Section: Anatomy

Original Research Article

ANATOMICAL VARIATIONS IN PAPILLARY MUSCLE SHAPES OF HUMAN ADULT HEARTS: INSIGHTS FROM A CADAVERIC STUDY AT GAUHATI MEDICAL COLLEGE AND HOSPITAL, ASSAM

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Abstract

Background: Papillary muscles are essential anatomical structures within the human heart, intricately involved in maintaining valvular integrity and cardiac function. Understanding their diverse anatomical variations is critical for optimizing surgical strategies and improving patient outcomes in cardiac interventions. **Materials and Methods:** This cadaveric study examined 40 formalin-fixed adult human hearts sourced from Gauhati Medical College and Hospital, Assam. Hearts were meticulously dissected to expose and classify papillary muscles in both the right and left ventricles. Shapes were categorized according to established criteria, including conical, flat-top, truncated, bifurcated, and trifurcated configurations. **Result:** Analysis revealed notable variations in papillary muscle morphology. Conical shapes predominated, comprising 30% and 40% in the right and left ventricles, respectively. Flat-top and truncated configurations were also observed, highlighting the diversity in anatomical presentations. **Conclusion:** The study underscores the intricate anatomical diversity of papillary muscles in human hearts, emphasizing their clinical relevance in surgical planning and diagnostic assessments. Knowledge of these variations enhances the precision of cardiac procedures, facilitating improved outcomes and patient care.

INTRODUCTION

Papillary muscles are pivotal components of the cardiac ventricles, integral to the complex mechanism of valvular function. In the human heart, these muscles vary significantly in size and shape, with the anterior papillary muscle of the right ventricle being the largest, followed by the posterior papillary muscle, while the septal papillary muscle is the smallest.[1] Functionally, papillary muscles support the tricuspid and mitral valves by providing attachments for chordae tendineae, thereby ensuring valve competence during cardiac cycles.[2]

The morphology of papillary muscles, predominantly conical in shape in the left ventricle, assumes critical clinical relevance. This anatomical feature influences the efficiency of ventricular contraction and the proper closure of valves, particularly the tricuspid valve in the right ventricle and the mitral valve in the left ventricle. Dysfunction or structural abnormalities in these muscles can predispose individuals to conditions such as mitral valve prolapse, exacerbated by left ventricular hypertrophy.[3-10]

Understanding the variations in papillary muscle anatomy is essential for cardiac surgeons, guiding surgical interventions such as mitral valve replacement and repair. By delineating these anatomical nuances, surgeons can tailor their approaches to individual patient characteristics, thereby optimizing procedural outcomes and minimizing postoperative complications.[11-13]

This study aims to systematically investigate the anatomical variations in papillary muscle shapes within human adult hearts, utilizing cadaveric specimens from Gauhati Medical College and Hospital, Assam. By elucidating these variations, this research seeks to contribute valuable insights into the clinical management and surgical treatment of cardiac conditions associated with papillary muscle morphology.[14,15]

MATERIALS AND METHODS

This study was conducted at the Department of Anatomy, Gauhati Medical College, utilizing cadaveric specimens sourced from two primary repositories: unclaimed bodies and donated cadavers managed by the Department of Anatomy and the Department of Forensic Medicine and Toxicology at Gauhati Medical College. Ethical clearance for this

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study was obtained from the Institutional Ethics Committee of Gauhati Medical College and Hospital, Assam, ensuring compliance with ethical guidelines governing research involving human cadaveric specimens. All specimens underwent embalming according to standard protocols to maintain anatomical integrity. Cadaveric hearts were dissected in the dissection hall following Cunningham's Manual of Practical Anatomy.[16] The dissection procedure involved a systematic approach: a midline incision from the suprasternal notch to the xiphisternum, with additional transverse incisions above the suprasternal notch and below the xiphisternum. A fourth incision extended from the xiphisternum superolaterally to the acromion. Parasternal incisions across the costal cartilage were made to facilitate sternal separation from the thoracic wall. Hearts, with intact pericardial coverings, were carefully dissected out and subsequently washed in running water to remove blood clots and residues. Specimens were then immersed in 10% formalin for preservation. The right and left ventricles were opened by making incisions along the sternocostal and diaphragmatic surfaces to expose the heart's interior. Papillary muscles were meticulously examined and classified based on established anatomical criteria into shapes such as conical, flat-top, truncated, bifurcated, and trifurcated.[1] Dissection was performed using a standard set of instruments and materials, including 10% formalin for preservation, normal saline for rinsing, and various containers (jars, buckets, trays). Surgical equipment included surgical gloves, blue cloth for draping, a dissecting box equipped with plain and toothed forceps, surgical blades, scalpels, scissors, pins, magnifying glasses, and vernier caliper for precise measurements.

Table 1: Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
1. Heart without congenital anomalies.	1. Heart with congenital anomalies detected during initial inspection
2. Hearts without any history of prior injury or surgical interventions.	2. Heart with pathological lesions upon macroscopic examination
3. Cadavers from individuals without a documented history of ventricular hypertrophy.	3. Cadavers from individuals with a documented medical history of hypertension (HTN).

RESULTS

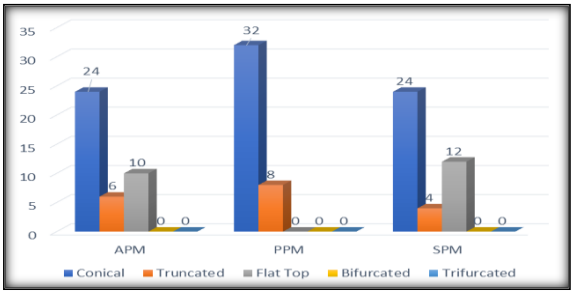

Figure 1: Histogram Showing the shape of different groups of papillary muscle of right ventricle. (APM-Anterior papillary muscles, PPM-Posterior papillary muscles, SPM- Septal papillary muscles)

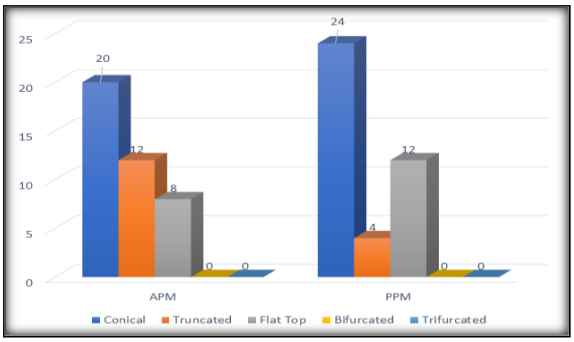

Figure 2: Histogram Showing the shape of different groups of papillary muscle of left ventricle.

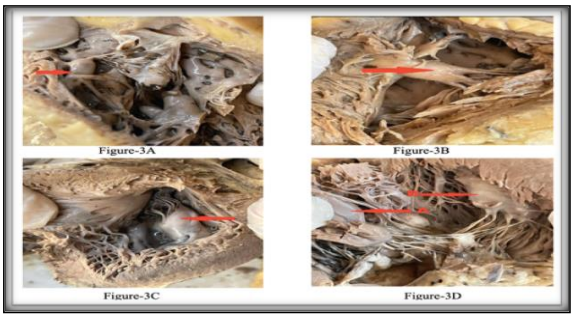

Figure 3: Showing with RED arrow mark the – (3A) Conical shaped papillary muscle , (3B) Truncated shaped papillary muscle, (3C) Flat -topped papillary muscle, (3D) Two types of Papillary muscles (3D-A) Conical & (3D-B) Truncated in the same side ventricle.

In the Right Ventricle

Table 2: Showing the data of different groups of papillary muscle of right ventricle.

Shape of papillary muscles	Group of papillary muscle					
	Anterior papillary muscles		Posterior papillary muscles		Septal papillary muscles	
	Numbers (40)	(%)	Numbers (40)	(%)	Numbers (40)	(%)
Conical	24	60%	32	80%	24	60%
Truncated	6	15%	8	20%	4	10%
Flat top	10	25%	0	0	12	30%
Bifurcated	0	0	0	0	0	0
Trifurcated	0	0	0	0	0	0

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In the Left Ventricle

Table 3: Showing papillary muscles of left ventricle.

Shape of the papillary muscles	Group of papillary muscle			
	Anterior papillary muscles		Posterior papillary muscles	
	Numbers(40)	(%)	Numbers(40)	(%)
Conical	20	50%	24	60%
Truncated	12	30%	4	10%
Flat top	8	20%	12	30%
Bifurcated	0	0	0	0
Trifurcated	0	0	0	0

DISCUSSION

The present study provides insights into the anatomical variations of papillary muscles within the ventricles of adult human hearts, highlighting their clinical relevance in cardiac surgical procedures and diagnostic imaging.

Anatomical Variations: Our findings reveal a notable prevalence of conical-shaped papillary muscles in both the right and left ventricles. This is consistent with existing literature, which underscores the functional advantages of conical morphology in facilitating cardiovascular physiology by minimizing obstruction to blood flow through the ventricles (Gunnal et al., 2013; Saha et al., 2018).

Clinical Implications: Understanding the diverse shapes of papillary muscles is critical for cardiac surgeons during mitral and tricuspid valve surgeries. The conical shape, predominant in our study, is particularly advantageous due to its optimal support of chordae tendineae and effective closure mechanisms during valve function (Ho, 2002; Hosapatna et al., 2014). Conversely, variations such as flat-topped and truncated shapes, though less common in our sample, necessitate careful consideration during surgical planning to ensure optimal valve repair and replacement outcomes (Saha et al., 2018; Victor and Nayak).

Comparison with Literature: Comparative studies by Hosapatna et al. (2014) and Saha et al. (2018) corroborate our findings of high prevalence of conical papillary muscles in the right ventricle, emphasizing its structural advantages in maintaining valvular integrity. The variability observed in papillary muscle shapes underscores the uniqueness of each individual's cardiac anatomy, akin to fingerprint uniqueness (Victor and Nayak).

Limitations and Future Directions: This study is limited by its sample size of 40 hearts, which may not fully represent the broader population variability. Future research with larger sample sizes and diverse demographic groups could provide deeper insights into regional and ethnic variations in papillary muscle anatomy. Additionally, incorporating advanced imaging techniques such as cardiac MRI and CT scans could further elucidate three-dimensional aspects of papillary muscle morphology and their functional implications.[17-19]

CONCLUSION

This cadaveric study on the anatomical variations in papillary muscle shapes within adult human hearts revealed predominance of conical shapes in both right and left ventricles. These findings emphasize the clinical importance of understanding such variations for optimizing surgical outcomes in mitral and tricuspid valve procedures.

The prevalence of conical papillary muscles supports efficient valvular function by minimizing blood flow obstruction. This anatomical knowledge is crucial for tailored surgical approaches, enhancing precision and reducing complications in cardiac interventions. While this study provides valuable insights, larger sample sizes and diverse demographic considerations are warranted to further explore regional and ethnic differences in papillary muscle morphology. Advanced imaging techniques could also enhance understanding of three-dimensional structural nuances and their implications for cardiac health.

Therefore, enhanced awareness of papillary muscle variations among healthcare providers is pivotal for advancing diagnostic accuracy and refining treatment strategies in cardiovascular medicine. This study underscores the importance of anatomical precision in improving patient outcomes and guiding future research initiatives.

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