the conus arteriosus. The left ventricular wall is three times thicker than the wall of the right ventricle. The thickness of the wall of the right ventricle is more towards the base of the heart and gradually narrows down towards the apex. Both right ventricle and left ventricle can carry approximately 85cc of blood during systole.

1The parts present in the right ventricle are as follows:.
The tricuspid vale complex (TCV), atrioventricular orifice, pulmonary orifice with semi lunar valves. There presents group of Papillary muscles and chordae tendinae .The trabeculae carneae covers most anterior surface with bridges and ridges.

There is a atrioventricular orifice which is the large oval aperture of communication between the right atrium and ventricle. It measures about 10cm in diameter and is situated at the base of the ventricle and is considerably larger than the orifice or atrioventriclar aperture of left sides and surrounded by a fibrous ring which is covered by the lining membrane of the heart. Right atrioventricular aperture is guarded by tricuspid valve and is sufficient to admit the ends of four fingers.

The opening of the pulmonary artery is guarded by the pulmonary semilunar valves. It is circular in form, and situated at the summit of

the conus arteriosus which in turn located close to the ventricular septum. It is placed above and to the left of the atrioventricular opening.

The tricuspid valve is formed by the duplication of the lining membrane of the heart. It is strengthened by the layers of the fibrous tissue which intervenes at places. The central part is strong and thick and marginal parts are translucent and thin. Sometimes small intermediate segments can be noticed between them. Thus, there are usually 3 cusps are seen. The largest cusp is termed infundibular cusp or anterior cusp. In relation to marginal of the right ventricle there is the second cusp called as marginal cusp or posterior cusp. In relation to interventricular septum there exists the third or the septal or medial cusp. The largest cusp is interposed between the right atrivoventricular orifice and the conus arteriosus. The bases of the cusps are attached to the fibrous ring surrounding the right atrioventricular orifice and they also joins to one another to form a continuous 2annular ring, consists of three somewhat triangular cusps or segments. The margins and apices of the cusps, give attachment to a number of delicate tendinous cords, the chordae tendinae**.** Their atrial surfaces, directed toward the blood current from the atrium, are smooth, their ventricular surfaces, directed toward the wall of the ventricle and are rough and irregular

Fig. 1: Heart seen from front

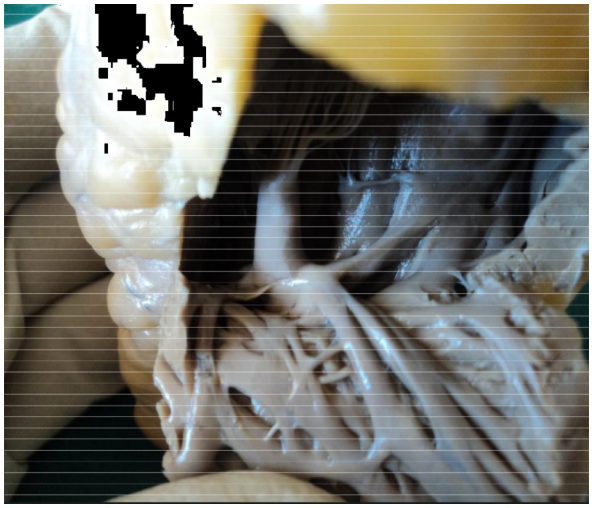


Fig.2: Interior of right ventricle after reflecting sternocostal surface

The trabeculae carneae are rounded or irregular muscular columns which project from the whole of the inner surface of the ventricle, with the exception of the conus arteriosus. They are of three kinds: a) some are attached along their entire length on one side and merely form prominent ridges b) some are fixed at their extremities but free in the middle. c) Third set are continuous by their bases with the wall of the ventricle, while their apices give origin to the chordae tendineae which pass to be attached to the segments of the tricuspid valve.

There are two papillary muscles, anterior and posterior. The 3rd or septal papillary muscle is not always present and not well defined. The anterior papillary muscle is the larger, and its chordae tendineae are connected with the anterior and posterior cusps of the valve: the posterior papillary muscle sometimes consists of two or three parts; its chordae tendineae are connected with the posterior and medial cusps. In addition to these, some chordae tendineae spring directly from the ventricular septum or from small papillary eminences on it, and pass to the anterior 4and medial cusps.

A muscular band, well-marked in sheep and some other animals, frequently extends from the base of the anterior papillary muscle to the ventricular septum. From its attachments it may assist in preventing over distension of the ventricle, and so has been named the moderator band[1]**.**

The pulmonary semilunar valves are three in number, two in front and one behind, formed by duplicators of the lining membrane, strengthened by fibrous tissue. They are attached, by their convex margins, to the wall of the artery, at its junction with the ventricle, their free borders being directed upward into the lumen of the vessel. The free and attached margins of each are strengthened by tendinous fibres, and the former presents, at its middle, a thickened nodule .From this nodule tendinous fibres radiate through the segment to its attached margins, placed one on either side of the nodule immediately adjoining the free margin. Between the semilunar valves and the wall of the pulmonary artery are three pouches or sinuses (*sinuses of Valsalva*).

In spite of numerous studies devoted to the septomarginal trabecula, the opinion of researchers is not uniform. The controversies focus mostly on its structure, phylogenies, and function. Only a few papers precisely describe its morphology,

but the still incoherent nomenclature imposes some significant limitations[2].

In 1837 King named it as the "moderator band" since, according to his concept, the trabecula limited the excessive expansion during diastole of the right ventricle[3].

The term "septomarginal trabecula" was first used by Tandler[4] based on its attachments: proximal (the septum), and distal (the wall). Nowadays, both terms are used interchangeably.

5This specialized bridge, septomarginal trabeculae, extends from the ventricular septum running towards right side and downwards to get attached to the base of the anterior papillary muscle projecting on the inner aspect of the sternocostal surface of the right ventricle. From its attachments it is clear that it may assist in preventing over distension of the ventricle, and so has been named the moderator band[1.] The septomarginal trabecula forms the antero-inferior border between the superior, smooth outflow tract of the ventricle and the trabeculated inflow tract. At its septal attachment, it is continuous with the supraventricular crest. Hence moderator band is often used by radiologists and obstetricians to more easily identify the right ventricle in prenatal ultrasound.

The moderator band, another marker for the morphological right ventricle, takes off from the body of the ventricular septum to cross to the parietal wall carrying within it a fascicle of the right bundle branch of the atrioventricular conduction system[5] allowing

coordinated contraction of the anterior papillary muscle. The right branch of 'His' bundle within the muscular part of the septum located is proved to be continuous with the moderator band. The results of analyses prove a relatively constant character of the presence of the conduction system within the moderator band[6]. The analyses of the functional characteristics and probable clinical implications of the pathology of the moderator band seem to be very interesting. Moreover, there are numerous studies confirming the presence of bifurcations of the right branch of His' bundle, as a constant element of the septo-marginal trabecula. Bargmann precisely describes the course of the conduction system fibres in the right ventricle, with a detailed division of the right bundle branch into the specific bunches. Thus, some probable pathologies occurring within the band, most often the ischemic in origin, can constitute an important aetiology of conduction disturbances of the heart[2,7].

6A large branch from the left anterior descending artery passes along the length of the moderator band in the right ventricle. This artery, which measured up to 1000 micro meter in diameter in hearts ,with prominent moderator bands may constitute an important part of the supply of the anterior papillary muscle of the right ventricle[7]. Any damage to moderator band might cause ischemia of distal structure. The moderator band or other large trabeculations, is the major obstacle for the repair of apical ventricular septal defects. The morphometric study of moderator band may help the surgeons during surgical procedures conducted for correction of such defects[8]. It can be helpful as a landmark in situations where the ventricles may be ambiguous (i.e. in some forms of congenital heart disease).

Moderator band artery lies in the first three anterior septal arteries, most often in the second one. In relation to the short axis of the heart, the artery of the moderator band can either follow a horizontal path to the septal papillary muscle of the right ventricle or an oblique route to the moderator band, depending on the position of its source. The moderator band artery has anastomotic connections at the base of the anterior papillary muscle of the right ventricle with various branches of the right coronary artery, which means that it can play a key role in collateral circulation following obstruction of the coronary arteries[9]. Collateral flow to the right ventricular myocardium, especially through the moderator band artery, protects against massive infarction in the presence of proximal right coronary artery occlusion[10].

The moderator band can be a source of premature ventricular contractions,
monomorphic ventricular tachycardia, and idiopathic ventricular fibrillation [11].

Moderator band is a normal structure and identifies a morphological Right Ventricle. If not properly evaluated it may be confused with a mass near Right Ventricular apex.[12].

7In order to do an efficient examination of the foetal heart during antenatal scan, it is important to use the standard foetal views .It is only through the standard view obstetrician or radiologist can identify the moderator band and diagnose the anomaly. Superior displacement of the moderator band is quantifiable by 2-dimensional echocardiography and may help to predict which infants with a Ventricular septal defect are at risk to develop sub pulmonary obstruction[13].

The right atrium is located anterior and to the right of the left atrium which lies posterior over the spine (obstetric ultra sound) .Although the Right Ventricle is usually on the right side of the heart and connects with the pulmonary artery, the anatomic Right Ventricle is defined by its structure and not by its position or connections. Features which help differentiate the anatomic Right Ventricle from anatomic Left Ventricle include 1) the more apical insertion point of the septal leaflet of the tricuspid valve relative to the anterior leaflet of the mitral valve 2) the presence of a moderator band 3) the presence of more than 2 papillary muscles, and 4) the trileaflet configuration of the tricuspid valve[14].

The trabeculae carneae begin to form at a rather early stage of prenatal development – their delicate structure can be observed at the 4th-5th week of foetal age. Firstly, two layers start to develop within the primary myocardium. A compact one (the peripheral layer) and a spongy one (the medial layer). The intense division of the cardiomyocytes of the spongy layer leads to the formation of the typical trabeculae. The local, radial concentration of these elements forms papillary muscles, which further, within the area of the atrioventricular outlets, transform into bundles known as chordae tendineae. At the 9th week of foetal age one can distinguish the septomarginal trabecula and the anterior papillary muscle of the right ventricle[2].

8The significant discrepancy of the literature data in both defining the moderator band structures and grading their clinical implications seems to fully justify detailed studies[2]. This present study intends to throw more light on morphology and morphometric evaluation of the moderator band. The length, the thickness, the height, the angle it forms with the interventricular septum and with the anterior papillary muscle is measured; the height is measured from both tricuspid valve annulus and from supraventricular crest as the land mark. The depth of moderator band to anterior papillary junction and the depth of junction of moderator band to the interventricular septum is measured from the sternocostal surface of the right ventricle and the surface marking of the moderator band is measured by noting its distance from the moderator band –papillary junction, moderator band – interventricular septal junction to the right border of the heart and to the apex of the heart. We also studied the morphological variations in all aspects, the difference in males and females .The results are tabulated and compared with previous results. Since there is less studies done on morphology of moderator band, our study is more aimed at differentiating the male and female characteristics, variations and the superficial surface marking of the moderator band on the wall of the right ventricle, on sternocostal surface in precise. The directions given in locating the moderator band will be of importance in anatomical dissection, guide to the surgeons and radiologists.

91.1 REVIEW OF LITERATURE

HannahSugirthabai Rajila Rajendran et al[15] (2015)

In their study morphometric and clinical analysis of moderator band in humans they found moderator band in all 50 specimens. The average length was found to be 14.71 4.9mm, the average thickness was 4.97 1.64mm, average distance from the tricuspid orifice was 19.85 5.9mm. The attachment to the anterior papillary muscle was found to be branched in 8 hearts and had a incidence of 14%. The septal end were branched and separated in only two specimens. Only one specimen had branched attachments on both apical and septal ends. In their study the incidence of origin of moderator band close to tricuspid orifice is 25%, midway between orifices to apex is 40% and towards the apex is 35%.

Raghavendra A.Y.et al[16] (2013)

In their study on 'Anatomical study of moderator band', they found moderator band in most cases. 5 moderator band origins visibly well separated from the surface of the interventricular septum. Out of twenty specimens of heart they could observe the presence of moderator band in seventeen specimens and in rest three it was not visible for record. In the their study out of seventeen specimens the moderator band was well separated from the muscular wall in 14 throughout its course, in another three it was found to be tethered to the muscular wall . A thin sheet of plastic could not be inserted between the wall and the moderator band. In as many as 14 specimens moderator band was arising from the lower segment of crista supraventricularis. In only three specimens, the single connection to anterior papillary muscle was found. In fourteen specimens it showed multiple connections to the anterior wall of

the right ventricle. Prominent septal portions were seen in eleven specimens as it is seen clearly emerging 10from the interventricular septum. In all other specimens the papillary portion was muscular thick and prominent. In two specimens they could see a thin slender moderator band with prominent papillary portion. Septoparietal trabeculations were found extending from the anterior margin of the septomarginal trabecula to the parietal wall in five specimens. In many other specimens there were multiple minor trabeculations extending from moderator band.

The average length of the moderator band was 13.82mm with the Standard deviation of +/-3.94mm and the average thickness was 4.46mm with the Standard deviation of +/- of 1.36mm. The average distance from tricuspid valve was 3.6cm with the Standard deviation of +/- 1.016735cm

Mamatha H et al[17] (2013)

In their study, 'A morphometric study of septomarginal trabeculae on south Indian cadavers' they found moderator band in all 30 specimens. Thickness of Septomarginal trabeculae less than 1mm was reported in their study. The thickness ranging between 2 to 5mm is found in 12 specimens and more than 5mm in 17 specimens. The length of the moderator band ranging from 5 to 10 is reported in 3 specimens, between 10 to 20mm in 26 specimens and more than 20mm in only 1 specimen. The height of the attachment of the moderator band is measured by considering the supraventricular crest as Land Mark .Height found to be more than 20mm in 28 specimens, and less than 20mm in 2 specimens. Based on their observation they classified moderator band in to single and double types. 28 specimens were found to be single type which was further sub divided into simple and complex type. 18 specimens were found to be simple variety where no branching is reported. In reaming 10 specimens the branching is noted at the papillary end and not at the septal end. 2 specimens were found to be double type variety where there were 2 moderator bands attached to 11intraventrucular septum separately to the base of the anterior papillary muscle. According to mode of attachment of moderator band to the intraventricular septum they classified thick and adherent and thin and adherent. 20 specimens were found to be thick and adherent type and 10 specimens were found to be thin and adherent type.

Loukas M et al[8] (2010)

In their study on 'Anatomical observations of moderator band' they studied one hundred cadaveric hearts. They identified the moderator band in 92% of hearts. In just over a) two-fifths (42%), the moderator band was a short and thick trabeculation. whereas, in b) one-eighth (12%), it was long and thick. In just under c) one-quarter of the hearts (24%), the band was short and thin and finally whereas it was d) long and thin in 14% of the hearts. In the remaining eight hearts, they were unable to identify the moderator band. The mean thickness of the band was 4.5 +/-1.8 mm, and its mean length was 16.23 +/- 2.3 mm, ranging from 11.3 to 24.3 mm. According to these measurements, they were able to classify the band as originating A) Less than 45% of the distance from the tricuspid valve to the apex (closer to tricuspid valve), which was seen in 12 hearts, between B) 45 and 55% of the distance from the valve to the apex, seen in 45 hearts, and C) Greater than 55% of this distance (closer to the apex), seen in thirty nine specimens.

S.T.F. Bandeira et al[18] (2011)

S.T.F Bandeira and team in their study on 'morphological classification of septomarginal trabeculae in humans' translated the article found on Moderator band which was basically written in Latin and French to English, the summary of those are as follows.

A. Horand examined 120 human hearts and put forward a classification based on the type of adhesion between the convex lower margin of the septomarginal trabecula and the ventricular wall. He concluded that three types were present: 1) freely arched fascicle, which was considered rare (4%), in which the septomarginal trabecula extended from the septum to the base of the anterior papillary muscle or to the anterior wall 2) semi-free, mentioned as very frequent and 3) complete adhesion, which was the most frequent type.

B. Weinberg took into account not only the type of adhesion of the lower margin but also the number and thickness of the connections, thus classifying the septomarginal trabecula into three types: 1) single, with adhesion to the wall and connections to the anterior wall and anterior papillary muscle .2) several filaments, among which the true septomarginal trabecula would be the largest of them, located on the right side and not always connected to the anterior wall and

3) bridge type, connected directly to the anterior papillary muscle without ramifications.

C. Bagalá analysed the posterior face of the septomarginal trabecula in 150 human hearts and distinguished four types: a) free path in the ventricular cavity b) semi-free path, with ramifications to the anterior wall or to the septum c) midpoint of the posterior face of the trabecula connecting to the anterior papillary muscle and d) adhesion, similar to a third-order fleshy column.

D. Kocyanic and Mrvaljevic studied one hundred hearts and used measurements and statistical data to classify the septomarginal trabecula into several types a) in 6% of the hearts, the trabecula that is usually described was absent b) in 20%, the trabecula was robust, with adhesion along its lower margin to the internal face of the ventricular wall, presenting two to five ramifications, of which one terminated at the anterior papillary muscle and the others at the anterior wall, but sometimes with two to four ramifications from its upper face. And c) in 39%, they found an arched septomarginal trabecula, jumping from the interventricular septum to the anterior papillary muscle, in accordance with the classical description.

E. Depreux et al.Investigated 100 hearts from several mammals and, based on observations and measurements, classified three types of trabecula: A — muscular and thick, B — fibrous and thin, and C— fibromuscular.

F. Becker et al. defined the septomarginal trabecula as an extensive septal trabecula going from close to the valve of the pulmonary trunk to the apex and to the ventricular wall; and Kosinski et al. stated that the supraventricular crest and septomarginal trabecula were common and continuous elements.

A. Wafae et al. they used the first of these classifications and also took the septal component into account. In this earlier study by their group, the septomarginal trabecula was divided into three groups. Group A presented a septal portion and a long free portion, and included three subgroups (72%).Group B showed only the free portion, of short length, and also included three subgroups (16%) and Group C was intermediate, with characteristics common to the two other groups (10%).

B. They therefore proposed to classify the septomarginal trabecula in the their study by the following criteria. a) situation of the septal component visible or not b) type of fleshy column of septal-papillary component and c) shape of connection with the papillary anterior muscle, and based on these criteria they observed 8 different types of septomarginal trabecula.

Classification:-

Group 1 — septomarginal trabecula with prominent septal portion, septal-papillary portion consisting of a second-order fleshy column, and single connection to the anterior papillary muscle (8.1%).

Group 2 — septomarginal trabecula with prominent septal portion, septal-papillary portion consisting of a second-order fleshy column, and complex connection to the anterior papillary muscle (24.2%).

Group 3 — septomarginal trabecula with prominent septal portion, septal-papillary portion consisting of a third-order fleshy column, and single connection to the anterior papillary muscle (5.0%).

Group 4 — septomarginal trabecula with prominent septal portion, septal-papillary portion consisting of a third-order fleshy column, and complex connection to the anterior papillary muscle (14.1%).

Group 5 — septomarginal trabecula without prominent septal portion, septal-papillary portion consisting of a second-order fleshy column, and single connection to the anterior papillary muscle (13.1%).

Group 6 — septomarginal trabecula without prominent septal portion, septal-papillary portion consisting of a second-order fleshy column, and complex connection to the anterior papillary muscle (21.2%).

Group 7 — septomarginal trabecula without prominent septal portion, septal-papillary portion consisting of a third-order fleshy column, and single connection to the anterior papillary muscle (6.1%).

Group 8 — septomarginal trabecula without prominent septal portion, septal-papillary portion consisting of a third-order fleshy column, and complex connection to the anterior papillary muscle (8.1%).

Although they are of the opinion that classification of the septomarginal trabecula is important for better anatomical and functional knowledge of this structure, they recognise the difficulties in establishing clear and objective criteria for grounding the suggested systems.

Paul Ravindran et al[19](1982)

In their study on 'The Moderator band', Moderator band was studied in 50 autopsy hearts. It was absent in 5 hearts. There was a wide variation in length and width .It appeared as the continuation of the septal end as band in eleven specimens. In the remaining specimens it arose from the lower part of the interventricular septum unconnected with the septal band. It was inserted to the lower end of anterior papillary muscle or to the anterior wall of the right ventricle or both. In one heart, it gave rise to a single chorda which replaced the anterior papillary muscle. The origin of two papillary muscles was noted in one specimen. Its role in fixation of endocardial leads, causation of intraventricular obstruction functional tricuspid incompetence and conduction disturbances are depends on morphology of the band. In 20 specimens they noted in addition to the classical moderator band, anterior and posterior vertical moderator bands. These described for the first time perhaps help to restrict the right ventricular distension.

Adam kosinski et al[2](2010)

In their study 'Morphogenetic aspects of the septomarginal trabecula in the human heart', they studied 220 human hearts in which 100 were adults. In most cases the trabecula originated from the upper part of the interventricular septum, separating at an angle increasing proportionally to the number of branches of the crista supraventricularis as well as the number of secondary trabeculae. The criteria established for their study, which they included the course of the trabecula in the lumen of the right ventricle and its relation to the anterior papillary muscle. They classified 4 types of septomarginal trabecula (I, II, III, IV). The most common was type III, the undivided trabecula, tightly connecting with the anterior papillary muscle.

The presence moderator band is confirmed in all hearts .The thickness of 2mm is observed in 7 hearts, 3mm thickness in 19 hearts, 4mm in 27 hearts, 5mm in 10 hearts, 6mm in hearts,7mm in 8 hearts, 8mm in 6 hearts, 9mm in 8 hearts and 10mm in 4 hearts.

The ratio of height of septomarininal trabecula branching from the crista supraventricularis(a) to the height of interventricular septum (b) is measured. The ratio a/b is 1/3 in 38 cases, 2/5 in 27 cases, and ½ in 21 cases. The results suggest the origin of moderator band at the higher end of interventricular septum.

The angle of the branching trabecula is divvied in 3 groups, 0^0-30^0 , 31^0-60^0, and 60^0-90^0 , with angle 0^0-30^0 , 20 cases with no bifurcation and 10 with dividing septomarginal trabecula were found. With angle range 31^0-60^0 , 14 cases were found without bifurcation and 9 cases with dividing septomarginal trabecula. With angle 60^0-90^0 , 29 cases without bifurcation and 16 hearts with dividing septomarginal trabecula were observed.

They proposed 4 morphological types. Type 1, septomarginal trabecula of variable thickness was a solid structure, not segmented into septo-papillary and papilo-mariginal parts. 3% belongs to this type. Sub type 1a was a configuration were papillary muscle was located at the anterior wall, high on the vertical trabecula and not firmly connected with the septomarginal trabecula. Its fibres derived from the anterior wall as well as the region of the right ventricular apex. In sub type 1b anterior papillary muscle was firmly connected to anterior wall of the right venrticle, while the septomarginal trabecula reached the muscle independently, below the attachment of the muscle. All 3 adult hearts belong to sub type b.

Within the distinguished Type 2 and Type 3 the septomarginal trabecula was also a solid, one piece structure, undivided by the anterior papillary muscle. The difference between Type 1, Type 2 and Type 3 was a tight attachment of the base of the anterior papillary muscle to the anterior wall of the right ventricle.

Type 2 of the trabecula characterized by contiguous partial connection with the anterior papillary muscle and partially with anterior wall of the right ventricle. Sub Type 2a determined by the trabecula adjoining the muscle, 7 cases belonged to this type. Sub Type 2b was characterized by was consolidation of septomarginal trabecula and anterior papillary muscle, while the remaining segment of the septomarginal trabecula reached anterior wall of the right ventricle. Only 1 heart belongs to this type.

In Type 3, the trunk of the muscle attached to the anterior wall was tightly connected to the distal, parietal end of septomarginal trabecula. 45 hearts belonged to this category. In sub Type 3a where the trabecula reached almost half of its height, was found in 35 hearts. In sub Type 2b it was connected to the base of the anterior papillary muscle. 10 out of 45 belonged to this type.

In Type 4 a septo-papillary segment connecting the intervetricular septum with the anterior papillary muscle, and a papilla-marginal segment between the muscle and anterior wall of the right ventricle. 44 hearts belonged to this category. In Type 4a, a centrally located anterior papillary muscle divided septomarginal trabecula in to two parts. The single, solid papilla-marginal part and septo-papillary part. It was found in 12 hearts. The sub Type 4b a well developed and horizontally running septo-papillary segment tightly connected at its distal end with the anterior papillary muscle located parietally. 19 hearts belonged to his varity. In sub Type 4c a well developed, solid septo-papillary segment running crosswise through the lumen of the ventricle, No of trabecula branching from the muscle. 13 hearts belongs to this category.

R. C. Truex et al[20] (1942)

In their study the incidence and size of moderator band in man and in mammals, they dissected 500 Human hearts from museum specimens, fresh heart examine at autopsy. They measured the Length, the region of its greatest thickness(width) The septal attachment were the band fuses with the septum the apex of the right ventricle is matured. The thickness of the right and left ventricular wall to the Moderator band is compared. The Heart specimens were from 8 weeks to 85 years regardless of sex. The

extreme Range they found due to the small Heart of infants to the dilated and Hypertrophied Hearts. They found there is no notable variation in regard to ventricular thickness to the length or width of the moderator Band.

They confirmed the presence of moderator band in 57% of specimens, mean length was found to be 12.7mm, mean thickness was found to be 6.0mm,the height is measured as the attachment of moderator band to the septum to the apex of the right ventricle and is found to be 39.1mm.

Depreux R et al[21] (1976)

They studied comparative morphology of trabecula septomariginails in terrestrial mammals. Macroscopic morphology and histologic structure of the moderator band - trabecula septomarginalis - in 100 earthly mammals. They never found true septomarginal trabeculae in carnivores animals as anterior papillary muscle was located very low on the anterior wall of the right ventricle. Or at times bridge-shaped above the anterior interventricular groove and attached on both septum and anterior wall of the right ventricle. They came across three types of trabecula eptomarginalis a) Mostly (66%), the trabecula septomarginalis is a short and thick fleshy column. The ratio of length in mm and thickness in mm amounts to about 4 to 7 and can be regarded as reasonably constant within each variety group of study. Moreover the quotients measured namely, the length in mm ,the height of septum and Thickness of the trabecula in mm ,highest thickness of the anterior wall in mm (measured just beneath the tricuspid attachment) keep constant in each group they studied. In all cases, the trabecula septomarginalis supports the right branch of the atrioventricular bundle and a thin artery which originates from the left coronary artery and branches into the right coronary vessels within the anterior papillary muscle. venous capillaries were also observed in some of the specimens but was only found in the muscular pattern of moderator band.in other specimens they are not constant and mouth into the right ventricular chamber or run towards the septal veins around the atrioventricular node. Therefore whatever is the size, the trabecula septomarginalis must be regarded as the shortest pathway from the septum to the anterior wall of the right ventricle and is a mere band bearing the "right nodal pedicle".

They Investigated 100 hearts from several mammals and based on observations and measurements, Classified three types of trabecula: I— muscular and thick, II —fibrous and thin, and III – Fibromuscular.

Adam Kosiński[22]

et al In their study 'Morphological remarks regarding the structure of conduction system in the right ventricle'. It was observed that in most cases the right branch of His' bundle locates itself deep in the muscular tissue of the septum irrespective of age; it is clearly separate along its whole run and gradually penetrates the muscular tissue with its fibers. Hardly ever does the right branch of His' bundle locate itself on the surface, subendocardially, with a minimum penetration into the muscular tissue. Moreover, in most cases, elements of conduction system are present in moderator band. The main tissue constituting its stroma is above all muscular tissue and to a lesser extent, connective tissue. In addition to this, fat tissue in variable proportion was also observed. In cross sections of the moderator band a distinctively circumscribed stripe of fibers of the conduction system was found. However, one could also observe samples in which its identification was not possible.

Kosiński A et al[23]

In their study 'The crista supraventricular is in the human heart and its role in the morphogenesis of the septomarginal trabecula', the moderator band originating from the muscle of the intervetricular septum. Lower segment of crista supraventricularis found to be give rise to the muscular band in majority of specimens and it is well separated from the interventricular septum. The crista supraventricularis lies in the midpoint between the atrioventricular orifice and pulmonary trunk orifice. Within the right ventricle.

It must be noticed that the septomarginal trabecula was connected to and derived from the lower segment of the crista supraventricularis. 5 Types of division of the lower segment of crista supraventricularis were distinguished (A to E) which were equivalent to the types of differentiation of the moderator band.

SR Mittal et al[12] (2012)

Illustrated the clinical importance of thick moderator band in 26 years old asymptomatic male was diagnosed to have a mass lesion in right ventricular apex . Clinical examination, ECG and skiagram chest were normal. Transthoracic echocardiography revealed a thick moderator band near right ventricular apex. Rest of the right ventricle was normal. Transoesophageal echocardiography confirmed a thick moderator band in the right ventricle. Rest of right ventricular cavity was clear.

If not properly evaluated it may be confused with a mass near right ventricular apex. As opposed to a mass lesion or thrombus, Moderator band is connected between anterior papillary muscle and intraventricular septum.

HARSHA BR ET ALL[24] (2015)

In their cadaveric study on anterior and posterior papillary muscle of tricuspid valve, they studied 96 formalin fixed Human Heart , they found 3 anterior Papillary Muscle in 6 Hearts (6.3%) , Two Anterior Papillary Muscle in 24 Hearts(25%) and Only one APM (66%) . In all cases moderator band was found to be attached to the base of the anterior papillary muscle.

D Gopalan et al[25] (2011)

In their study they said, In Multi detector Row Computerised Tomography, the structure in each ventricle can be clearly distinguished .There are three muscular bands within the Right ventricle. One of the bands extends from the base of the anterior papillary muscle to the ventricular septum and may assist in preventing over distension of the ventricle. This is therefore called the moderator band can be distinguished with computerised tomographic scan. The parietal and septal bands form a prominent muscular shelf, the supraventricular crest, which separates the sinus and conus regions. This crest courses between the pulmonary and the tricuspid valves and assists in right ventricular free wall contraction towards the interventricular septum. It plays an important role in emptying the Right ventricle and closing the tricuspid valve.

They suggested that in recent years there has been tremendous expansion in MDCT and its cardiac applications. They have shown the possibility to make the comprehensive assessment to the right ventricle.

Mamatha Hosapatna et all[26] (2014)

In their study on morphology of papillary muscles in human adults; A cadaveric study, in fifteen formalin soaked Heart, they found Moderator band in all cases. In thirteen specimens it was attached to the lower third and two specimens it was attached to the middle and upper third of anterior papillary muscle. they found double anterior and posterior Papillary Muscle in few of the specimens. The length of Papillary Muscle was longer in the left ventricle when compared to the right ventricle which was statistically significant. In the right ventricle cone-shaped Papillary Muscle was identified in the majority of the cases, whereas flat topped Papillary Muscle was noticed in only two cases. The double headed anterior papillary Muscle was not associated with the existence of the septal papillary muscle in seven Heart specimens. They found double anterior papillary muscle in three specimens in right vertical.

SY Ho et al[5] (2006)

In their study they on 'Anatomy, echocardiography and normal dimensions of the heart', found out in some hearts, moderator band can be seen clearly as a Y shaped strap that cradles the ventriculo-infundibular fold between its arms. The arm that is directed posterio-inferiorly, medial papillary muscle inserted. The other arm points antero-cephalad and blends into the sub pulmonary infundibulum. The body of the Y is adherent to the septum in many cases but not in all. It appears as a bump on the septum when the sectional images are taken. The abnormal or hypertrophied moderator band can divide the right ventricular cavity into two chambers. The moderator band, another marker for the morphologically right ventricle, takes off from the body of the Y to cross to the parietal wall, carrying within it a fascicle of the right bundle branch of the atrioventricular conduction system. The insertion of the medial papillary muscle is the landmark for the more proximal portion of the right bundle branch. From there, it descends like a cord in the subendocardium of the septomarginal trabeculation, Moderator band.

Nicola Galea et al[27]

In their study on 'Right ventricular cardiovascular magnetic resonance imaging: normal anatomy and spectrum of pathological findings 'They stated that, the right ventricle has been defined as the "forgotten chamber", as its role in cardiac physiopathology has long been underestimated. Since right ventricle can be involved in many pathological conditions, its altered function will affect the overall clinical status of patients. Magnetic resonance imaging is proved to be effective mode of diagnosing the interventricular pathology. Although the right ventricle has complex morphology, thin myocardium and trabeculated apex, it can be accurately imaged by CMR, revealing its involvement in ischaemic and non-ischaemic heart disease. CMR has proven to be the pre-eminent modality in monitoring ventricular performance in congenital heart disease, pulmonary hypertension and cardiomyopathies. Most difficult diagnosis like Arrhythmogenic right ventricular cardiomyopathy and the recently revised task force criteria confirmed a crucial role of CMR to increase diagnostic accuracy, by combining detection of right ventricular dilation, regional wall motion and structural abnormalities such as ventricular defects, mass near the apex etc. Moreover, a multiparametric approach of CMR is often necessary for delineation and characterisation and accurate imaging of cardiac masses. Hence The Morphological variations and Morphometry of Moderator band as a marker of right ventricle visualization will help in diagnosing rare ventricular pathologies.

Nigri GR et all[28]

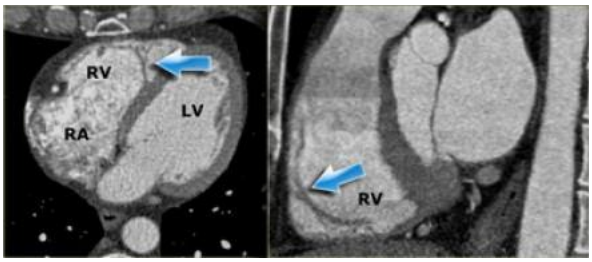
Studied a series of 79 normal human hearts, focusing on the 'morphological characteristics of the papillary muscles of the right ventricle and their tendinous cords (chordae tendineae)'. The number, incidence, length and shape of the anterior, septal and posterior papillary muscles were observed. The anterior and posterior papillary muscles (APM, PPM) were present in all specimens. The septal papillary muscle (SPM) was absent in 21.5% of the hearts. The APM presented 1 head in 81% and 2 heads in 19% it was 19.16 mm in length. The SPM was one-headed in 41.7% and presented two heads in 16.5% the presence of a 3 and 4 heads appeared in 12.7% and 7.6% respectively the SPM was 5.59 mm in length. The PPM had 1 head in 25.4%, 2 heads in 46.8%, 3 heads in 21.5% and 4 heads in 6.3% of the cases it was 11.53 mm in length.

Mathada V Ravishankar et al[29]

In their study 'A brief observation study of septomarginal trabaculae in cadavers' they studied 20 male cadavers between the age of 50 to 70.Their main focus wasto find out the incidence of the 2nd or additional moderator band. They recorded 2 specimens with 2 moderator bands which connects interventricular septum to the base of the anterior papillary muscle.

ineke Willems and Marieke Hazewinkel[30]

Radiology department of university medical centre Groningen and Medical Centre, Alkmaar, The Netherlands. They studied Cardiac Anatomy through computerized tomography, the image can be seen below:-



CT Scan[30]

Axial (left) and sagittal oblique (right) reconstructions showing the right ventricle. The blue arrow indicating the Moderator band.

1.2 AIMS AND OBJECTIVES

1. To study the morphology of septomarginal trabeculae in human hearts.

2. To study the morphometric variations of septomarginal trabeculae in human hearts.

3. To compare study variations both in morphology and morphometry with previous studies on septomarginal trabeculae in human hearts.

4. Classification according to type, sex, morphology and variations

2. EXPERIMENTAL METHODOLOGY

50 formalin soaked cadaveric heart chosen from the department of anatomy, KS Hedge Medical Academy, aged between 30 to 75, as obtained from the registry. 36 male and 14 female cadaveric hearts were taken. The hearts were tagged in accordance to ascending age, both in male and in female. Age is approximated as in registry wherever it was difficult to get the exact figure and labelled with 'star sign', as superscript in the results.

2.1 Inclusion and exclusion criteria

Only the adult male and female hearts were taken between the age group of 30 to 75.The heart with gross pathology, if any, externally or internally is excluded from the study. No foetal or neonatal hearts were taken.

2.2 Materials used

The surgical blade with scalpel, toothed and non-toothed forceps, and needle pointer, measuring tape, transparent protractor, digital Vernier callipers, ordinary thread, magnifier lens, Light source, display signs, hand digital camera and markers were used in each step during the study.

2.3 Medium used

All the hearts obtained from the routine dissection in anatomy department are preserved in 10% formalin with glycerine and thymic granules in plastic tub. Periodic changing of the fixative and preservative was done.

2.4 Methodologies

First a parallel incision is placed along the upper border of right ventricle, around 1.5 to 2cm below and to the right of the surfacement of the pulmonary trunk .Starting from the left end; the incision is dragged till the right border, making sure of the feel of cutting through the thickness of the ventricular wall. Care is taken not to cut the chordae tendinae of the anterior papillary muscle by introducing a finger and extending the incision.

The incision is extended from the right end, downwards .1cm parallel along the right border, continuously visualising the interior

as some of the papillary muscle will be attached at the higher end or towards the right border. Clots, debris found is washed with running water and/or removed with help of toothed forceps. In case of hard mass, first the mass is broken into pieces by sharp needle, such method will prevent any damage which can be caused in abrupt removal of the debris.

Once the anterior papillary muscle is visualised the incision from the left upper end is carried out, in parallel and, 0.5 cm from interventricular groove, visualising the interventricular septum, tracing down extending the incision to reach the origin of the moderator band. Care is taken not to pull the wall too anteriorly, as this might cause the tear of anterior papillary muscle.

Once the moderator band is defined, further careful extensions of the incisions are done in order to ease out the measurements.

In case of very thick walled heart, where the retraction and reflection becomes difficult, the upper sternocostal wall is dissected and detached completely till proximal to the papillary attachment. The fine clots or blood is removed with forceps and running water. A jet spray of water is used to remove all the fine particles which makes the view will be clearer for pictures to be taken.

2.4.1 Measurement of the length

The length is measured by using digital callipers from the septal end to papillary end in both upper or superolateral border and the lower or infero medial border.

In case of curved course of the moderator band, a ordinary thread is kept tracing the band and later the measurement of the thread is taken.

2.4.2 Measurement of the thickness

The thickness is measured at the septal end, papillary end and the midpoint connecting them. Both end thickness are taken at uniform ending or origins of the moderator band, the variation like fan shaped origin, division at its insertion and thickness of the branches are noted /taken separately.

2.4.3 Measurement of the height

The height of the band is taken in two methods. First, as the distance between tricuspid orifice at its left end and the lower margin of the annular ring to the origin of moderator band at its upper border. And second measurement from supraventricular crest, the land mark being the midpoint of atrioventricular orifice to the pulmonary orifice to the to the origin of moderator band at its upper border is taken, as done in some studies.

2.4.4 Measurement of the Angle

The Angle between the longitudinal axis of the moderator band to the longitudinal axis of interventricular septum is measured using the transparent protractor. The angle between the longitudinal axis of anterior papillary muscle and longitudinal axis of moderator band to its base is also measured.

2.4.5 Measurement of the depth

Measurement of the depth of the junction between the base of the anterior papillary muscle and the papillary insertion of the moderator band is noted by piercing needle probe trough the anterior wall of the right ventricle, followed by its measurement. The depth of the junction of moderator band to the interventricular septum is also measured in the same way.

2.4.6 Surface marking of moderator band on sternocostal surface of right ventricle.

Measurement of the superficial surface marking of the moderator band on the sternocostal surface of the right ventricle is done in following steps

1. A needle is inserted at the junction of band and the anterior papillary muscle. The distance from the right border and the apex is measured by keeping the heart in anatomical position and measuring the distance along line in horizontal direction meeting the right border, and line joining the point of the needle to the tip of apex of the heart.

2. The needle is inserted at the origin of the moderator band from the interventricular septum. The distance from it to the right border and to the apex of the heart is measured.

3. Distance between above two points is measured and the direction is noted on the sternocoastal surface of the right ventricle.

2.4.7 Recording the morphological pattern

Meticulous dissection is carried out to expose the septal and papillary attachment of the band to note the simple or complex mode of origin and insertion. The band is traced towards the papillary end .The branching variations is noted throughout its the course. Additional findings found are documented as 'peculiarities'. All the parameters obtained are plotted on the prior tables kept ready. Photo graphs are taken using digital camera.

2.4.8 Collection and recording of data.

The measurements taken are statistically analysed using SPSS software with the help of the statistician. All measurements are taken in millimetres except the surface marking , of which the readings are taken in centimetres. The results are compared with previous studies and variation in morphology and morphometry in males and in females are plotted in different tables and graphs.

Fig. 3: Digital Veinier Callipers

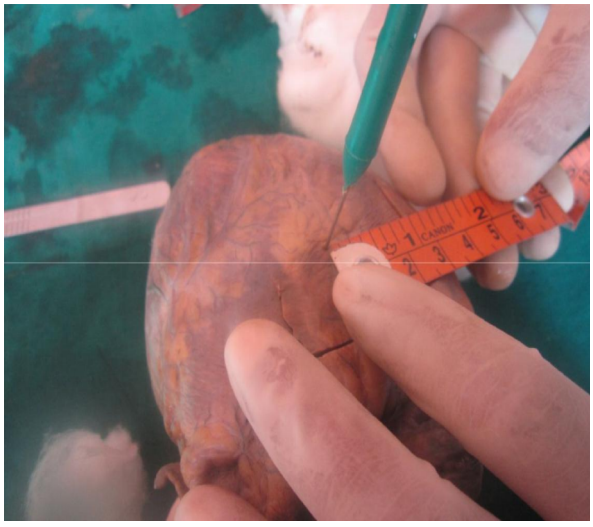


Fig. 4: Inserted Needle at the junction of Anterior Papillary Muscle & Moderator Band

Fig. 5: Instrument Used During the Procedures

Fig. 6: Measuring the Length of Moderator Band

Fig. 7: Measuring the distance between the junction of Anterior Papillary Muscle and Moderator Band to the right Border

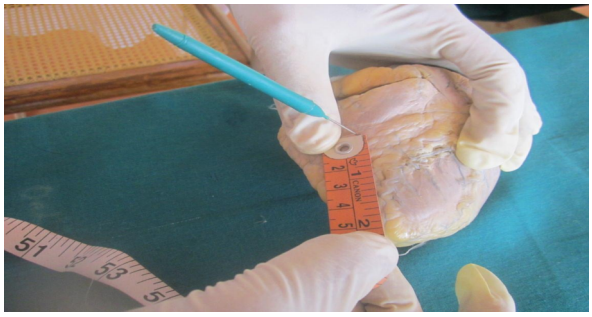


Fig. 8: Measuring the distance between the junction of Moderator band and Interventricular Septum to the apex of the Heart

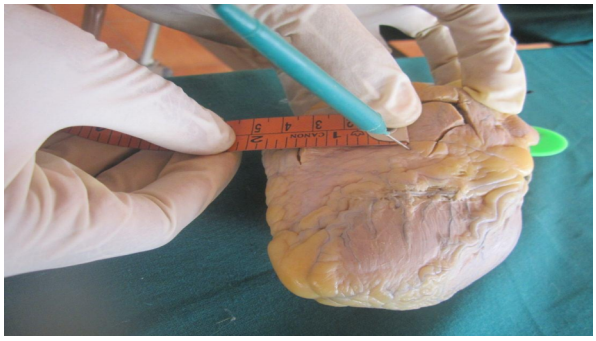


Fig. 09: Measurement of distance between moderate band and the interventricular junction to right border

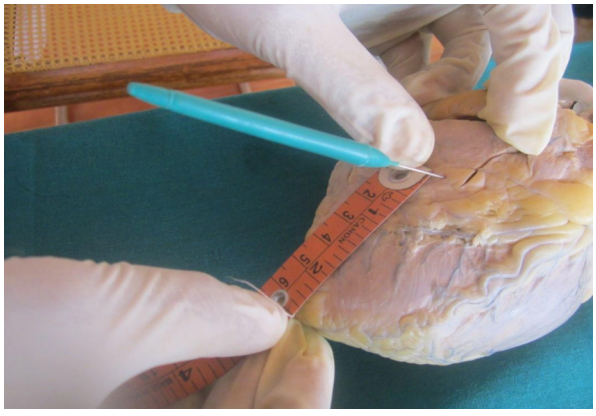


Fig. 10: Measuring the distance between the junctions of moderator band and interventricular junction to apex of the heart

Fig. 11: Measuring the distance between the tricuspid valve to the Origin of the Moderator band

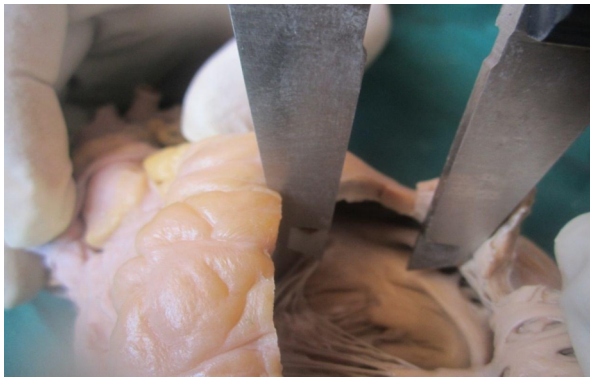


Fig. 12: Measuring the Height from supraventricular crest to the Origin of the Moderator band

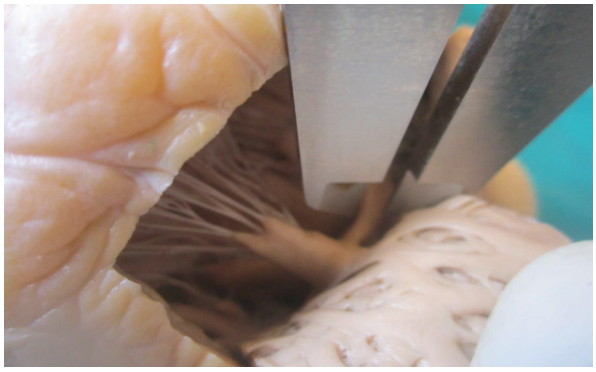


Fig. 13: Measuring the Thickness at the septal end of the Moderator band

Fig. 14: Measuring the Length of the upper Border of the Moderator band

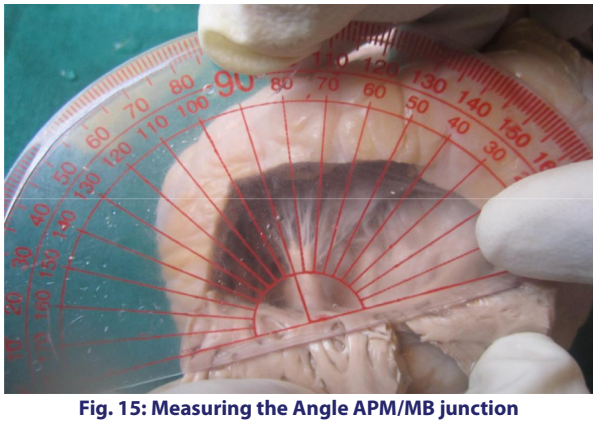


Fig. 15: Measuring the Angle APM/MB junction

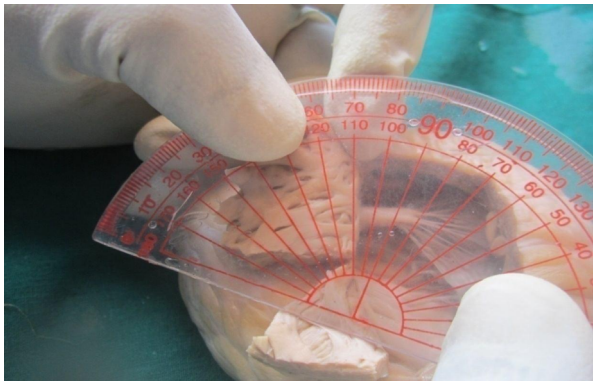


Fig. 16: Measurement of the angle at MB/ septal junction

Fig. 17: Measurement of the height (oblique view)

3 OBSERVATION AND RESULTS

3.1 Result- Length

The length of the moderator band is measured from the septal end to the papillary end using digital Vernier Callipers, the pointed divider or by placing the tread through the course of the moderator band on its upper and lower border and measuring its Length on scale. This method helps in getting accurate measurements.

In our study we found the mean length of the Moderator Band to be 15.06 mm.

The longest Moderator Band is of length 28mm. and the shortest one being 2.66mm. Since there was wide variation in origin, insertion and in the course of the Moderator Band, A tread is used to Measure the upper and lower border of the Moderator Band, whenever the course is found to be curved or tortuous.

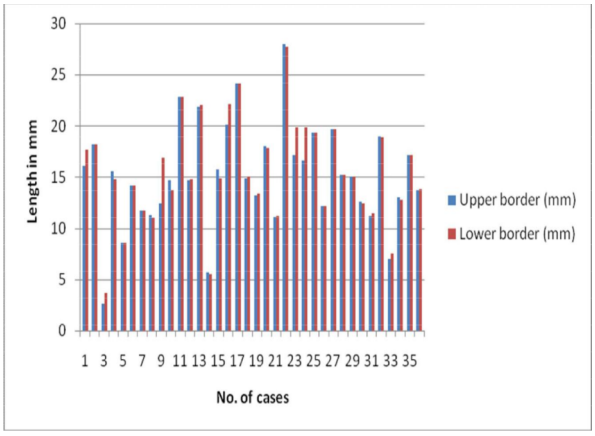
In few instances where partially or completely embedded lower border of Moderator Band ,only upper border reading is taken, whenever the accurate measurement couldn't be taken.

In most of the cases a thin Needle can be passed underneath the Moderator Band throughout its course except when it is partially embedded at the septal, papillary or with the wall of the sternocostal surface. The difference in the data of Male and Female are plotted in the chart. The difference in Length of Upper and Lower border is due to the difference in its attachment to the interventricular septum or to the APM. When it originates as two or more trabeculations or which later joins to form the proper band or divide before insertion to APM, only longest length is measured. The variations are recorded under morphology section.

Table No. 1: measurements of moderator band length (mm)in males

Specimen No	Age	Sex	Upper border (mm)	Lower border (mm)
1.	32		16.09	17.63
2.	37		18.16	18.16
3.	42		2.66	3.66
4.	48		15.60	14.74
5.	51		8.60	8.61
6.	53		14.15	14.15
7.	53		11.74	11.74
8.	59		11.24	11.00
9.	59		12.43	16.89
10.	60*		14.73	13.73
11.	60*		22.84	22.80
12.	60		14.71	14.74
13.	62		21.90	22.0

14.	62		5.70	5.50
15.	65*		15.78	14.88
16.	65		20.13	22.13
17.	65		24.12	24.10
18.	66		14.89	15.0
19.	66		13.24	13.40
20.	67		17.98	17.81
21.	67		11.1	11.2
22.	67		28.0	27.71
23.	68		17.14	19.89
24.	68		16.58	19.87
25.	68		19.3	19.30
26.	68		12.12	12.16
27.	68		19.65	19.65
28.	69		15.20	15.20
29.	69		15.02	15.00
30.	69		12.56	12.43
31.	70*		11.23	11.45
32.	70*		18.98	18.90
33.	70		7.00	7.50
34.	72		13.00	12.80
35.	72		17.16	17.16
36.	75*		13.7	13.8
Average			15.11	15.69
Standard Deviation			+/-5.08	+/-5.15



Graph No.1: Difference in length lower and upper borders in males

Fig.19 : Largest length MB(No M 22)

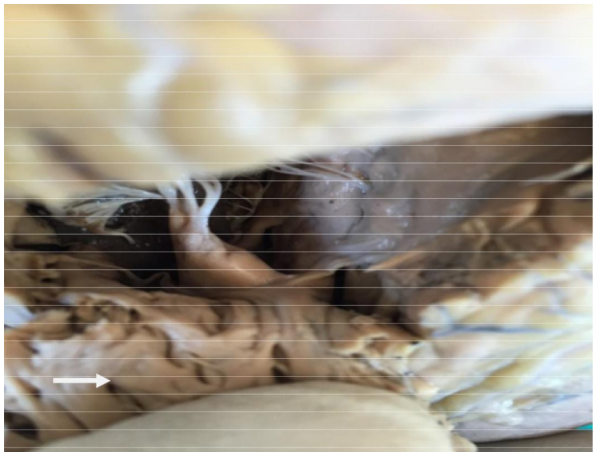
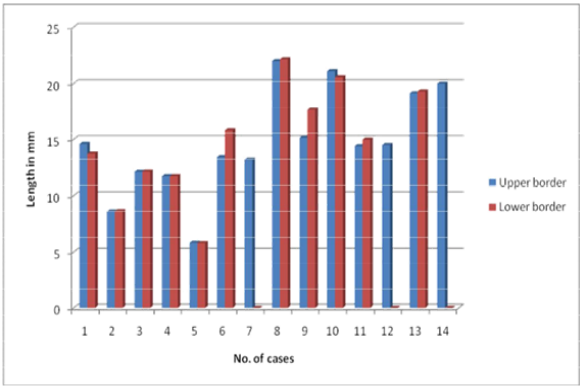


Fig. 20: Shortest Length (No M 3)

Fig. 21: Double headed APM with insertion of MB to its base and Anterior wall of the ventricle (No M 14)

Table No. 2: Length of MB in females

Specimen No	Age	Sex	Upper border	Lower border
01	32	F	14.60	13.74
02	38	F	8.60	8.62
03	58	F	12.13	12.15
04	58	F	11.74	11.74
05	59	F	5.83	5.80
06	60	F	13.43	15.80
07	60	F	13.20	-
08	62	F	22.00	22.15
09	62	F	15.15	17.65
10	65	F	21.10	20.56
11	65	F	14.40	14.98
12	67	F	14.50	-
13	68	F	19.13	19.30
14	70*	F	20.00	-
Average			14.70	14.77
Standard Deviation			+/-4.61	+/-5.03



Graph No. 2: Difference in length of MB in females

Fig. 22: Largest length MB in females (No F8)

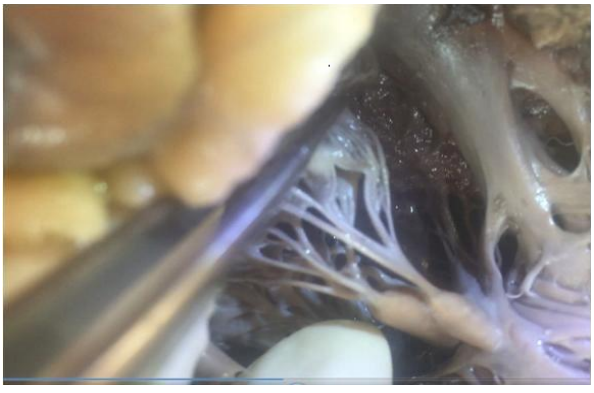
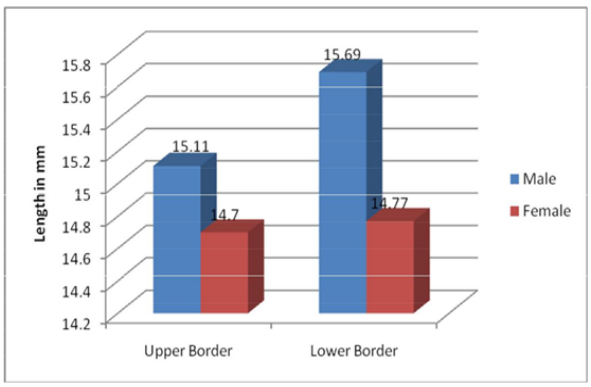


Fig. 23: Shorest and thinest MB also note 2nd MB(No F5)



Graph 3: Comparison in length in males and females.

3.2 Thickness:

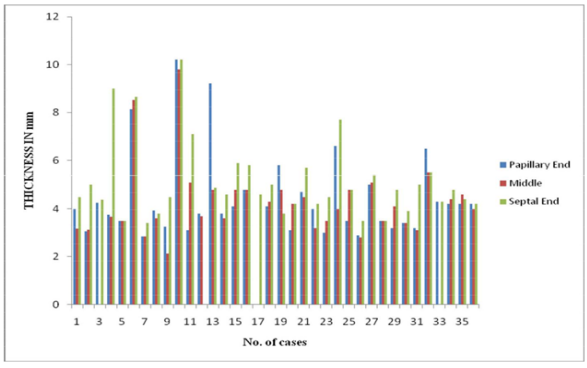
Thickness is measured at three points.

First at the Papillary end, Second at the Septal End and the Third at the mid of these Points. The mean average at septal end is found is 5.19mm. The mean average at the centre is, 4.41mm, and mean thickness at papillary end is 4.52mm. The average mean thickness in males is found to be 4.59. The average thickness in females is found to be 4.82. The over all thickness of moderator band is 4.70mm. The mean deviation the thickest Measurement being 10.20mm and thinnest one being 2.14mm.

At the three sites the values Measured is highlighted in the graphs. The difference in male and the female is plotted in the graph and tables. Due to the broad origin and insertion and its undue thinning or thickening throughout the course of moderator band is responsible for the variations found as shown in the figures.in case of short length of MB, or in case of partially buried ends, where the measurements couldn't be accurate ,only the clearly obtained readings are taken.

Table No. 3: Measurement of the Thickness

Specimen no	Age	Sex	Papillary End	Middle	Septal End
1.	32		4.00	3.17	4.50
2.	37		3.07	3.12	5.01
3.	42		4.26	-	4.38
4.	48		3.75	3.66	9.0
5.	51		3.5	3.5	3.5
6.	53		8.13	8.53	8.66
7.	53		2.84	2.84	3.4
8.	59		3.93	3.6	3.80
9.	59		3.25	2.14	4.5
10.	60*		10.20	9.80	10.20
11.	60*		3.1	5.1	7.1
12.	60		3.8	3.7	-
13.	62		9.22	4.8	4.88
14.	62		3.8	3.6	4.6
15.	65*		4.1	4.8	5.9
16.	65		4.8	4.8	5.8
17.	65		-	-	4.6
18.	66		4.1	4.3	5.0
19.	66		5.8	4.8	3.8
20.	67		3.1	4.2	4.2
21.	67		4.7	4.5	5.7
22.	67		4.0	3.2	4.2
23.	68		3.0	3.5	4.5
24.	68		6.6	4.0	7.7
25.	68		3.5	4.8	4.8
26.	68		2.9	2.8	3.5
27.	68		5.0	5.1	5.4
28.	69		3.5	3.5	3.5
29.	69		3.2	4.1	4.8
30.	69		3.4	3.4	3.9
31.	70*		3.2	3.1	5.0
32.	70*		6.5	5.5	5.5
33.	70		4.3	-	4.3
34.	72		4.2	4.4	4.8
35.	72		4.2	4.6	4.4
36.	75*		4.2	4.0	4.2
Average			4.43	4.28	5.08
Standard Deviation			+/-1.74	+/-1.49	+/-1.60



Graph No. 4: Difference in thickness at papillary middle and septal ends in males

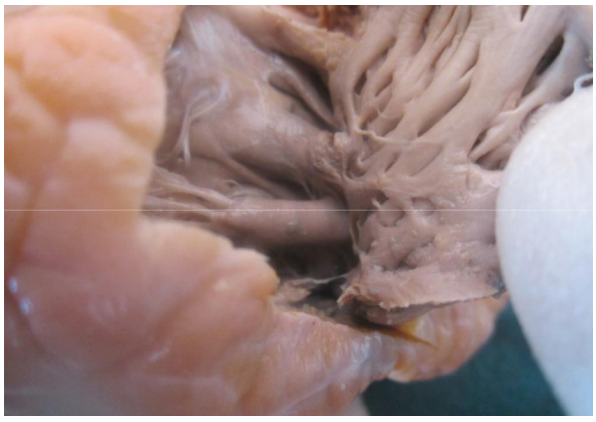


Fig.24 : Thickest MB (No M 10)

Fig.25 : The Thinnest MB (No M 7)

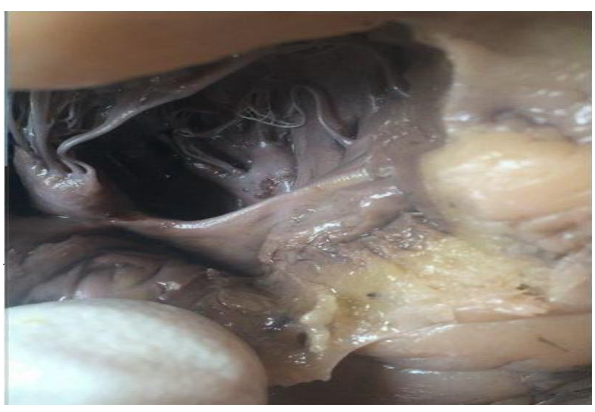
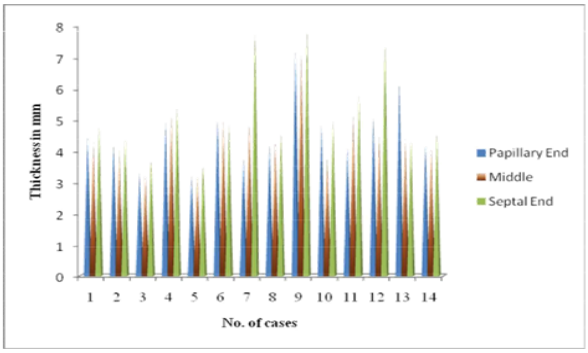


Fig.26 : Sheet like origin and insertion of MB(No M 6)

Table No. 4: Thickness of MB in female heart.

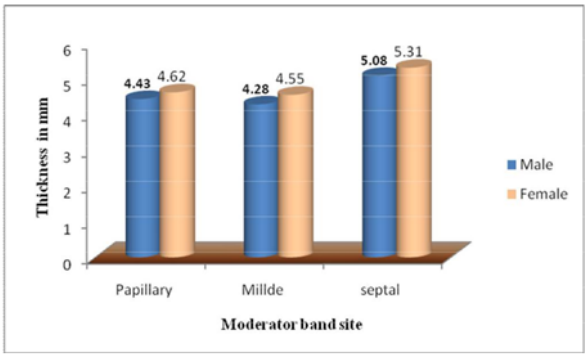
Specimen No	Age	Sex	Papillary End	Middle	Septal End
01	32	F	4.5	4.3	4.8
02	38	F	4.2	4.0	4.4
03	58	F	3.3	3.3	3.7
04	58	F	4.9	5.2	5.4
05	59	F	3.2	3.2	3.6
06	60	F	5.0	5.0	4.8
07	60	F	3.8	5.0	7.8
08	62	F	4.2	4.4	4.6
09	62	F	7.2	7.2	7.9
10	65	F	4.8	3.8	5.0
11	65	F	4.1	5.2	5.8
12	67	F	5.1	4.5	7.6
13	68	F	6.2	4.4	4.4
14	70*	F	4.2	4.2	4.6
Average			4.62	4.55	5.31
Standard Deviation			+/-1.06	+/-0.99	+/-1.44



Graph No. 5: Difference of thickness at papillary, middle and septal end in females

Fig. 27 : Thickest MB in females heart (No F 9)

Fig. 28: Thickest at septal end and partially embedded (No F 7)



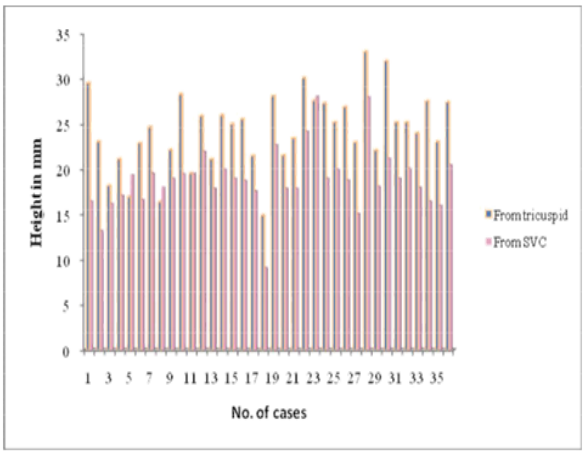
Graph no. 6: Comparison in thickness of MB in males and females

3.3 Height:

The Height is measured using vernier Callipers and pointed divider from two land marks. One from the annulus of left end of Tricuspid valve at its lower margin to the origin of MB at its upper border. and other being supraventricular Crest, the point taken is the mid point between the tricuspid orifice to the pulmonary orifice to the upper end origin of moderator band . The mean average Of the Height from the Tricuspid valve is found to be 23.64 mm. The highest Value is found to be 33mm and lowest one being 9.11mm. The comparative distance between Male and Female are plotted in the graph. Other Highlights are shown in the Figures.

Table No. 5 : Measurement of the Height in males.

Specimen no	Age	Sex	From tricuspid	From SVC
1.	32		29.55	16.49
2.	37		23.06	13.22
3.	42		18.20	16.20
4.	48		21.15	17.11
5.	51		16.96	19.37
6.	53		22.90	16.65
7.	53		24.70	19.56
8.	59		16.40	18.00
9.	59		22.15	19.00
10.	60*		28.31	19.50
11.	60*		19.57	19.57
12.	60		25.89	21.98
13.	62		21.13	17.89
14.	62		25.98	20.00
15.	65*		25.00	19.00
16.	65		25.54	18.78
17.	65		21.5	17.6
18.	66		14.9	9.11
19.	66		28.1	22.7
20.	67		21.55	17.88
21.	67		23.45	17.89
22.	67		30.1	24.2
23.	68		27.6	28.10
24.	68		27.3	19.00
25.	68		25.2	20.00
26.	68		26.9	18.8
27.	68		23	15.1
28.	69		33	28
29.	69		22.1	18.1
30.	69		32	21.2
31.	70*		25.2	19.0
32.	70*		25.2	20.1
33.	70		24	18
34.	72		27.55	16.49
35.	72		23.06	16.00
36.	75*		27.43	20.50
Average			24.32	18.87
Standard Deviation			+/- 4.14	+/- 3.45



Graph No. 7: Difference in height from tricuspid and SVC in males.

Fig.29 : Heightest Height of MB at TCV (No M 28)

Fig. 30: Lowest hieght of MB (No M 18)

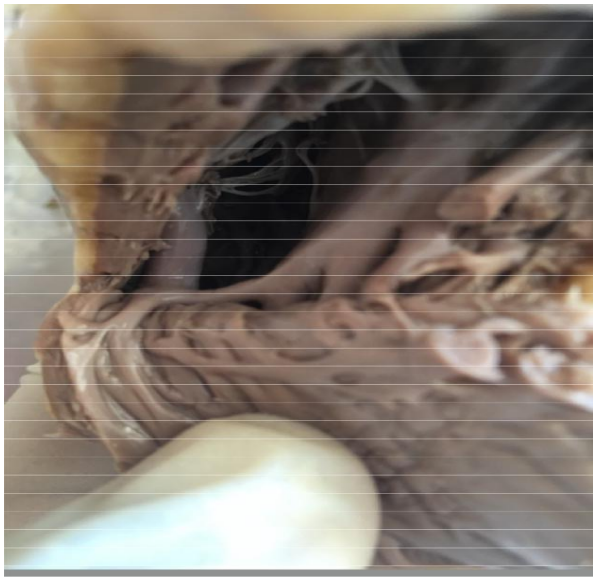
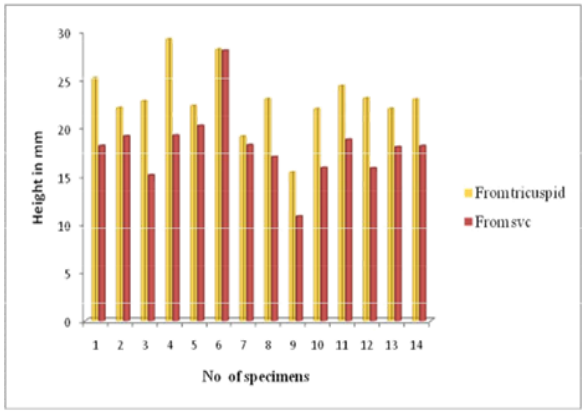


Fig. 31: Hightest distance from SVC (No M 23)

Table No. 6: Measurement of height in females

Specimen No	Age	Sex	From tricuspid	From svc
01	32	F	25.15	18.11
02	38	F	22.10	19.12
03	58	F	22.80	15.10
04	58	F	29.20	19.20
05	59	F	22.30	20.20
06	60	F	28.13	28.00
07	60	F	19.10	18.20
08	62	F	23.00	17.00
09	62	F	15.40	10.80
10	65	F	21.98	15.87
11	65	F	24.37	18.76
12	67	F	23.10	15.83
13	68	F	22.00	18.00
14	70*	F	22.98	18.10
Average			22.97	18.02
Standard Deviation			+/- 3.34	+/- 3.70



Graph No. 8: Difference in height from tricuspid and SVC in females

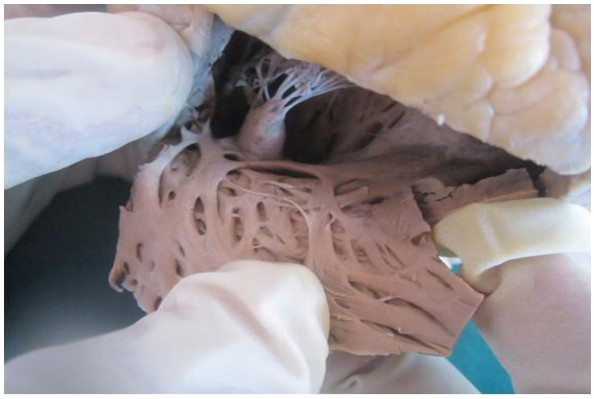
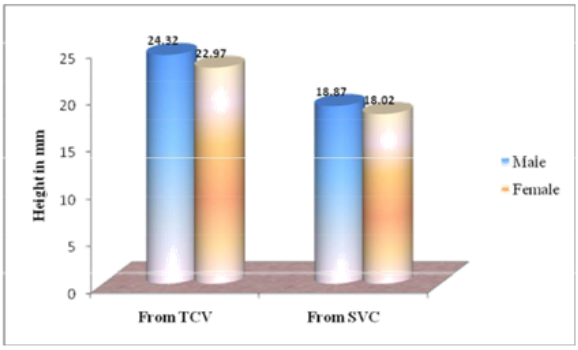


Fig. 32 : Highest height (No F 4)



Graph 9: Comparison of Height of MB in males and females

3.4 Measurement of the Angles:

The angles are measured in two junctions. Common transparent plastic glass Geometric protractor is used for the Measurement.

1. The angle between the longitudinal axis of the interventricular septum (IVS)to the Longitudinal axis of the Moderator Band.(moderator band to septal junction)

2. The angle between the Longitudinal axis of the anterior papillary Muscle to The Longitudinal axis of the Moderator Band.(moderator band to papillary junction)

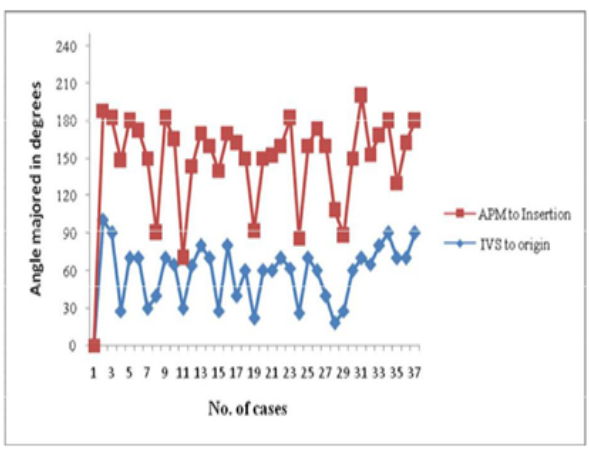
The average angle between the interventricular septum to the Longitudinal axis of the Moderator Band is found to be 1150. , measured from the upper end of attachment of moderator band or 600 when measured from the lower end of attachment of moderator band. The Highest value recorded to 1600 and the lowest one is 800 when measured from the axis of the inerventricular septum to the axis of the moderator band or 200 and 1000 when measured from the axis of the interventricular septum to axis of the moderator band from its lower attachment.

The average angle between the Longitudinal axis of the anterior papillary Muscle to The Longitudinal axis of the Moderator Band is found to be 800. The highest value recorded to be 1200 and the lowest one being 500 . The difference in male and female and the variations are plotted in the graph and represented in the diagrams.

Table No. 7: Measurements of the Angle in males

Specimen No	Age	Sex	Interventricular Septum to origin	APM to Insertion
1.	32		100	88
2.	37		90	92
3.	42		28	120
4.	48		70	110
5.	51		70	102

6.	53		30	120
7.	53		40	50
8.	59		70	112
9.	59		65	100
10.	60*		30	40
11.	60*		64	80
12.	60		80	90
13.	62		70	90
14.	62		28	112
15.	65*		80	90
16.	65		40	122
17.	65		60	90
18.	66		22	70
19.	66		60	90
20.	67		60	92
21.	67		70	90
22.	67		62	120
23.	68		26	60
24.	68		70	90
25.	68		60	114
26.	68		40	120
27.	68		18	90
28.	69		28	60
29.	69		60	90
30.	69		70	130
31.	70*		65	88
32.	70*		80	88
33.	70		90	90
34.	72		70	60
35.	72		70	92
36.	75*		90	90
Average			60	92
Standard Deviation			+/- 22	+/- 21



Graph No. 10: The difference of angle at septal and papillary end of MB in males

Fig. 33: Lowest angle at septal end of MB (No M 27)

Fig. 34: Heigest angle at the septal end, also note tortous course (No M01)

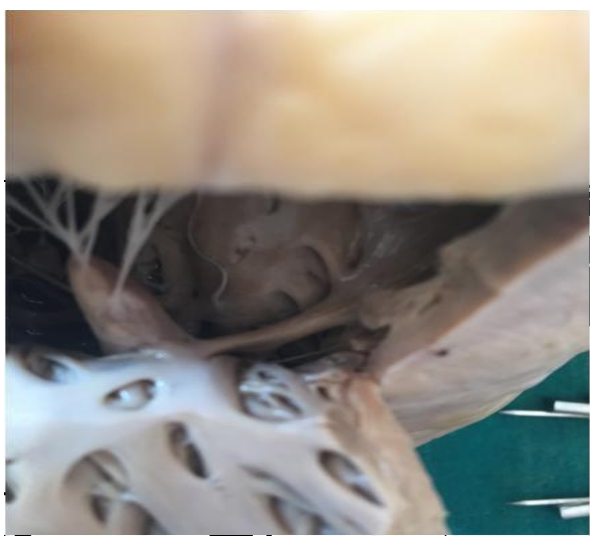
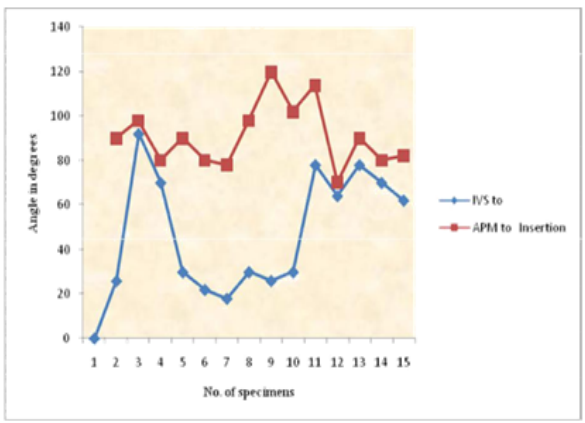


Fig. 35: Angle at septal 400 and papillary end 122° (NO M 16)

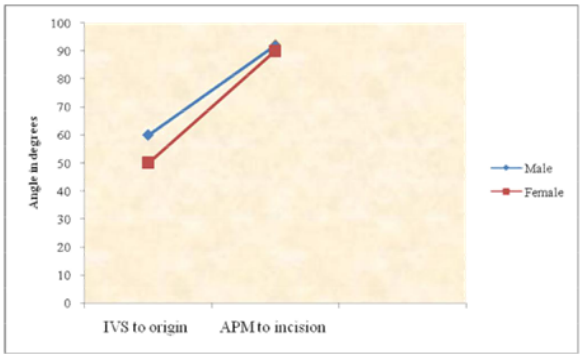
Table No. 8: In females

Specimen no	Age	Sex	IVS to origin	APM to Insertion
01	32	F	26	90
02	38	F	92	98
03	58	F	70	80
04	58	F	30	90
05	59	F	22	80
06	60	F	18	78
07	60	F	30	98
08	62	F	26	120
09	62	F	30	102
10	65	F	78	114
11	65	F	64	70
12	67	F	78	90
13	68	F	70	80
14	70*	F	62	82
Average			50	90
Standard Deviation			+/- 26	+/- 14



Graph No. 11: The difference of angle at septal and papillary end of MB in females

Fig. 36: Lowest angle at septal end (No F 6)



Graph No. 12: Comparison of angles in males and females.

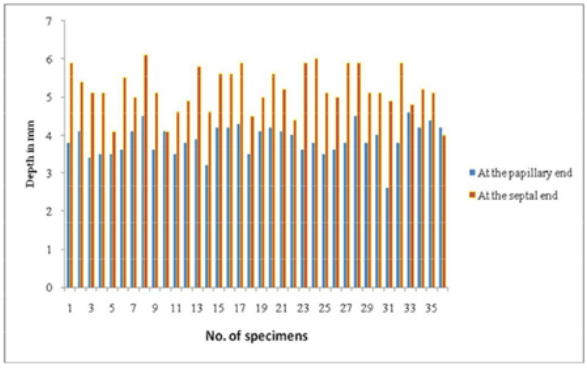
3.5 Measurement of the Depth:

The insertion of MB to APM is noted. A needle is passed through the anterior wall of sternocostal surface to this point; penetrated depth of the needle is marked and measured over scale. In similar way the septal end depth is also measured .The average depth in male and female, the difference is noted, compared and recorded on the graph and table.

Table No. 9: Measurement of the Depth /Distance in males

Specimen No	Age	Sex	At the papillary end	At the septal end
1.	32		3.8	5.9
2.	37		4.1	5.4
3.	42		3.4	5.1
4.	48		3.5	5.1
5.	51		3.5	4.1
6.	53		3.6	5.5
7.	53		4.1	5
8.	59		4.5	6.1
9.	59		3.6	5.1
10.	60*		4.1	4.1
11.	60*		3.5	4.6
12.	60		3.8	4.9
13.	62		3.9	5.8
14.	62		3.2	4.6
15.	65*		4.2	5.6
16.	65		4.2	5.6
17.	65		4.3	5.9
18.	66		3.5	4.5
19.	66		4.1	5.0
20.	67		4.2	5.6
21.	67		4.1	5.2
22.	67		4.0	4.4
23.	68		3.6	5.9
24.	68		3.8	6.0
25.	68		3.5	5.1
26.	68		3.6	5.0
27.	68		3.8	5.9
28.	69		4.5	5.9
29.	69		3.8	5.1
30.	69		4.0	5.1
31.	70*		2.6	4.9
32.	70*		3.8	5.9
33.	70		4.6	4.8
34.	72		4.2	5.2

35.	72		4.4	5.1
36.	75*		4.2	4.0
Average			3.87	5.19
Standard Deviation			+/- 0.41	+/-0.57



Graph No. 13: The difference in depth at septal and papillary junction of MB in males

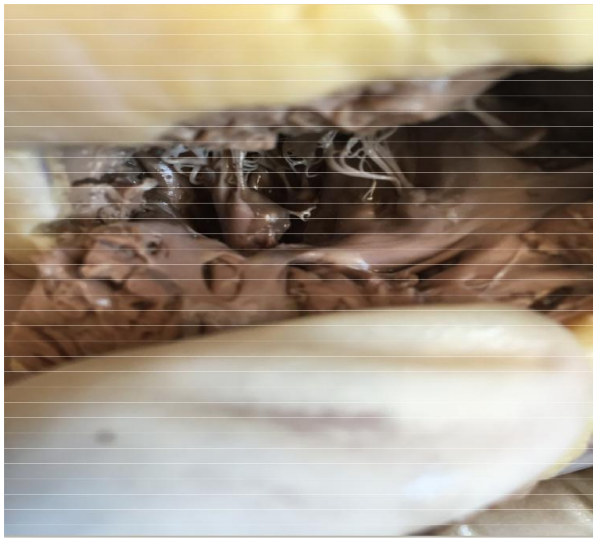
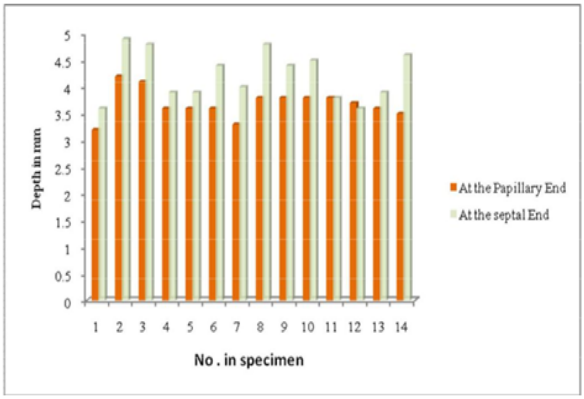


Fig. 37: Deeply placed MB/papillary juction. (No M 33)

Fig.38: Deeply placed MB and septal juction. (No M 8)

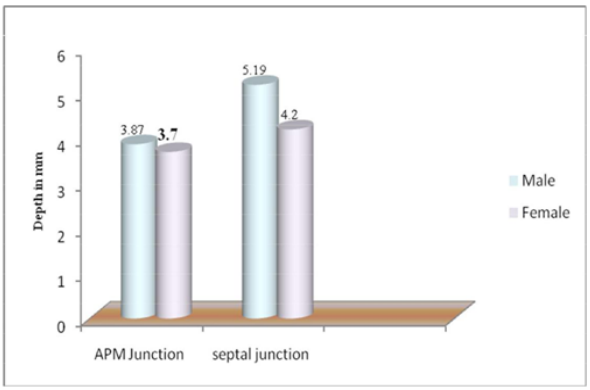
Table No. 10: Measurement of the Depth /Distance in females

SPECIMAN NO	AGE	SEX	At the Papillary End	At the septal End
01	32	F	3.2	3.6
02	38	F	4.2	4.9
03	58	F	4.1	4.8
04	58	F	3.6	3.9
05	59	F	3.6	3.9
06	60	F	3.6	4.4
07	60	F	3.3	4.0
08	62	F	3.8	4.8
09	62	F	3.8	4.4
10	65	F	3.8	4.5
11	65	F	3.8	3.8
12	67	F	3.7	3.6
13	68	F	3.6	3.9
14	70*	F	3.5	4.6
Average			3.7	4.20
Standard Deviation			+/-0.26	+/- 0.45



Graph No.14: The difference in depth at septal and papillary junction of MB in females

Fig. 39: Note the bridge shaped MB, most superficially placed both MB/papillary and MB/septal junction.(No F 1)



Graph No. 15: Comparison of depth of MB in males and females

733.6 Surface Marking of the Moderator Band Distance and Direction on the Sternocostal Surface of the right ventricle:

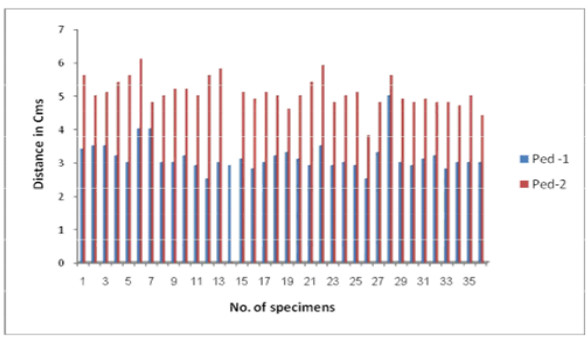
The measurements are taken at two points.
1. A sharp Needle is inserted through the anterior wall or sternocostal surface of the right ventricle, at the junction of anterior Papillary Muscle to the base of the Moderator Band. Further the distance between these points to the right border of the Heart is measured by keeping Heart in Anatomical Position and the distance between these points to the apex of the Heart. The average distance from this point to the right border is found to be 3.13cm and average distance from this point to the apex of the Heart is found to be 5.06cm. The Male and Female difference and variation are plotted in the graph.

2. The sharp needle is inserted through the anterior wall or sternocostal surface of the right ventricle, to the junction of Interventricular septum to the origin of the Moderator band. The distance between this point to the right border is measured by keeping the Heart in anatomical Position and the distance between this point to the apex of the Heart is Measured. The average distance from this Point the right border of the Heart is found to be 4.71cm and average distance from this point to the apex of the Heart is found to be 5.40cm The Deference in Male and Female and the variation are plotted in the graph and the table. The distance between the junction of the anterior Papillary Muscle to the base of the Moderator Band and junction of Interventricular septum to the origin of the Moderator band on the sternocostal surface of the right ventricle is measured. The average distance is found to be 1.7cm .The Male and Female difference and variation are plotted in the graph. Moderator band found to run from

74MB/septal junction to the right, downwards to join MB/papillary junction .however 6% it can be found running upwards and to the right as MB/septal junction is found to be located lower than the MB/papillary junction.

Table No. 11: Measurement of Distance Junction between Moderator Band & Anterior Papillary Muscle to Right Border of the Heart (Ped-1) and to Apex of the Heart (Ped-2)

Specimen no	Age	Sex	Ped-1	Ped-2
1.	32		3.4	5.6
2.	37		3.5	5.0
3.	42		3.5	5.1
4.	48		3.2	5.4
5.	51		3.0	5.6
6.	53		4.0	6.1
7.	53		4.0	4.8
8.	59		3.0	5.0
9.	59		3.0	5.2
10.	60*		3.2	5.2
11.	60*		2.9	5.0
12.	60		2.5	5.6
13.	62		3.0	5.8
14.	62		2.9	5..0
15.	65*		3.1	5.1
16.	65		2.8	4.9
17.	65		3.0	5.1
18.	66		3.2	5.0
19.	66		3.3	4.6
20.	67		3.1	5.0
21.	67		2.9	5.4
22.	67		3.5	5.9
23.	68		2.9	4.8
24.	68		3.0	5.0
25.	68		2.9	5.1
26.	68		2.5	3.8
27.	68		3.3	4.8
28.	69		5.0	5.6
29.	69		3.0	4.9
30.	69		2.9	4.8
31.	70*		3.1	4.9
32.	70*		3.2	4.8
33.	70		2.8	4.8
34.	72		3.0	4.7
35.	72		3.0	5.0
36.	75*	M	3.0	4.4
Average			3.15	5.08
Standard Deviation			+/- 0.44	+/-0.44

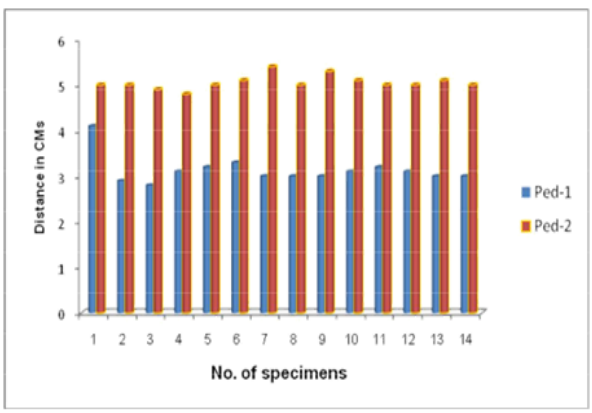


Graph No. 16: Measurement of distance from the junction between MB and APM to the right border and apex of the heart in males

Fig. 41: Note two origin and one insertion of MB and the shorest distance from Papillary juction to apex.(No M 36)

Table No. 12: Measurement of Distance Junction between Moderator Band & Anterior Papillary Muscle to Right Border of the Heart (Ped-1) and to Apex of the Heart (Ped-2)

Specimen no	Age	Sex	Ped-1	Ped-2
01.	32	F	4.1	5.0
02.	38	F	2.9	5.0
03.	58	F	2.8	4.9
04.	58	F	3.1	4.8
05.	59	F	3.2	5.0
06.	60	F	3.3	5.1
07.	60	F	3.0	5.4
08.	62	F	3.0	5.0
09.	62	F	3.0	5.3
10.	65	F	3.1	5.1
11.	65	F	3.2	5.0
12.	67	F	3.1	5.0
13.	68	F	3.0	5.1
14.	70*	F	3.0	5.0
Average			3.12	5.05
Standard Deviation			+/-0.30	+/-0.15



Graph No.17: Measurement of distance from the junction between MB and APM to the right border and apex of the heart in females

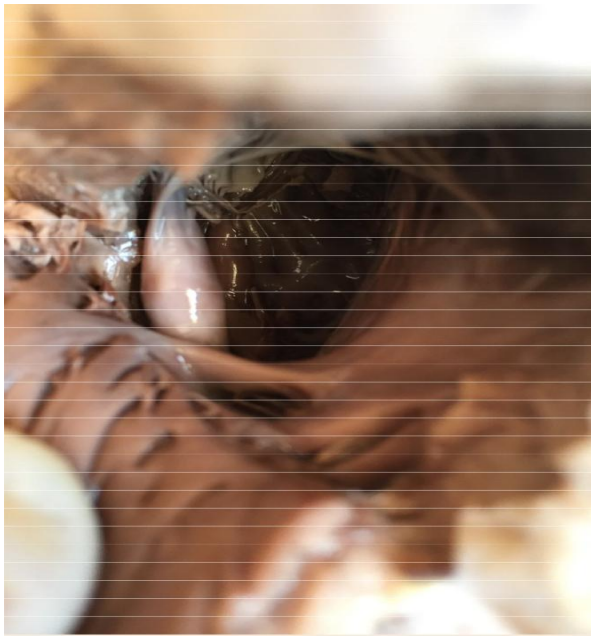


Fig. 42: Most laterally,deeply placed APM and noteMB/septal junction sligthly lower than the APM/MB juction.(No F 02)

Table No. 13: Measurement of Distance Junction between Moderator Band & Septal End to Right Border of the Heart (Sed-1) & to Apex of the Heart (Sed-2)

Specimen no	Age	Sex	Sed-1	Sed-2
01.	32		4.5	5.6
02.	37		5.2	5.1
03.	42		3.9	5.1
04.	48		4.9	5.4
05.	51		3.9	5.6
06.	53		4.9	5.6
07.	53		5.2	5.4
08.	59		5.0	5.2
09.	59		4.8	5.2
10.	60*		4.2	5.4
11.	60*		4.6	5.0
12.	60		4.9	5.6
13.	62		4.8	5.8
14	62		5.4	5.3
15.	65*		5.4	6.1
16.	65		4.9	4.9
17.	65		5.0	5.0
18.	66		5.2	5.6
19.	66		4.9	5.6
20.	67		4.8	5.2
21.	67		4.8	5.4
22.	67		5.9	5.9
23.	68		5.0	6.1
24.	68		4.9	6.0
25.	68		4.8	5.3
26.	68		3.8	3.7
27.	68		4.8	5.8
28.	69		5.8	6.6
29.	69		4.9	5.9
30.	69		4.8	4.7
31.	70*		5.0	5.9
32.	70*		4.8	5.4
33.	70		4.8	5.1

34.	72		4.1	5.4
35.	72		4.8	5.2
36.	75*	M	4.5	4.6
Average			4.83	5.40
Standard Deviation			+/-0.45	+/-0.51

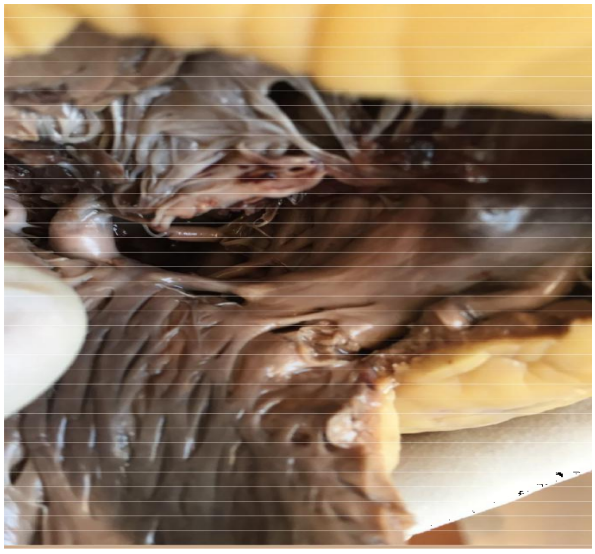


Fig. 43: Low located MB/APM and MB/septal junction, and MB/septal located slightly lower than the MB/APM (No M 26)

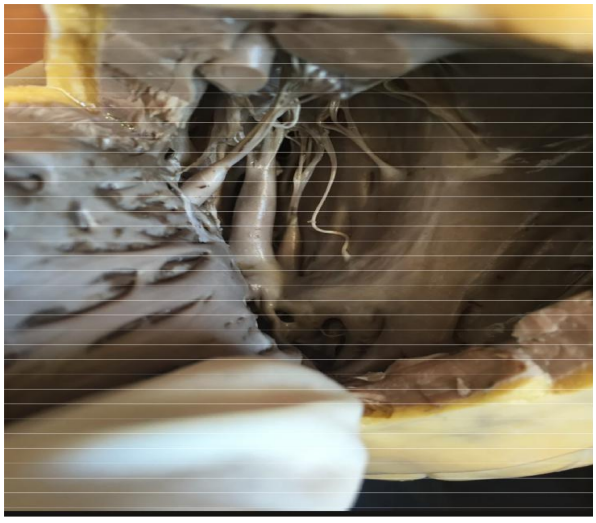


Fig. 44:APM in close attched to IVS, MB not clearly defined, also note the origin of accessory papillary muscle between APM and IVS.(M 37)

Table No. 14: Measurement of Distance Junction between Moderator Band & Septal End to Right Border of the Heart (Sed-1) & to Apex of the Heart (Sed-2)

Specimen No	Age	Sex	Sed-1	jjjSed-2
01.	32	F	4.5	5.2
02.	38	F	3.4	4.8
03.	58	F	4.5	5.2
04.	58	F	5.1	4.8
05.	59	F	4.0	5.1
06.	60	F	4.7	6.0
07.	60	F	5.0	6.0
08.	62	F	5.1	5.1
09.	62	F	4.5	5.8
10.	65	F	5.0	5.1
11.	65	F	4.8	5.8
12.	67	F	4.8	5.5
13.	68	F	4.5	5.5
14.	70*	F	4.6	5.5
Average			4.60	5.40
Standard Deviation			+/-0.45	+/-0.40

3.7 Morphological variations of Moderator Band:

Complex type of attachment of moderator band is seen in more than 50% of specimens. Complex type is more in males (61%) when compared to females (51%).As much as 90% of its insertion is to the base of the anterior papillary muscle is complex. In five specimens, there was two distinct branch of origin from the intervetricular septum. In four specimens origin of the second Moderator Band is seen. However two anterior papillary muscles are seen in this one of the case.

Broad shaped origin is seen 10% of the cases, and a narrow insertion is seen in 10 % of the cases. At the papillary end the Moderator band is attached usually to the base as seen in nearly 90% of specimens. In more than 10% it is attached to the mid of the anterior Papillary Muscle. At the papillary attachment usually a fan shaped extension is seen which merges with the trabecula carniae .Extending one slip usually on to the Sternocostal surface and one slip to the posterior papillary muscle. The numerous branching is noted originating from the Moderator Band. The frequency of branches is more from the under surface or the lower border of the Moderator Band. However Branches from upper end and superior surface is also noted.

Majority of the lower or anterior Branches seen to be merging with the Trabeculae carneae.25% of the Moderator band is seen to be embedded in its course, either more at septal end, or throughout the course and less at papillary end. Often the superficial Dissection exposes the Moderator band. However in some cases it is seen a completely embedded is the substance of right ventricle. In one case a Moderator Band sheath is seen which completely envelopes the band before it attachment to the base. In one case the Longest Band is seen

84taking a curve after its attachment to sternocostal surface and Turing back to its attachment to the base of the moderator band. other peculiarities are noted as mentioned in tables.

Table No. 15: Morphological details in males - A

Specimen No	Age	Sex	Consistency	Branches (Upper/Lower)	Type
1.	32		Muscular	-	Type 1
2.	37		Muscular	0/1	Type 8
3.	42		Muscular	0/1	Type 4
4.	48		Fibrous	-	Type 4
5.	51		Muscular	1/0	Type 4
6.	53		Fibromuscular	-	Type 3
7.	53		Muscular	1/2	Type 1
8.	59		Fibromuscular	-	Type 1
9.	59		Fibrous	1/0	Type 6
10.	60*		Muscular	2/1	Type 8
11.	60*		Muscular	-	Type 1
12.	60		Muscular	-	Type 7

13.	62		Fibromuscular	3/0	Type 2
14.	62		Muscular	-	Type 6
15.	65*		Muscular	-	Type 4
16.	65		Muscular	1/0	Type 1
17.	65		Fibromuscular	0/2	Type 1
18.	66		Muscular	0/1	Type 2
19.	66		FibroMuscular	0/1	Type 5
20.	67		Fibromuscular	-	Type 2
21.	67		Muscular	4/0	Type 6
22.	67		FibroMuscular	0/2	Type 1
23.	68		Muscular	0/2	Type 6
24.	68		Fibromuscular	-	Type 7
25.	68		Fibromuscular	1/0	Type 4
26.	68		Muscular	-	Type 5
27.	68		FibroMuscular	-	Type 6
28.	69		FibroMuscular	0/4	Type 1
29.	69		Fibromuscular	-	Type 4
30.	69		Muscular	-	Type 2
31.	70*		Fibrous	0/1	Type 1
32.	70*		Muscular	1/4	Type 2
33.	70		Muscular	-	Type 8
34.	72		Fibromuscular	0/3	Type 8
35.	72		Muscular	0/1	Type 3
36.	75*		Fibromuscular	0/1	Type 1

Fig. 45: Complex attchment of MB APM junction, Note the false cordae tendinae originating from MB(No M 34)

Fig. 46: Two origins of MB, fused AMP's, complex attchments to its base and anterior wall.(No. M 25)

Table No. 16: Morphological details in females – B1

Specimen No	Age	Sex	Consistency	Branches (Upper/Lower)	Type
01.	32	F	Muscular	0/1	Type 1
02.	38	F	Muscular	0/2	Type 1
03.	58	F	Fibromuscular	0/2	Type 5
04.	58	F	Fibromuscular	-	Type 1
05.	59	F	Fibrous	0/1	Type 1
06.	60	F	Fibromuscular	-	Type 1
07.	60	F	Fibromuscular	-	Type 6
08.	62	F	Fibromuscular	0/4	Type 4
09.	62	F	Fibromuscular	0/1	Type 6
10.	65	F	Fibromuscular	-	Type 2
11.	65	F	Muscular	-	Type 8
12.	67	F	Muscular	0/2	Type 3
13.	68	F	Muscular	0/1	Type 2
14.	70*	F	Muscular	0/8	Type 3

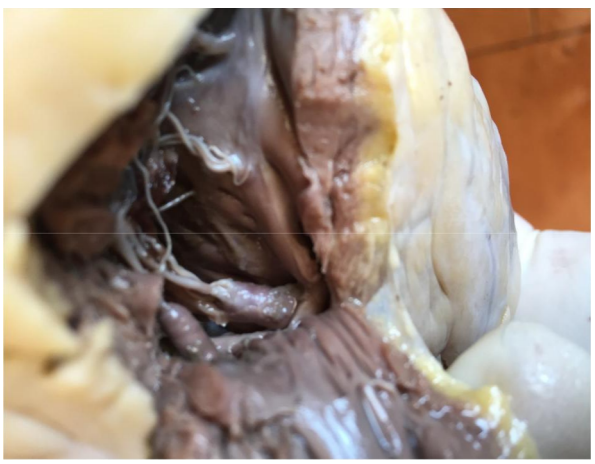


Fig. 47: Note the 2 APM , the MB passes in between these two to get inserted to PPM (No F 11)

Fig. 48: Laterally Placed APM. also note the mesh like branches orininating from the lower border of MB(No F 14)

Table No. 17 : Morphological details in males - A2

PE= ATTCHEMENT OF MB TO APM AT BASE (+) OR ABOVE (-)
ED=Embedded (++), Partially Embedded (+), Free (-)
ST=Complex©, Simple(S)

Specimen no	Age	Sex	PE	ED	ST
1.	32		+	-	S
2.	37		+	++	C
3.	42		-	+	S
4.	48		+	-	S
5.	51		+	++	C
6.	53		-	++	C
7.	53		+	-	S
8.	59		+	-	S
9.	59		+	-	S
10.	60*		+	+	C
11.	60*		+	+	C
12.	60		+	+	S
13.	62		+	-	C
14.	62		+	-	C
15.	65*		+	-	C
16.	65		+	-	S
17.	65		+	+	C
18.	66		-	-	S
19.	66		+	-	S
20.	67		+	-	S
21.	67		+	++	C
22.	67		+	+	C
23.	68		+	-	C
24.	68		+	-	C
25.	68		-	+	C
26.	68		+	+	C
27.	68		+	-	C
28.	69		-	-	S
29.	69		+	-	C
30.	69		+	+	C
31.	70*		+	+	S
32.	70*		+	-	C
33.	70		+	-	C
34.	72		+	+	C
35.	72		+	-	C
36.	75*		+	-	S

Fig : 49 Two origin and one complex insertion of MB, also note2 more APM's.(NO M 30)

Fig. 50: 'cup' shaped depression of the moderator band before insertion to the base of the papillary muscle. (No M 19)

Fig. 51: Note the divideing of MB at papillary juction, false cordae tendenae arisung from upper boarder (No M 32)

Table No. 18: Morphological details in females - B2

Specimen no	Age	Sex	PE	ED	ST
01.	32	F	+	-	S
02.	38	F	-	-	S
03.	58	F	+	+	S
04.	58	F	+	+	S
05.	59	F	-	-	S
06.	60	F	+	+	S
07.	60	F	+	+	C
08.	62	F	+	+	C
09.	62	F	+	+	C
10.	65	F	+	-	S
11.	65	F	-	+	S
12.	67	F	+	-	C
13.	68	F	+	-	S
14.	70*	F	-	-	S

Fig. 52: Two MB origins and united towards insertion (No F 13)

Table No. 19: Morphological variations in males - A3

SL NO	Fig No	Peculiarities found
1.	19.	Largest MB curving after getting attached to the anterior wall,
		APM is large
2.	20.	Shortest MB, stout APM, the junction partially embedded with anterior wall
3.	21.	Double headed APM, The lower border is slightly lengthier the upper border
4.	24.	Thickest MB, note the complex attachment to the base of the APM and to the anterior wall.
5.	25.	The thinnest MB, note the false cordae tendinae originating from the upper surface
6.	26.	Sheet like origin and insertion partly in to the base of APM and partly in to anterior wall, also note the prominent septal papillary muscles.
7.	29.	Very tall APM, MB getting inserted at its middle.
8.	30.	Double headed APM, note the broad origin and mid papillary insertion of MB.
9.	31.	Laterally placed APM, prominent secondary trabeculae from the lower border and the complex attachment to APM and anterior wall.
10.	33.	Almost horizontal MB/septal junction.
11.	34.	MB curving upwards and then downwards, before attachment to APM.
12.	35.	Typical bridge like pattern of MB.
13.	37.	Short double headed APM with complex attachment of MB.
14.	38.	Prominent septal end and ramifications at papillary end of MB.
15.	40.	Latterly placed, broad based APM, with attachment of partially embedded MB.
16.	41.	Additional MB and one insertion to the stout APM.
17.	43.	Short APM, complex insertion of MB to its base and anterior wall.
18.	44.	Not well defined MB with two APM's, one tall and one short. Also note an accessory papillary muscle at the APM/ septal junction.
19.	45.	Not the complex attachment of MB/APM junction. A false chordate tendinae arising just laterally and partially attached.
20.	46.	Two APM's fused at the upper end. Two origins and complex insertion of MB/papillary junction.
21.	49.	Two origins immediately uniting, and complex insertion to the base of the APM. Also note two more APM's placed latterly.
22.	50.	The MB is expanded at the papillary end to form a cup shaped depression, the complex attachment. Also note the prominent septal origin and tall APM.
23.	51.	MB dividing in to two at the papillary end, one branch is inserted in to APM and other to anterior wall.

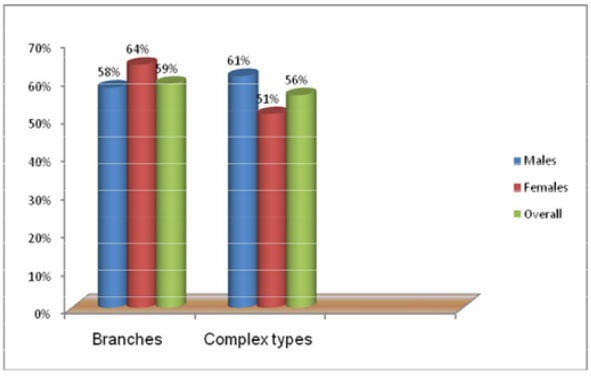
Table No 20: Morphological variations in females. - B3

SL NO.	Fig No	Peculiarities found
1.	22.	The angle at MB/septal junction and MB/papillary junction is more than 1200. Note the complex attachment at the septal end and extension of lower border in to anterior wall via ramifications.
2.	23.	Two MB, separate origin and separate insertion to two APM's.

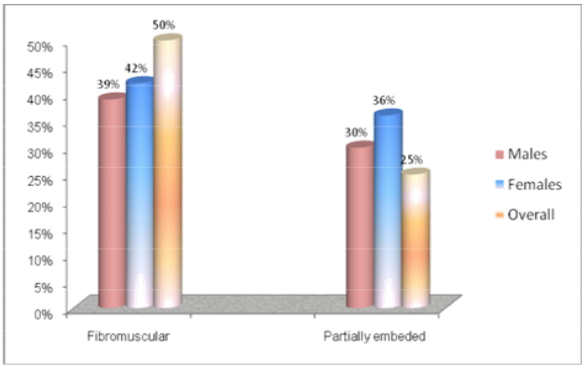
3.	27.	Slope shaped MB presenting, well defined upper and lower surface as well. Complex attachment at the papillary end.
4.	28.	Thick origin and narrow insertion of MB to the tall APM.
5.	32.	Complex attachment at papillary end and partially embedded at the septal end.
6.	36.	Broad based APM with division of MB at its attachment.
7.	39.	Typical bridge like pattern of MB.
8.	42.	MB/septal junction is placed slightly lower than the MB/papillary junction.
9.	47	Unusual MB which passes between 2 APM's and runs over the floor of the right ventricle turns posteriorly to get attached to PPM.
10.	48.	Numerous branches originating from the lower border of MB to form mesh like network and inserted just above the base of APM.
11.	52.	Two MB and one broad insertion at APM.

Table no.21: Morphological statistics

Morphology	Males	Females	Overall
Branches	58%	64%	59%
Complex types	61%	51%	56%
APM attachment -Mid	12%	12%	12%
Consistency (fibromuscular)	39%	42%	50%
Partially embedded	30%	36%	25%



Graph No. 18: Morphological statistics -1



Graph No. 19: Morphological statistics -2

4. DISCUSSION

Septomarginal trabeculae or the moderator band is a well-known structure present in the right ventricle of the heart. it connects the interventricular septum to the base of the anterior papillary muscle. it is proved that it carries a moderator band artery and right bundle branch of His. Within our study specimens, even though the size of the moderator band is variable it is clearly visible and well developed structure. There were many misleading names given in the past such as muscular string, left ventricular chordae tendinae, fascicles ect.Histology of moderator band in left ventricle was described by Turner[31].

During the development of moderator band the right ventricular inlet tract outgrowth results in division of the primary fold of the septal part, with its lateral part, which extends laterally as moderator band upto the right atrioventricular ring. The electro physiological readings taken in the embryonic heart, supports the atrioventricular connection via the moderator band .the observations provide the functional and morphological importance of septomarginal trabeculae in carrying accessory pathway in mahaim tachycardia[32].

The hypertrophy of moderator band can lead to double chambered right ventricleand which in turn leads to the stenosis of pulmonary outlet[33] In moderator band anatomy is of important in correction of high located congenital ventricular septal defects.[34] The various parameters studied are discussed in respective headings.

Morphometry of Moderator band length

In our study the mean length of moderator band is found to be 15.06mm, the standard deviation is +/-4.97mm.

In HannahSugirthabai RajilaRajendran et al[15] study the average length was found to be 14.71mm and mean deviation was +/-4.99mm..Our study results are in par with this study,

In. *Raghavendra A.Y et al[16] study* the average length was found to be 13.83mm and mean deviation was +/-3.94mm. There is slight variation ,may be due to the 50 specimens used in our study when compared to 20 specimens used.

In Laukas et al[8] study the mean length is found to be 16.23mm. With standard deviation +/-2.3mm.the difference may be due to the racial variations.

In Mamatha et al[17] study the range of length was 10 to 20mm in 26 specimens out of 30 specimens. The length was less than 5 to 10mm in 3 specimens and more than 20mm in 1 specimen. In our study we got 38 specimens with the range of 10 to 20mm 6 in range of 5to 10mm.both these readings are in par with the sudy.however we got 6 specimens of more than 20mm in length. In our study we recorded one moderator band (specimen no 3) which is less than 5mm.

In Truex et al[20] study the average length is found to be 12.70mm, between the range of 3.5 to 29mm. However in 500 human hearts they studied they reported absence of moderator band as much as 47% of the cases. The large number of specimens and comparatively higher number of absence of moderator band recorded may be reason for the difference and also their study include foetal and neonatal hearts.

In our study the upper boarder mean length in males is found to be 15.11 and the lower border mean length is found to be 15.69, indicating the difference which does exists between the two borders. In females the mean upper border length is found to 14.70 and lower border length is found to be 14.77. The results clearly show the variations in length in males and females, both in upper and lower border. However there is no study to compare the results

Morphometry of Moderator band thickness.

In our study the mean thickness moderator band is found to 4.70mm with mean deviation +/-1.52mm In Hannah Sugirthabai

Rajila Rajendran et al[15] study the average thickness was found to be 4.97mm and mean deviation was +/-1.64mm.the difference is due to the three point measurements.

In Raghavendra A.Y et al[16] study . The average of thickness was found to be 4.46mm with mean deviation of +/-1.36mm.the difference may be due to the 50 specimens used in our study.

In loukas M et al[8], the average thickness of moderator band was found to be 4.5mm+/-with mean deviation of +/-1.8mm.differnce may be due to the 100 specimens use in their study.

In Mamatha et al[17] they found 12 specimen's, thickness ranging between 2mm to 5mm, and more than 5mm in 17 specimens. They found one specimen less than 1mm. In our study we did not came across any specimens of 1mm thickness. 16 specimens were of thickness more the 5mm and rest falls between 2mm to 5mm.

In Traux et al[20] study the mean thickness taken at the thickest part of the moderator band is found to be 6mm.the range was from 1.5mm to 14mm.This may explain the racial variation .the thickest moderator ban they recorded was 14mm.in our study we came across a max of10.2mm.and minimum thickness of 2.14mm.

In our study the average thickness in males is found to be 4.59mm and average thickness in females is found to be 4.82mm, indicating the thickness is comparative more in females. Further there is a clear cut difference in the thickness measured at septal, papillary ends usually due to the broad origin and insertion of the moderator band. there is no study to compare with of theses readings.

Morphometry of Moderator band height

In our study the mean height of moderator band from tricuspid orifices is found to be 23.64mm with mean deviation of +/-3.95mm.

In Hannah Sugirthabai Rajila Rajendran et al[15] study the average height was found to be 19.85mm and mean deviation was +/-5.92mm.in our study we measured the height from the left end of the tricuspid orifice o the origin of the moderator band may be the reason for the difference.

In Raghavendra A.Y et al[16] study, the average height is found to be 36mm with standard deviation of +/-1.01mm.the difference again due to the distance taken from the left end of the atrio ventricular orifice.

In Mamatha et al[17] study the height was measured by taking the supraventricular crest as land mark. In our study we used this parameter as well. The midpoint between the tricuspid orifice and pulmonary orifice on the supraventricular crest is taken as land mark. In Mamatha study the height was found to be around 20mm. In our study it is found to be 18.44mm with mean deviation of 3.51mm.

In males it is 18.87mm and in females it is 18.02mm. The supraventricular crest may be the better land mark to record the height of the moderator band in view of the difference found its measurement from tricuspid orifices and also suprventricular crest falls in same plane of origin and the continuation from the septal end of the moderator band.

In Trux et al[20] study the height is measured from the attachment of moderator band from the septal end to the apex of the right ventricle and the mean value is found to be 39mm. In our study we also calculated the distance between the moderator band and septal junction to the apex of the heart.

In our study the average of height in males is found to be24.32mm and average height in females is found to be 22.97mm. The difference may be due to comparatively smaller sized heart in females. There is only one study to compare the height taken from the supraventricular crest. There is no study to compare the difference obtained with regard to height in male and in females.

Morphometry of Moderator band angle

In our study the mean angle at septal junction of moderator band is found to be ^{0} with variation of +/- 5^0 , when angle measured from the axis of the IVS to the axis of the MB from its upper end or 60^0 when measured from the axis of the IVS to the MB from tits lower attachment.

In Adam Kosinski et al[2] study they divided arising of the secondary trabeculae with respect to the angle of moderator band to the axis of the IVS to into 3 groups. 1). 0^0 to 30^0 2). 30^0 to 60^0 and 3) 60^0 to 90^0. In 100 heart they studied 22 hearts belong to group 1. And gave rise to only one secondary trabeculae.

14 hearts belong to group 2 and gave only one secondary trabeculae. 29 hearts belong to group 3, out of which only one gave one secondary trabeculae, 12 hearts gave two trabeculae and 3 hearts gave three trabeculae. In our study 15 hearts found to be group 1 type, 10 hearts found to be group 2 , and remaining 25 belongs to group 3 . This grouping in agreement with adam study, however secondary trabeculae pattern Varies. 10 heart belongs to group 1 had one secondary trabeculae, 3 had 2 secondary trabeculae, in group 2 we got one trabeculae in 9 hearts 2 trabeculae, 2 trabeculea in 2 hearts and 3 trabeculae in 3 hearts. In group in we had one trabeculae in 3 heart, 2 trabeculae in one heart and 3 trabeculae in one heart.

Further in our study we documented more than 3 secondary trabeculaes and we also classified the branches given from upper border and lower border. A mesh like trabeculae pattern can be noted in one of the female specimen., There is one evidence of false chordate tandinae originating from the upper border of the moderator band . In one case a accessory papillary muscle originate of the junction of APM to IVS.

We further measured the angle of MB to papillary junction. The average angle recorded to be 91^0 with the standard deviation of 23^0. These two measurements helps to find the course of MB. In 50% of the cases it is found to be Horizontal, 48% it is found to be running downwards and to the right, in 2% it runs above and to the right , since the low location of MB / septal junction when compared to MB /papillary junction.

Morphometry of Moderator band Depth

It is measured at two junctions, one at the moderator band/APM junction and other at the moderator band /IVS junction. Since MB/APM junction lies on the anterior wall itself, the depth almost equivalent to the thickness of the right ventricle. The average depth of this junction is found to be 3.7mm. The MB/septal junction lies usually deeper, upper and to the left of MB/papillary junction. This average of this depth is found to be 4.2mm. In 2 cases the MB/IVS junction is found to be Laing lower than the MB/APM. The moderator band /septal junction is found to be more in superficial plane in females than in males.

In S.T.F Bandeira et al[18] study the type 1 septomarginal trabeculae was found to be 8%.which referrers to the attachment of moderator band only to the base of anterior papillary muscle without ramification to the anterior ventricular wall.

In our study in agreement with the above study. And hence the depth at moderator band to the papillary junction is found in deeper plane when compared with other types.

Surface marking of the moderator band on the sternocostal surface of the right ventricle.

In our study average distance of the moderator band/papillary junction to the right border of the heart is found to be 3.13mm,the average distance of moderator band/papillary junction to the apex of the heart is found to be 5.06mm,. Average distance of the

moderator band/septal junction to the right border of the heart is found to be 4.71mm,, and Average the distance of the moderator band/septal junction to the apex of the heart is found to be 5.4mm .through this we can find that the moderator band is located almost mid region of the sternocoastal surface of the right ventricle .in 60% of specimens the moderator band is directed downwards and to the right. in 36% it is found to be having a horizontal course. But in 4%of the cases where the moderator band/septal junction is located lower than the moderator band/papillary junction, the direction of the moderator is running upwards and to the right. The average distance between the two junctions is found to be 17.3mm. the difference in distance is due to the low lying junction, mainly the moderator band/sepal and also the convexity of the right ventricle.

In R.C Traux et al[20] study, the mean septal attachment distance is found to be 3.91cm with range of 1.5 cm to 7.2cm. They reported the incidence of moderator band in 56% of specimens. And the distance taken was to the apex of the right ventricle.

Morphology of Moderator band

In Adam Kosinski et al[2] study, the percentage of secondary of secondary trabeculae is found to be 65%.our study is in agreement .however the moderator band with more than 4 trabeculations was found in our study. we reported 2 specimens with mesh like trabeculations from the lower border. in more 3 specimens there is trabeculations from the upper border as well.

In S.T.F Bandeira et al[18] study the complex type recorded was 67%.in our study the complex type found was 56%.in males it was found to be 61% and in females it was 51%.there is no study to compare the sex variations.

In Dupreux et al[21] study septomarginal trabecular can be classified into muscular, fibrous and fibromuscular. in our study we came across all three types. And the fibromuscular type is predominant at 50%.

In Mamatha et al[17] study moderator band was found to be attached o the base of the anterior papillary muscle in over 85%.in our study It is about 88%.all 12% are attached at the mid of the anterior papillary muscle. Out of which 50% showed the ramifications.

In S.T.F Bandeira[18] study the moderator band with third order fleshy column or partially embedded was found to be 33%.in our study it was 25%.in females it was 36% and in males 30%.the typical bridge type was found to be predominant. However the complex attachment of it is more seen at the papillary end in both studies.

Paul Ravindran et al[19] reported in one case the origin of chordae tendinae from moderator band. Where the anterior papillary muscle was absent. in our study we reported one case in male specimen the origin of false chorde tendinae.

Mamatha et al[26] reported 12% cases of double anterior papillary muscle .we reported it to be 14%.however 2 cases there was more than 2 APM's seen. in few cases the APM's are fused, double headed..

Mamatha et al[26] and Mathada Ravishanker et al[29] reported the occurrence of additional moderator and 3% and 20% respectively .we found 2nd moderator band in 8% of the specimens. However there are 4 specimens with 2 separate origins of moderator band which later unites to form the single band.

S.R. Mittal et al[12] reported a case where the moderator band can be confused with a mass near the right ventricle during echocardiography in our study we found a sheet like origin of moderator band near the apex which may appear like amass in routine echo cardiograph.

We reported a moderator band which curves backward in between the two anterior papillary muscles, runs along the floor of the right ventricle and attached to the posterior papillary muscle this was never recorded.

We reported a case where the moderator band was not clearly identifiable. the anterior papillary muscle was in close contact with the intraventricular septum. a slender accessory papillary muscle originates from this junction.

5. CONCLUSIONS

Morphometry of length of moderator band

There a difference found in measurement of upper and lower border. Since the course of the moderator band is found to be tortuous or curved at times, the measurements using thread gives the accurate results. There is difference found in males and females. Since there is 10% variation interms of origin and insertion of moderator band, the mention of the same while taking the measurements becomes mandatory.

Morphometry of thickness of moderator band

There a variation of thickness found at the all three sites of measurements taken namely septal, papillary and the midpoint, both in males and females. The broad origin, narrow insertions has to be taken in a account while taking the readings. The variations in origin and insertion are to be noted and recorded separately.

Morphometry of height of moderator band

The exact land marks for taking the height of the moderator band is mentioned in our study. Since without these there might be a large variation in readings. We feel that the height taken as supraventricular crest as a landmark is better than that taken from the tricuspid orifice as the continuation of moderator band falls on the same plane. we found the difference in height both in males and in females.

Morphometry of angles of moderator band

The angle of origin of moderator band from the interventricular septum and the angle formed at its insertion to the anterior papillary muscle give a clear picture about the direction of the band. In 4%of cases moderator band is found to be running upwards and to the right, as the junction of moderator band/interventricular septum lies slightly at the lower level than the moderator band and papillary junction .there is a difference in male had female specimens.

Morphometry of depth of moderator band

The depth measured from the sternocostal surface to the moderator band/intervaentricular junction and of the moderator band /papillary junction differs as the latter lies in deeper plane .the measurements of the former also shows the thickness of the right ventricle as moderator band is found to be attached at its base in most of the cases .there is a difference found both in male and female measurements.

Surface marking of moderator band on the sternocostal surface of the right ventricle.

We took the measurements from the right border and from the apex of the heart to the moderator band /papillary junction and moderator band/septal junction. In more than 60% of cases, the moderator band found to run downwards and to the right. and location is found to lie in the mid region on the sternocostal surface of the right ventricle.

Morphology

We found an addition moderator band in 4 specimens. Two origins were found in 5 specimens. in one case moderator band origins and inserts like a sheet .which can be confused with the mass near apex of the heart. The pictures taken of the complex insertion of moderator band to the anterior papillary muscle shows wide variety of variation. in one case moderator band is found to run along the floor of the right ventricle and goes posteriorly to get attached to the posterior papillary muscle.

In our study we mentioned the accurate method of incisions for opening up the sternocostal surface of right ventricle and tracing the moderate band and recording or measurements of the different parameters. These guide lines will help in further studies in which the injury to the chordae tendinae, anterior papillary muscle can be minimised and the trabeculations can be well preserved. Our findings and photographs will help in identifying accurate location and variations of moderator band trough echocardiography, computerized tomography and in magnetic resonance imaging study of right ventricle, moderator band in particular. The knowledge of variations will help cardio thoracic surgeons in performing surgeries on interventricular septum, mass in right ventricular apex ect. since there is evidence that the septal ,anterior ,and posterior papillary muscles are connected by extensions of the moderator band as slips ,the rationale of rhythmic contraction and electrophysiology of the papillary muscles can be studied.

ANNEXURE - 1
MASTER CHART

Sl No.	Results			In males	In females	Overall average
1.	Length	Upper border		15.11	14.70	14.90
		Lower border		15.69	14.77	15.23
		Mean		15.40	14.73	15.06
		Standard deviation	Upper	+/-5.08	+/-4.61	+/-4.97
			Lower	+/-5.15	+/-5.03	
2.	Thickness	Papillary end		4.43	4.62	4.52
		At mid point		4.28	4.55	4.41
		Septal end		5.08	5.31	5.19
		Mean		4.59	4.82	4.70
		Standard deviation	Papillary	+/-1.74	+/-1.06	+/-1.53
			Mid pt	+/-1.49	+/-0.99	
			Septal	+/-1.60	+/-1.44	
3.	Height	From TCV		24.32	22.97	23.64
		From SVC		18.87	18.02	18.44
		Standard deviation	TCV	+/-4.14	+/-3.34	+/-3.95
			SVC	+/-3.45	+/-3.70	+/-3.51
4.	Angle	At septal end		60	50	55
		At papillary end		92	90	91
		Standard deviation	Septal	+/-22	+/-26	+/-19
			Papillary	+/-21	+/-14	+/-23
5.	Depth	Papillary junction		3.87	3.70	3.78
		Septal junction		5.19	4.20	4.69
		Standard deviation	septal	+/-0.57	+/-0.45	+/-0.38
			papillary	+/-0.41	+/-0.26	+/-0.69
6.	Surface Marking	Ped-1		3.15	3.12	3.13
		Ped-2		5.08	5.05	5.06
		Sed-1		4.83	4.60	4.71
		Sed-2		5.40	5.40	5.40
		Standard deviation	Ped-1	+/-0.44	+/-0.30	+/-0.41
			Ped-2	+/-0.44	+/-0.15	+/-0.38
			Sed-1	+/-0.51	+/-0.45	+/-0.46
			Sed-2	+/-0.38	+/-0.40	+/-0.47
7.	Morphology	Branches		58%	64%	59%
		Complex types		61%	51%	56%
		APM attachment -Mid		12%	12%	12%
		Consistency (fibromuscular)		39%	42%	50%
		Partially embedded		30%	36%	25%

ANNEXURE – 2
MD Dissertation Protocol

"MORPHOLOGICAL STUDY OF SEPTOMARGINAL TRABECULA (MODERATOR BAND) IN HUMAN HEART"

By

DR PRAVEEN SHENOY M.
Under the able guidance of
Dr. MARTIN LUCAS A. MMBS,MS
Professor and Head
Department of Anatomy
KS Hegde Medical Academy
Nitte University
Mangalore – 575018

September 2014

Title of MD/MS research protocol:

"MORPHOLOGICAL STUDY OF SEPTOMARGINALTRABECULA IN HUMAN HEART (MODERATOR BAND)"

Name and designation of the Guide
Dr MARTIN LUCAS A.MBBS, MS
Professor and HOD

.....
Signature of the Candidate

.....
Signature of the Guide

.....
Signature of the HOD

.....
Signature of the Dean

BACKGROUND

In the Renaissance, Leonardo Davinci drew the structure of trabecula in detail. Hence, for some time it was called Leonardo's trabecula (Bochenek and Reicher, 1993)1.In 1837, while analyzing hearts of different mammals, King named the structure "moderator band,, (Grant et al., 1961;Tandler, 1913)[2].

According to his concept, the trabecula limited expansion of the right ventricle during systole. Tandler was the first to call the structure "septomarginal trabecula", due to its proximal (septal) and distal (wall of the right ventricle) attachments (Tandler, 1913)2.contemporary williams et al. (1989) as well as Grant et al" (1961) interchangeably use names such as ,"septomarginal (1961)[4,5,6]

Some authors (James, 1985; Maron et al., 1993; Restivo et al., 1989; Rowland et al., 1975 ; smith et Restivo et al , 1989; Rowland et aL.,1975; smith etal., 1986) distinguish two arms of the proximal, so called septal, segment of the septomarginal trabecula.The larger and more prominent postenor ann was directly adjacent to the pulmonary trunk outlet. Smith et al. (1986), in presenting a definition of the septomarginal trabecula, emphasized that it gave rise to small trabeculae running toward the anterior wall (he called them as "moderator band") and to the anterior papillary muscle as well as the medial complex of the septal papillary muscles[7].

The right bundle branch of the conducting system of the heart passes down the interventricular septum and continues by way of the moderator band (septomarginal trabecula) to the base of the anterior papillary muscle. From here branches issue to the subendocardial plexus of purkinje fibres and pass to the conus arteriosus, to the free wall of the ventricle and to the septum (Tawara, 1906; Aagaard & Hall, 1914;Hara, 1967). The Purkinje fibres are accompanied by nerve fascicles and delicate nerve fibres, which form a plexus on the surface of the Purkinje fibres (Tawara, 1906; wilson,1909; Truex & copenhaver 1947; Field, 1951; Davies, Francis & King, 1952;Hayashi, 1962). Because of the morphological relationship between the two tissues Blair & Davies (1935) called the conducting system a neuromuscular bundle.

The study is undertaken to record the various morphological features of septomarginal (moderator band) in human hearts. Though there are many similar studies on the septomarginal in the hearts of lower animals, very few authors have described the morphology in humans.

Apical ventricular septum defects are rare pathologies of the Apical ventricular. The moderator band or other large trabeculations, is the major obstacle for the repair of such defects.

The right bundle branch is presented in the moderator band of right ventricle; there may be some relationship between fat infiltration in the moderator band and complete or incomplete right bundle branch block (RBBB), or other conduction abnormalities according to Shirani J et al. A large branch from the left anterior descending artery passes along the length of the moderator band in the right ventricle. According to Loukas M et al the moderator band, or other large trabeculations, is the major obstacle for the repair of apical ventricular septal defects. The morphological study of moderator band may help the surgeons during surgical procedures conducted for correction of such defects.

REVIEW OF LITERATURE

James, T.N.1985.One protrusion in the right ventricle, the septomarginal trabecula or septal band, is particularly prominent. It reinforces the septal surface where, at the base, it divides into limbs that embrace the supra-ventricular crest. Towards the apex, it supports the anterior papillary muscle of the tricuspid valve and, from this point, crosses to the parietal wall of the ventricle as the 'moderator band' (this alternative name records an old idea that the septomarginal trabecula prevents over distension of the ventricle)[7]

Richard Van Praagh, Tal Geva, Jacqueline Kreutzer describes that , the term "trabecular" septum comes from trabecula septomarginalis, the Latin term for the moderator band that runs from the septum (hence, septo) to the acute margin of the right ventricle (hence, marginalis)[8].

The moderator band crosses the ventricular cavity from the septal to the anterior wall. It conveys the right branch of the atrioventricular bundle, which is part of the conducting system of the heart[9].

In the cavity of right ventricle, there are many muscular ridges. One of these ridges has broken free and lies in the cavity attached by its two ends to the interventricular septum and the anterior papillary muscle. This is the septomarginal trabecula (formerly the moderator band); it contains part of the right branch of the conducting bundle[10].

According to Kenneth D. Horton, Rick W. Meece, and Jeffrey C. Hill, "within the RV cavity, there are 3 muscular bands: the parietal band, the septomarginal band, and the moderator band. In abnormal or congenital heart disease, the moderator band may serve as a landmark to differentiate the right from the left ventricle"[11].

Francois Haddad et al. stated in their review article that, "three prominent muscular bands divide the right ventricle: the parietal, the septal and the moderator band. The parietal band and the infundibular septum make-up the crista supraventricularis, which separates the sinus and the conus regions. The moderator band extends from the base of the anterior papillary muscle to the ventricular septum[12].

According to Robert h Anderson et al, the right bundle branch is a narrow, cord-like structure it generally passes intramyocardially to reach the right side of the septum, running through the posterior limb of the septomarginal trabecula and passing beneath the medial papillary muscle comple[13].

In the study done by Burkhard Sievers et al. indicate that areas of disordered motion may be seen.

In the right ventricular wall in healthy subjects with no diagnostic criteria for (Arrhythmogenic right ventricular cardiomyopathy). Such "abnormalities" were found by CMR(cardiac magnetic resonance imaging) in 93.1% of the subjects investigated and were mostly located around the area of insertion of the moderator band and trabeculae . The regions of wall motion abnormalities are likely to result from tethering of the free wall by the moderator band. Because the moderator band inserts mediolaterally to apicolaterally on the free wall of the right veutriclela[14].

Geoffrey Farrer-Brown observed that, the large artery in the moderator band, was found to be consistently present and measured up to 1000 ,u in diameter. It appears to provide a major blood supply to the anterior papillary muscle of the right ventricle, and has been shown in this study to exist in the heart of an infant (2 weeks old) and communicate with the lateral wall of the right ventricle even at this early age[15].

Bharati S, Lev M states that, in both the normal and some forms of the abnormal heart, the anatomic course of the right bundle branch proceeds along the lower margin of the crista supraventricularis to reach the moderator band below the papillary muscle of the conus (muscle of Lancisi)' It traverses the moderator band to reach the angle formed by it and the anterior papillary muscle where it divides into three terminal rami continuous with the purkinje network of the inferior and anterior right ventricular walls and the lower septal surface[16].

Craig J. Byrum et al observed that central right bundle branch injury results in prolongation of activation time at all three endocardial sites. Injury to the more distal right bundle branch, sustained by cutting the moderator band, preserves the normal apex activation

time, but prolongs the right ventricular, inflow and outflow activation[17].

HYPOTHESIS

The present study is intended towards recording and documenting the various morphological features, classification and variations of septomarginal trabeculae in human hearts.

The summary of previous studies shows the ill-defined or not very well defined trabeculae in 5 to 10 per cent of specimens, through this fact other anomaly or variations in gross structure of the heart can be assessed. As the right branch from atrioventricular bundle and a large branch of the anterior ventricular artery passes through this moderator band, the micro dissection and histology will help in understanding the clinical manifestation of cardiac problems. Once the morphology, morphometry, classifications and the variations clearly understood, will give way for further studies in cardiology, cardiothoracic surgery and in radiological fields, where moderator band pathology is been suspected.

AIMS AND OBJECTIVES

1. To study the morphology of septomarginal trabeculae in human hearts.

2. To study the morphometry of septomarginal trabeculae in human hearts.

3. To study variations of septomarginal trabeculae in human hearts.

4. Classification according to type, morphology and variations.

METHODOLOGY

The study will be conducted in the dept. of anatomy, K S Hegde medical academy. A total number of 50 hearts will be selected randomly from dissected human cadavers for the study. The study will be done over a period of three years from September 2014 to September 2016.

INCLUSION CRITERIA

1. Hearts from dissected human cadavers.
2. Both male and female cadavers.

EXCLUSION CRITERIA

Gross pathology, if any, will be excluded

EXPERIMENTAL PROCEDURES

The study will be conducted in the dept. of Anatomy, K S Hegde medical academy. A total number of 50 hearts will be selected randomly from dissected human cadavers for the study.

The hearts fixed and kept in a 10% formalin solution will be selected for dissection. The Sterno-coastal surface is dissected with one incision parallel to anterior inter-ventricular sulcus and another parallel to right half of inferior margin about half an inch above. Anterior wall is pulled carefully to right to visualize inside of right ventricle. The septomarginal trabecula will be exposed.

The septomarginal trabecula is identified as a fleshy band extending from inter-ventricular septum to the base of anterior papillary muscle. The length is measured from the papillary end to the septal end with the help of digital Vernier caliper. Thickness is measured at its approximate middle portion. An approximate distance of the septal end of septomarginal trabecula to the tricuspid valvular margin is measured.

Information about the age, sex, occupation, clinical findings and cause of death will be obtained from records if available.

ETHICAL CONSIDERATIONS: Institutional ethical clearance will be obtained.

IMPLPICATION AND JUSTIFICATION

The study was done extensively in lower animals and septomarginal trabecualae was found to be well defined in herbivores .It is not found or grossly ill-defined in carnivores animals.

Limited numbers of studies done in human heart and all the authors have felt the necessity of detailed study of moderator band.

The more detailed study will help in defining the Moderator band structure in contrast CT scan (Computerised tomography), MRI (magnetic resonance) imaging, and in interventional radiology.

The study of vasculature and nervous contents in the moderator band will help cardiologists in assessment of post myocardial infarction patients with right bundle branch block.

Detailed morphological study and morphometric evaluation will help cardio thoracic surgeon's surgeries on interventricular septum and to minimise the post-surgical complications.

ANNEXURE – 3

INSTITUTIONAL ETHICS COMMITTEE

K.S. HEGDE MEDICAL ACADEMY
(Constituent College of Nitte University)
Post Nithyananda Nagar, Deralakatte, Mangalore - 575 018, Karnataka, India.
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Ref. INST.EC/EC/063/2014-15 Date 28.08.2014

To

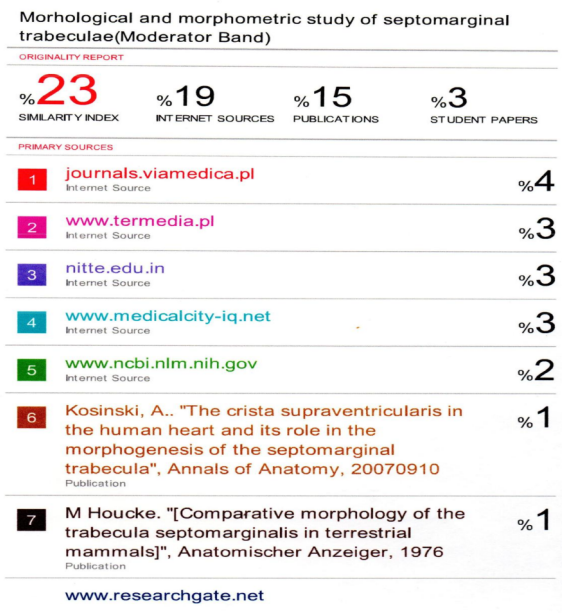
Dr. Praveen Shenoy M
Ist year Post graduate,
Department of Anatomy
K. S. Hegde Medical Academy,
Deralakatte, Mangalore – 575018

Through the Head of the Department Anatomy

Ethical Clearance is hereby issued to **Project titled: Morphological study of septomarginal trabecula (Moderator band) in human heart"** Dr. Praveen Shenoy M, Postgraduate, Department of Anatomy, K. S. Hegde Medical Academy Deralakatte, Mangalore, as discussed and approved by members of the Institutional Ethics Committee during the meeting held on 27th August 2014.

Dr. Sathyanarayana Rao K.N
Member Secretary
Institutional Ethical Committee

Member Secretary
INSTITUTIONAL ETHICS COMMITTEE
K. S. Hegde Medical Academy
NITHYANANDANAGAR - 575 018



Morhological and morphometric study of septomarginal trabeculae(Moderator Band)

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5	www.ncbi.nlm.nih.gov Internet Source	%2
6	Kosinski, A.. "The crista supraventricularis in the human heart and its role in the morphogenesis of the septomarginal trabecula", Annals of Anatomy, 20070910 Publication	%1
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NITTE

CERTIFICATE

This is to certify that the Dissertation titled **"Morphometric and Morphological Study of Septomarginal Trabeculae(Moderator Band)"** submitted by **Dr Praveen Shenoy M, U.S. NO. NU14MDAT01, Department of Anatomy**, K.S. Hegde Medical Academy, Deralakatte, has been subjected to TURNITIN software for Anti-Plagiarism and it is found to have similarity index of 23%.

This is within 30% permitted by **NITTE University** for the acceptance of Dissertation.

Dr Martin Lucas A.
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