

Study of Types of Papillary Muscles of Tricuspid Valve in Central Indians

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ABSTRACT

Introduction: A thorough knowledge of normal Anatomy and normal variations is necessary for the correct interpretation of information by echocardiography and for the repair of diseased valves surgically. The present study was carried out with the aim to know the morphology of papillary muscles of Tricuspid valves in Central Indians and to try to classify the normal variations.

Material and Methods: In 100 normal hearts Tricuspid valves were dissected carefully. The Anterior, Extra-anterior, Posterior, Extra-posterior and Septal infundibular and septal inferior papillary muscles were identified. It was noted whether these muscles were undivided or divided for variable distance from the distal end. If the apex of the muscle was notched or slightly grooved, it was not considered as divided.

Result: Extra-anterior and Extra-posterior papillary muscles were observed in 35% and 83% hearts respectively. The septal papillary muscles were found in 62% hearts. 50 anterior, 35 extra-anterior, 55 posterior, 133 extra-posterior, and 119 septal papillary muscles ie. 392 papillary muscles were undivided. 28 anterior, 3 extra-anterior, 32 posterior, 8 extra-posterior, and 7 Septal ie. 78 papillary muscles were bifid. 34 papillary muscles (21 anterior and 13 posterior) were trifid and only 1 anterior papillary muscle was tetrafid. Out of the 505 papillary muscles found in 100 hearts 392 (77.62%) were undivided and 113 (22.38%) were divided muscles.

Conclusion: Anterior and posterior papillary muscles could be bifid and trifid. Extra-anterior and extra-posterior muscles and septal papillary muscles could also be bifid

Keywords: Anterior, Posterior, Septal Extra-anterior and Extra-posterior Papillary muscles.

INTRODUCTION

Wooley¹ mentioned that since 4th century observations on the structure of the cardiac valves were being recorded by the Anatomists. King T.W.² in 1837 paid emphasis on the role of tricuspid valve in maintaining the uni-directional flow of blood. The echocardiographic appearances of the tricuspid valve were described by Matsumoto and Matsuo³ in 1978. In 1983 the visualization of the tricuspid valve by non-invasive imaging was done in details and accurately by Brown and Anerson and Tei et al.⁴

Wooley¹ and Hauck et al⁵ mentioned that a lot of clinical interest in the tricuspid valve diseases had arisen.

Jondinad et al⁶ proposed functional terminology for the papillary muscles of tricuspid valve calling the anterior as antero-posterior, posterior as postero-septal and septal as antero-septal papillary muscles.

Wafae et al⁷ in a study carried out on 50 hearts found an average number of 3.86 papillary muscles per heart. They found an average number of 4 papillary muscles in 46% hearts. They mentioned that variability in the number and localization of papillary muscles is well known. They adopted the following

classification of these muscles.

1. Anterior
2. Posterior- consisting of postero-lateral, postero-medial and posterior
3. Septal- consisting of septal infundibular and septal inferior

According to Seccombe et al⁸ the muscles supplying the antero-posterior commissure are commonly multiple, rather than being a single large structure and they termed this collection of papillary muscles as the posterior papillary muscle group. The collections or groupings of neighbouring basal papillary muscles in the vicinity of postero-septal commissure were termed as the deep postero-septal papillary muscle group. Identification of these papillary muscles was difficult yet it helped in the identification of the postero-septal commissure. They had not made any mention about the septal papillary muscles.

Grochowski P.⁹ introduced the concept of multi-apical and multi-segmental papillary muscles. Muscles with more than one point from which the tendinous cords grew were considered as multi-apical papillary muscles and apparently separate muscles lying on one wall of the ventricle as multi-segmental papillary muscles.

According to Ken Ashwell¹⁰ the insertion of an artificial valve may be surgically done to replace a damaged or abnormal valve depending on the condition of heart. The present study was carried out to observe the undivided and divided papillary muscles in the right ventricle.

MATERIAL AND METHODS

The present study was carried out at N.S.C.B. Medical College, Jabalpur, on 100 normal human hearts obtained from post-mortem room. The hearts were preserved in 5% formalin solution. The Tricuspid Valve complexes were dissected very carefully to avoid the cutting of papillary muscles and chordae tendinae. The anterior and posterior papillary muscles were identified. Extra-anterior and extra-posterior and septal papillary muscles were looked in for.

In all these hearts it was noted whether the said papillary muscle was undivided or divided for a variable distance from its distal end showing number of bellies/heads. Depending upon the non division or number of divisions the

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Group	Anterior	Extra-anterior	Anteriorly Placed	Posterior	Extraposterior	Posteriorly Placed	Septal			Average
							Infundibular	Inferior	Total	
I	8	1 (in 1 heart)	9	8	10 (in 7 hearts)	18	5	4	9 (in 5 hearts)	4.50
II	29	11 (in 11 hearts)	40	29	41 (in 22 hearts)	70	15	20	35 (in 18 hearts)	5.00
III	63	26 (in 23 hearts)	89	63	90 (in 54 hearts)	153	27	55	82 (in 39 hearts)	5.14

Table-1: Different papillary muscles in Tricuspid Valve

muscles were classified as:

1. Undivided
2. Divided - (a) bifid (b) trifid (c) tetrafid.

The hearts were kept in 3 groups

Group I- Eight hearts (2 female and 6 male) in the age group of 1 to 8 years.

Group II – Twenty nine female hearts in the age group of 16 to 80 years.

Group III – Sixty three male hearts in the age group of 16 to 61 years.

In the present study the papillary muscles were classified as under:

- I. Anteriorly placed papillary muscles: (a) Anterior and (b) Extra-anterior papillary muscles
- II. Posteriorly placed papillary muscles: (a) Posterior and (b) Extra-posterior papillary muscles
- III. Septal papillary muscles (a) Septal infundibular and (b) Septal inferior papillary muscles.

STATISTICAL ANALYSIS

The results were calculated by using the descriptive statistics such as mean and percentage Microsoft office 2007 was utilized in generating the tables.

RESULT

138 Anteriorly placed papillary muscles were found. In Group I, II and III hearts 9,40 and 89 of these muscles were found respectively. 241 Posteriorly placed papillary muscles were found. In Group I, II and III hearts 18, 70 and 153 of these muscles were observed (table-1).

Extra- anterior and Extra-posterior papillary muscles: 01 extra-anterior papillary muscle was found in 1, 11 and 20 hearts of children, females and males respectively. 02 extra-anterior papillary muscles were found in 3 male hearts only. Thus in 35 hearts 38 extra-anterior papillary muscles were found. 01 extra-posterior papillary muscle was found in 4, 9 and 24 hearts of children, females and males. 02 extra-posterior papillary muscles were found in 3, 9, 24 hearts of children, females and males respectively. 03 extra-posterior papillary muscles were found in 2 and 6 hearts of females and males. 04 extra-posterior papillary muscles were found in 2 female hearts only. Thus in 83 hearts 141 extra-posterior papillary muscles were found.

Septal Papillary Muscles: 01 septal papillary muscle was present in 3, 8 and 21 hearts of children, females and males. 02 septal papillary muscles were found in 5 female and 5 male hearts. 03 septal papillary were present in 2, 3 and 4 hearts of children, females and males. 04 septal papillary muscles were seen in 2 and 6 hearts of females and males. 05 septal papillary muscles were found in 3 male hearts only. 05, 15 and 27 Septal Infundibular papillary muscles were found in the hearts of children, females and males respectively. 04, 20 and

55 Septal Inferior papillary muscles were seen in the hearts of children, females and males respectively. Thus 36,145 and 324 papillary muscles were found in the hearts of 8 children, 29 females and 63 males with an average of 4.50, 5.00 and 5.14 per heart respectively.

In Group I (children):- Out of 36 papillary muscles, 30 were undivided, 3 were bifid and 3 were trifid.

In Group II (female):- Out of 145 papillary muscles, 117 were undivided, 20 were bifid and 8 were trifid.

In Group III (male):- Out of 324 papillary muscles, 244 were undivided, 56 were bifid, 23 were trifid and 01 was tetrafid.

Thus out of total 505 papillary muscles 391 were undivided, 79 were bifid, 34 were trifid and just 01 anterior papillary muscle was tetrafid (table-2).

In Group I (children), the anterior papillary muscles were undivided in 5 hearts, bifid in 1 heart and trifid in 2 hearts. The solitary extra-anterior papillary muscle found in this group was undivided. The posterior papillary muscles were undivided in 6 hearts, bifid and trifid in 1-1 heart each. All the 10 extra-posterior papillary muscles were undivided.

Out of the 9 septal papillary muscle present, 8 were undivided and 1 was bifid. 01 Infundibular septal papillary muscle was bifid while 4 of these were undivided. All of the 4 inferior septal papillary muscles were undivided. Thus out of the 9 anteriorly placed papillary muscles, 6 were undivided, 1 was bifid and 2 were trifid and out of the 18 posteriorly placed papillary muscles, 16 were undivided, 1 was bifid and 1 was trifid.

In Group II (female), the anterior papillary muscles were undivided in 18 hearts, bifid in 6 hearts and trifid in 5 hearts. Out of the 11 extra-anterior papillary muscles found in this group, 10 were undivided and 1 was bifid. The posterior papillary muscles were undivided in 16 hearts, bifid in 10 hearts and trifid in the remaining 3 hearts. Out of the 41 extra-posterior papillary muscles found in this group, 40 were undivided and 1 was bifid.

Thus out of 40 anteriorly placed papillary muscles, 28 were undivided, 7 were bifid and 5 were trifid and out of 70 posteriorly placed papillary muscles, 56 were undivided, 11 were bifid and the remaining 3 were trifid.

Out of the 35 septal papillary muscles present, 33 were undivided and 2 were bifid. All of the 15 Infundibular septal papillary muscles were undivided. 18 Inferior septal papillary muscles out of 20 were undivided and only 2 were bifid.

In Group III (male), the anterior papillary muscles were undivided in 27 hearts, bifid in 21 hearts and trifid in 14 hearts and tetrafid in the remaining 1 heart. Out of the 26 extra-anterior papillary muscles present 24 were undivided and 2 were bifid. The posterior papillary muscles were undivided in 32 hearts, bifid in 22 hearts and trifid in 9 hearts. Out of the 90 extra-posterior papillary muscles found in

Papillary muscles	Type of muscle	Group I		Group II		Group III	
		Number	%	Number	%	Number	%
Anterior	Undivided	05	62.50	18	62.06	27	42.85
	Bifid	01	12.50	6	20.68	21	33.33
	Trifid	02	25.00	5	17.24	14	22.22
	Tetrafid	00	0	0	0	1	1.58
Extra-anterior	Undivided	01	100	10	90.90	24	92.30
	Bifid	00	0	1	9.09	2	7.69
Posterior	Undivided	06	75.00	16	55.17	33	52.38
	Bifid	01	12.50	10	34.48	21	33.33
	Trifid	01	12.50	3	10.34	9	14.28
Extra-posterior	Undivided	10	100	40	97.56	83	92.22
	Bifid	00	0	1	2.43	7	7.77
Anteriorly placed	Undivided	06	66.66	28	70.00	51	57.30
	Bifid	01	11.11	7	17.50	23	25.84
	Trifid	02	22.22	5	12.50	14	15.73
	Tetrafid	00	0	0	0	1	1.12
Posteriorly placed	Undivided	16	88.88	56	80.00	115	75.16
	Bifid	01	5.55	11	15.71	29	18.55
	Trifid	01	5.55	3	4.26	9	5.86
Septal	Undivided	08	88.88	33	94.28	78	95.12
	Bifid	01	11.11	2	5.71	4	4.87

Table-2: Types of papillary muscles

this group, 83 were undivided and 7 were bifid.

Thus out of the 89 anteriorly placed papillary muscles, 51 were undivided, 23 were bifid, 14 were trifid and the remaining 1 was tetrafid and out of the 153 posteriorly placed papillary muscles 115 were undivided, 29 were bifid and the remaining 9 were trifid.

Out of the 82 septal papillary muscles present, 78 were undivided and 4 were bifid. All of the 27 Infundibular septal papillary muscles were undivided. 51 Inferior septal papillary muscles were undivided and 4 were bifid.

DISCUSSION

The number of papillary muscles in Tricuspid valve ranges from 2-9, but usually 2 or 3 papillary muscles can be seen: the anterior is the most prominent and the posterior is often bifid and trifid. The septal papillary muscle is the least prominent and sometimes can even be absent.¹¹

Waller et al¹² mentioned that in the right ventricle, the third, a small septal papillary muscle originates from the wall of the infundibulum which at times may be absent.

In the present study the average number of papillary muscles present in an individual heart is 4.50 in children, 5.00 in females and 5.14 in males. The number of papillary muscles present in the tricuspid valve is ranging from 2 to 11 with an overall average of 5.05 per heart which is greater than the average number 3.86 mentioned by Wafae et al.⁷ Most of the hearts (93%) are showing the presence of 3 to 8 papillary muscles whereas 2 papillary muscles are found in 4% hearts, 9 papillary muscles are found in 2% hearts and 11 muscles are found in 1% heart only. In the tricuspid valve extra-anterior and extra-posterior papillary muscles have been noticed in 35% and 83% hearts respectively. Septal papillary muscles have been seen in 62% hearts.

Aktas E.O. et al¹³ observed that the one headed anterior papillary muscle was found to be more in cardiac deaths. However, they noticed conical and flat topped configurations in all the posterior

papillary muscles more frequently.

Josyk et al¹⁴ in their study on 111 hearts found in majority. conus muscle supplied chordae tendinae to anterior leaflet while the other septal papillary muscles provided chordae tendinae to the anterior. and anterior part of septal cusp predominantly.

According to the Cunningham's Manual of Practical Anatomy¹⁵ the anterior and posterior Papillary muscles are divided into a number of projections and according to the Manipal Manual of Clinical Anatomy¹⁶ the septal papillary muscles are usually divided into a number of small ridges.

In the 41st edition of Grays Anatomy¹⁷ it is mentioned that the 2 major papillary muscles in the right ventricle are located in anterior an inferior positions. A third smaller muscle lies medially together with several smaller variable muscles attached to the inter-ventricular septum. The anterior papillary muscle could be bifid while the inferior papillary muscle is often bifid and trifid. The septal muscle of the conus, the muscle of Lancisi, is almost always present and is the most superior and largest of small septal papillary muscles.

Nigri et al¹⁸ studied the papillary muscles in 79 hearts. The septal papillary muscle was absent in 21.5% of the hearts. The anterior papillary muscle possessed 1 head in 81% and 2 heads in 19% cases. Double headed Anterior Papillary Muscles were mostly V or H shaped. Often the anterior papillary muscle presented with 3 or 4 papillae giving attachment to chordae tendinae. The Posterior papillary muscle showed the presence of 1 head in 25.4%, 2 heads in 46.8%, 3 heads in 21% and 4 heads in 6.3% of the hearts. The Septal papillary muscle was not present in some cases. When more than 1 septal papillary muscle was present each muscle had a very small head. In their study they found septal papillary muscle with 1 head in 41.7%, with 2 heads in 16.5%, with 3 heads in 12.7% and with 4 heads in 7.6% cases. They found that when 1 septal papillary muscle was present it had a small head with only 1 tip and when more than 1 septal papillary muscles were present each of these possessed a very small head. According to them the septal papillary muscles

could occur in 2 groups, one consisting of the constant musculus conus arteriosus and the second represented by other variable septal papillary muscles.

Loukas et al¹⁹ in their study on 100 hearts found the presence of conus muscle in 82% hearts. It was found to be present as a single (51.8%) double (32.9%) or triple (15.25%) papillae. Additionally, accessory Septal papillary muscles were seen which were single in 42, double in 32 and triple in 26 hearts. According to B.D.Chourasia²⁰ the septal papillary muscle is divided into a number of nipples and according to Vishram Singh²¹ it is divided into 2 or 3 nipples.

In the present series the papillary muscle which did not show any division is called an undivided muscle and the muscles with divisions are called bifid, trifid or tetrafid depending upon the number of divisions. The anterior papillary muscle is undivided in 50%, bifid in 28%, trifid in 21% hearts and tetrafid in only 1% heart. The extra-anterior papillary muscle is undivided in 35 (92.11%) hearts and bifid in 3 (7.89%) hearts. In Gray's Anatomy (41st edition, 2016) it is mentioned that the anterior papillary muscle could be bifid. In the present study bifid anterior papillary muscles are found in 28% hearts. However, additionally trifid and tetrafid anterior papillary muscles are found in 21% hearts and just 1% heart respectively. The posterior papillary muscle is undivided in 55% hearts, bifid in 32% hearts and trifid in 13% hearts. The findings in the present study are in line with the description given in Gray's Anatomy (41st edition, 2016) regarding the presence of bifid and trifid posterior papillary muscles.

In the present study out of the 126 septal papillary muscles found in 62 hearts, 47 (37.30%) were infundibular and 79 (62.69%) were inferior. There were 119 (94.44%) undivided and 7 (5.55%) bifid septal papillary muscles.

7.90% of the extra-anterior and 5.68% of the extra-posterior papillary muscles were found to be bifid.

Fifty percent of the anterior papillary muscles are undivided. In addition to bifid anterior papillary muscles, trifid and just 1 tetrafid anterior papillary muscles have been observed. Fifty five percent of the posterior papillary muscles are undivided and 45% of these are bifid or trifid.

CONCLUSION

The Anterior Papillary Muscles could be bifid or trifid. The Posterior Papillary Muscles are frequently bifid and trifid. Extra anterior and extra-posterior papillary muscles and the Septal Papillary muscles could also be bifid. The detailed knowledge of these variations is essential for the Cardiac Surgeon while performing various operative procedures on the Tricuspid valve.

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