

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

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Introduction: A sound knowledge of normal Anatomy and normal variations is essential for accurate interpretation of information by echocardiography and for the surgical repair of diseased valves. The present study was carried out with the aim to know the morphology of papillary muscles of Mitral valves in Central Indians and to try to classify certain prominent normal variations.

Material and Methods: The present study was carried out on 100 normal hearts from both sexes and of different age. The Mitral valves were dissected very carefully. The anterior, extra-anterior, posterior and extra-posterior papillary muscles were identified. It was noted whether the individual muscles were undivided or divided for variable length from their distal ends.

Result: 33 extra-anterior and 30 extra-posterior papillary muscles were seen in 31% and 25 % hearts respectively. Overall 2 to 5 papillary muscles with an average of 2.63 per heart were noticed. The muscles were observed to be either undivided or divided. 31 Anterior, 29, Extra-anterior, 14 posterior and 27 extra-posterior papillary muscles were undivided while 69 anterior, 4 extra-anterior, 86 posterior and 3 extra-posterior papillary muscles showed divisions. 39 anterior, 3 extra-anterior, 45 posterior and 2 extra-posterior papillary muscles were bifid. 28 anterior, 1 extra-anterior, 37 posterior papillary muscles were trifid. 2 anterior, 4 posterior and 1 extra-posterior papillary muscles were tetrafid.

Conclusion: Anterior and Posterior papillary muscles are commonly divided being bifid and trifid and uncommonly these could be tetrafid. Uncommonly Extra-anterior and Extra-posterior muscles could show divisions. Knowledge of these variations is of great help to the Cardiac surgeon.

Keywords: Anterior and posterior papillary muscles, Extra-anterior and Extra-posterior Papillary muscles, Undivided, Bifid, Trifid and Tetrafid.

INTRODUCTION

Wooley¹ mentioned that anatomists had been recording their observations on the structure of cardiac valves since 4th century B.C. King T. W.² in his publication described the anatomical features and functions of the Mitral valve. According to Walmsley³, it was Andreas Vesalius who suggested the picturesque term "mitral" to describe the left atrio-ventricular valve owing to its resemblance to a plan view of the bishops mitre. Waller et al⁴ described that regurgitation was produced by rupture and disfunction of papillary muscle or rupture of the chordae tendinae attached to the muscle. They also mentioned that myocardial hypoxia is indicated by the apices of the papillary muscles. Brock R.C.⁵ mentioned that the papillary muscles are typically two in number but extra muscles may exist. The knowledge of the normal Anatomy and normal variations in the Anatomy of Mitral valve is very much necessary during the performance of non-invasive imaging and surgery. Rusted et al⁶ reported that the anterior (or antero-lateral) was usually single and posterior (or postero-medial) papillary muscles were

2 or 3 (or 1 muscle with 2 or 3 heads) in more than 60% of the cases. Cheichi et al⁷ mentioned about the different types of papillary muscles. They considered a muscle as single if its apex was not grooved or slightly grooved. They considered two muscles or a muscle with two heads as double and three muscles or a trifid muscle as triple. They found single, double, triple and even more than 3 papillary muscles in their study. Thomas M. Joundinad et al⁸ have concluded in their experimental study that the papillary muscles act as shock absorbers for the maintenance of the basic Mitral valve geometry constant during the cardiac cycle. So the present study was carried out with the aim to know the morphology of papillary muscles of Mitral valves in Central Indians and to try to classify certain prominent normal variations.

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 Mitral valve complexes were dissected very carefully to avoid the cutting of papillary muscles and chordae tendinae. The procured hearts were kept in the following 3 groups:

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

Group II (female) - Twenty nine female hearts in the age of 16 to 80 years.

Group III (male) - Sixty three male hearts in the age of 16 to 61 years.

In these hearts Anterior and posterior papillary muscles were identified. Extra-anterior and extra-posterior papillary muscles, if present, were identified. In the present study the papillary muscles have been classified as under:

- (A) Anteriorly placed papillary muscles: (i) Anterior papillary muscle (ii) Extra-anterior papillary muscle
(B) Posteriorly placed papillary muscles: (i) Posterior papillary muscle (ii) Extra-posterior papillary muscle

It was noted whether the papillary muscle was undivided or was divided for variable length from its distal end towards its proximal end. Depending upon the non division or presence

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How to cite this article: A. V. Lakhanpal, S. K. Shrivastava, S.K. Verma. Study of types of papillary muscles of mitral valve in central Indians. International Journal of Contemporary Medical Research 2016;3(9):2707-2710.

of number of divisions the muscles were considered as (1) Undivided (2) Bifid (3) Trifid (4) Tetrafid. showing 1,2,3 or 4 bellies / heads.

STATISTICAL ANALYSIS

The results were calculated by using descriptive statistics such as average and percentage. The tables were generated by using Microsoft Office 2007.

A total number of

- (a) 2 papillary muscles were present in 53 hearts: In Group I (children) in 4 hearts; in Group II (female) in 17 hearts and in Group III (male) in 32 hearts.
- (b) 3 papillary muscles were present in 34 hearts: In Group I (children) in 2 hearts; in Group II (female) in 9 hearts and

in Group III (male) 23 hearts).

- (c) 4 papillary muscles were present in 10 hearts: In Group I (children) in 1 heart, in Group II (female) in 2 hearts and in Group III (male) in 7 hearts.

- (d) 5 papillary muscles were present in 3 hearts: In Group I (children) 1 heart, in Group II (female) in 1 heart and in Group III (male) 1 heart.

No. of different Papillary muscles

In Group I (children): 8 Anterior, 4 extra-anterior (12 anteriorly placed) papillary muscles and 8 posterior, 3 extra-posterior (11 posteriorly placed) papillary muscles were present. Thus in 8 hearts 23 papillary muscles were present with an average of 2.87 muscles per heart.

In Group II (female): 29 Anterior, 8 extra-anterior (37 anteriorly placed) papillary muscles and 29 Posterior, 8 extra-posterior (37 posteriorly placed) papillary muscles were present. Thus in 29 hearts 74 papillary muscles were present with an average of 2.55 muscles per heart.

In Group III (male): 63 Anterior, 21 extra-anterior (84 anteriorly placed) papillary muscles and 63 Posterior, 19 extra-posterior (82 posteriorly placed) papillary muscles were present.

Groups	2 muscles	3 muscles	4 muscles	5 muscles
I (children) hearts	4	2	1	1
II (female) hearts	17	9	2	1
III (male) hearts	32	23	7	1

Table-1: Total number of Papillary muscles in the mitral valve

No. of Extra papillary muscles		Group I (children) No. of hearts	Group II (female) No. of hearts	Group III (male) No. of hearts
Extra-anterior papillary muscles	0	5	21	43
	1	2	8	19
	2	1	0	1
Extra-posterior papillary muscles	0	6	22	47
	1	1	6	14
	2	1	1	1
	3	0	0	1

Table-2: No. of extra-papillary muscles in the mitral valve

Papillary Muscles	Type of Muscle	I		II		III	
		No.	%	No.	%	No.	%
Anterior: 8, 29 and 63 in Groups - I, II and III	Undivided	4	50	9	31.03	18	28.57
	Bifid	2	25	12	41.37	25	39.68
	Trifid	2	25	8	27.58	18	28.57
	Tetrafid	0	0	0	0	2	3.17
Extra-anterior: 4, 8 and 21 in Groups - I, II and III	Undivided	4	100	8	100	17	80.95
	Bifid	0	0	0	0	3	13.63
	Trifid	0	0	0	0	1	4.54
	Tetrafid	0	0	0	0	0	0
Anteriorly placed: 12, 37 and 84 in Groups - I, II and III	Undivided	8	66.66	17	45.95	35	41.66
	Bifid	2	16.66	12	32.43	28	33.33
	Trifid	2	16.66	8	21.62	19	22.61
	Tetrafid	0	0	0	0	2	2.38
Posterior 8, 29 and 63 in Groups - I, II and III	Undivided	2	25	4	13.79	8	12.69
	Bifid	2	25	11	37.93	32	50.79
	Trifid	4	50	12	41.37	21	33.33
	Tetrafid	0	0	2	6.89	2	3.17
Extra-posterior 3, 8 and 19 in Groups - I, II and III	Undivided	1	33.33	7	87.50	19	100
	Bifid	1	33.33	1	12.50	0	0
	Trifid	0	0	0	0	0	0
	Tetrafid	1	33.33	0	0	0	0
Posteriorly placed 11, 37 and 82 in Groups - I, II and III	Undivided	3	27.27	11	29.72	27	32.92
	Bifid	3	27.27	12	32.43	32	39.02
	Trifid	4	36.36	12	32.43	21	25.60
	Tetrafid	1	9.09	2	5.40	2	2.43

Table-3: Different types of papillary muscles in Mitral valve

Thus in 63 hearts 166 papillary muscles were present with an average of 2.63 muscles per heart. In the present study 263 papillary muscles were observed in 100 hearts with an average of 2.63 per heart.

Extra papillary muscles

The extra-anterior and extra-posterior papillary muscles were not found in 69 and 75 hearts respectively.

31 hearts showed the presence of 33 extra-anterior papillary muscles. In 29 hearts 1 and in 2 hearts 2 of these muscles were observed.

In Group I (children): None of these were present in 3 hearts. In 2 hearts 1 and in 1 heart 2 of these muscles were observed.

In Group II (female): 8 of these were observed in 8 hearts, each showing presence of 1 of these muscles.

In Group III (male): 21 of these were seen in 20 hearts; 1 of these was present in 19 hearts and 2 of these were seen in 1 heart.

In 25 hearts a total number of 30 extra-posterior papillary muscles were observed. 1 of these was seen in 21 hearts; 2 of these were present in 3 hearts and 3 of these were seen in 1 heart.

In Group I (children): 3 of these muscles were seen in 2 hearts; 1 heart showed the presence of 1 while the other heart had 2 of these muscles.

In Group II (female): 8 of these muscles were observed in 7 hearts; 6 hearts had 1 and 1 heart had 2 of these muscles.

In Group III (male): 19 of these muscles were noticed in 16 hearts; 14 hearts had 1; 1 heart had 2 and 1 heart had 3 of these muscles.

In Group I (children), the anterior papillary muscles were undivided in 4 hearts (50%), bifid in 2 hearts (25%) and trifid in the remaining 2 hearts (25%). All the 4 extra-anterior papillary muscles found in this group were undivided. The posterior papillary muscles were undivided in 2 hearts (25%), bifid in 2 hearts (25%) and trifid in the remaining 4 hearts (50%) Out of the 3 extra-posterior papillary muscles found in this group, 1 muscle (33.33%) was undivided, 1 muscle (33.33%) was bifid and the remaining 1 muscle was tetrafid.

Thus out of the 12 anteriorly placed papillary muscles; 8 (66.66%) were undivided, 2 (16.66%) were bifid and 2 (16.66%) were trifid. Out of the 11 posteriorly placed papillary muscles; 3 (27.27%) were undivided, 3 muscles (27.27%) were bifid, 4 muscles (36.36%) were trifid and the remaining 1 muscle (9.09%) was tetrafid.

In Group II (female), the anterior papillary muscles were undivided in 9 hearts (31.03%), bifid in 12 hearts (41.37%) and trifid in the remaining 8 hearts (27.58%). All the 8 extra-anterior papillary muscles (100%) present were undivided. The posterior papillary muscles were undivided in 4 hearts (13.79%); bifid in 11 hearts (37.93%); trifid in 12 hearts (41.37%) and tetrafid in the remaining 2 hearts (6.89%). Out of the 8 extra-posterior papillary muscles present in this group, 7 (87.50%) were

undivided and 1 (12.50%) was bifid.

Thus out of the 37 anteriorly placed papillary muscles; 17 (45.95%) were undivided, 12 (32.43%) were bifid and 8 (21.62%) were trifid. Out of the 37 posteriorly placed papillary muscles; 11 (29.72%) were undivided, 12 muscles (32.43%) were bifid, 12 muscles (32.43%) were trifid and the remaining 2 muscles (5.40%) were tetrafid.

In Group III (male), the anterior papillary muscles were undivided in 18 hearts (28.57%); bifid in 25 hearts (39.68%); trifid in 18 hearts (28.57%) and tetrafid in the remaining 2 hearts (3.17%). Out of the 21 extra-anterior papillary muscles found; 17 muscles (80.95%) were undivided, 3 muscles (14.28%) were bifid and the remaining 1 muscle (4.76%) was trifid. The posterior papillary muscles were undivided in 8 hearts (12.69%); bifid in 32 hearts (50.79%); trifid in 21 hearts (33.33%) and tetrafid in the remaining 2 hearts (3.17%). All the 19 extra-posterior papillary muscles (100%) were undivided.

Thus out of the 84 anteriorly placed papillary muscles; 35 (41.66%) were undivided, 28 (33.33%) were bifid, 19 (22.61%) were trifid and the remaining 2 (2.38%) were tetrafid. Out of the 82 posteriorly placed papillary muscles 27 (32.92%) were undivided, 32 (39.02%) were bifid, 21 (25.60%) were trifid and the remaining 2 muscles (2.43%) were tetrafid.

DISCUSSION

Brock R.C.⁵ mentioned that each of the two papillary muscles may be a single papilla or may be split to a greater or lesser degree so that it is either notched at its apex, deeply grooved along its sides or bifid. Rusted et al⁶ following a study of 200 normal hearts reported that the anterior (antero-lateral) papillary muscle was usually single and that in more than 70% of cases it contained a groove which led in the direction of the commissure immediately above the apex of the papillary muscle. At the postero-medial location 2 or 3 muscles (or 1 muscle with 2 or 3 heads) were found in 60% hearts.

In their study in 105 normal hearts, Cheichi et al⁷ found that the antero-lateral papillary muscles were single in 87 (82.80%), double in 15 (14.30%) and triple in 3 (2.90%) and the postero-medial papillary muscles were single in 31 (29.50%), double in 57 (54.30%), triple in 12 (11.40%) and even more than three in 5 (4.80%) hearts.

Ranganathan et al⁹ mentioned that the antero-lateral papillary muscle usually possesses one belly whereas the postero-medial papillary muscle has frequently two or more bellies. In the 41st edition of Gray's Anatomy (2016)¹⁰ it has been described that the anterior and posterior papillary muscles might be bifid.

Jacob P. Dal-Bianco, and Robert A. Levine¹¹ have mentioned that the lateral Papillary muscle in most of cases possesses one head while the medial Papillary Muscle most commonly possesses 2 heads.

S. Y. Ho¹² mentioned that there are usually groups of papillary muscles arranged fairly close together. At their bases, the

Types of papillary muscles	Antero-lateral muscles Hearts	Percent	Postero-medial muscles Hearts	Percent
Single	87	82.80	31	29.50
Double	15	14.30	57	54.30
Triple	3	2.90	12	11.40
More than three	0	0	5	4.80

Table-4: Types of Papillary muscles in 105 Normal hearts (Cheichi et al. 1956)

muscles sometimes get fused or have bridges of muscular or fibrous continuity before getting attached to the ventricular wall. Extreme fusion of the muscles results in parachute malformation with potential for stenosis of the mitral valve. Rupture of the entire muscle or its groups will result into excessive regurgitation whereas the result of rupture of one head of the muscle complex will be similar to that of breaking of a major cord.

P. McCarthy et al¹³ mentioned that the antero-lateral and postero-medial papillary muscles in the majority of adults could have up to three heads. However, they further observed that there could be significant variation in this distribution, particularly, in patients with myxomatous-type leaflets (degenerative Mitral Valve disease).

Victor S, Nayak VM¹⁴ studied the papillary muscles of the mitral valve in 100 human autopsy hearts. They found that the antero-lateral papillary muscles were having 1 muscle belly in 67 hearts while these muscles showed the presence of 2, 3, 4 and 5 bellies in 27, 4, 1 and 1 hearts respectively. The postero-medial papillary muscles were having 1 muscle belly in 50 hearts while these muscles showed the presence of 2, 3 and 4 bellies in 36, 11 and 3 hearts respectively.

The classification of the types of muscles done by Cheichi et al⁷ is not agreed upon. The single muscle called by various other authors has been called as undivided muscle. The number of divided posterior papillary muscles (86) was more than that of the anterior papillary muscles (69). Only 4 (12.12%) out of 33 extra-anterior and 3 (10%) out of 30 extra-posterior papillary muscles showed divisions. Out of the 133 anteriorly placed papillary muscles 60 (45.11%) were undivided and 73 (54.89%) were divided. Out of the 130 posteriorly placed papillary muscles 41 (31.54%) were undivided and 89 (68.46%) were divided.

The anterior papillary muscles were bifid (39%) or trifid (28%) and even tetrafid (2%). A small number of bifid (3 muscles) and trifid (1 muscle) extra-anterior papillary muscles have been noticed in the male hearts only. In the present series of hearts Posterior papillary muscles were mostly bifid (45%) and trifid (37%), a few of these were undivided (14%) and fewer (4%) were tetrafid. Only two bifid (1 in the heart of a child and 1 in the heart of a female) and only one tetrafid extra-posterior papillary muscles have been found.

In addition to the bifid and trifid papillary muscles we have observed tetrafid papillary muscles in 7 hearts in the present study. The Anterior papillary muscles in 2 male hearts; Posterior papillary muscles in 2 female and 2 male hearts; and the extra-posterior papillary muscle in the heart of a child were tetrafid. Five divisions were not observed in any muscle.

CONCLUSION

The Anterior and posterior papillary muscles are commonly divided being bifid and trifid and uncommonly these could be tetrafid. Uncommonly extra-anterior and extra-posterior papillary muscle could show divisions. The variations seen in the pattern of divisions of different papillary muscles can be explained on the basis of development. Knowledge of these variation is of great help to the Cardiac surgeon in performing various operative procedures on the Mitral valve.

ACKNOWLEDGEMENT

We are thankful to Mrs. Renu Bala Lakhanpal and Mr. Devpriya Lakhanpal for their generous help.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 03-08-2016; **Published online:** 10-09-2016