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A morphometric study of the papillary muscle in the right ventricle of the heart in the Bangladeshi population

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Abstract---Papillary muscles are one of the important components of the musculature of the ventricles of the heart. Various diseases of papillary muscle dysfunction such as papillary muscle ischemia, left

ventricular dilation, non-ischemic papillary muscle atrophy, papillary muscle or chordae congenital anomalies, dilated or hypertrophic cardiomegaly are commonly observed. Apparently normal postmortem hearts (n=60) were used in this study. Based on gender, specimens were grouped as follows: group A (n=41) 'male' and group B (n=19) 'female'. The length and breadth of the anterior, posterior and septal papillary muscles were measured. The mean length of the anterior papillary muscle was 17.27 (± 4.30) mm in males, 16.98 (± 3.70) mm in females, the posterior papillary muscle was 14.04 (± 3.78) mm in males, and 13.81 (± 2.47) mm in female, and septal papillary muscle was 7.35 (± 2.78) mm in male and 6.73 (± 1.94) mm in female. The breadth of anterior papillary muscle was 5.75 (± 1.24) mm and 5.94 (± 1.76) mm, posterior papillary had 5.02 (± 1.09) mm and 4.77 (± 0.80) mm, and septal papillary was 3.97 (± 0.81) mm and 3.86 (± 0.38) mm in male and female accordingly. The unpaired student's t-test was used to compare the values of the above-mentioned variables between groups A and B, and the results were statistically insignificant. The current study provides baseline data on variations in the number of papillary muscles in the right ventricle, as well as a specific treatment plan for various cardiac diseases involving papillary muscles in both genders of the Bangladeshi population.

Keywords---papillary muscle, tricuspid valve, right ventricle.

Introduction

Modern cardiac surgery necessitates a better understanding of the morphology and variations of the mitral and tricuspid valvular complexes, all of which are important in the surgical treatment of valve prolapse and valve replacement. Many cardiac diseases are associated with mitral valve disorders and include prolapse and stenosis (Sheikh et al., 2017). The papillary muscles of the heart are conical projections into the myocardial chamber. The papillary muscles are essential components of the corresponding valve complex. They prevent the cusps of the valve from everting when the ventricle contracts (Kavitha et al., 2018). Left ventricular (LV) dilatation causes greater sphericity and changes the location and orientation of papillary muscles (PMs), which may influence their ability to do work (Duchenne et al., 2019). According to Santiago Rivera et al., 2019, papillary muscles are widespread in patients with ventricular arrhythmias (VA) (Rivera et al., 2019).

The anterior papillary muscle is the largest and longest of the right ventricle's three papillary muscles, whereas the septal papillary muscle is the smallest. The two papillary muscles in the left ventricle remain bifid and give support to the cusps of the mitral valve (Sinha et al., 2021), whereas the three papillary are seen in the right ventricle. Papillary muscles are located superolateral from the sternocostal and inferolateral from the diaphragmatic surface, respectively. Changes in the size and shape of the ventricle can cause changes in the location of the papillary muscles, resulting in decreased valvular function (Saha & Roy., 2018).

The morphology of the papillary muscles in fan-shaped papillary hypertrophy affects blood flow, and papillary muscles with a big apex are more likely to produce left ventricular blockage. In papillary muscle failure, valve prolapse, and valve replacement surgery, accurate detection of chordo-papillary differences is required. Anatomical Variations in the tricuspid valve have also been linked to a number of syndromes and congenital anomalies. As a result, differences in the number, length, and form of the papillary muscles become clinically significant (Marius et al., 2018). Papillary muscle differences are also described in terms of development. Papillary muscle morphology differs due to incomplete trabecular ridge distortion.

Although advanced noninvasive technologies are currently employed for anomaly identification and confirmation, radiological data analysis and interpretation require extensive anatomical knowledge. The increasing clinical and surgical importance of the papillary muscle, as well as the lack of thorough information on its anatomical characteristics, is a potential risk factor for unexpected fatalities. The anatomical variations of papillary muscles mentioned in the textbooks are predominantly based on the studies carried out in the western population. Documented evidence of these anatomical variances is sparse in the Asian population in developing countries such as Bangladesh, Pakistan and India. Thus, the current study aimed to collect morphometric data to identify anatomical variations such as the length and breadth of the papillary muscle in the tricuspid valve in both male and female Bangladeshi populations.

Materials and Methods

Cadaveric study

The present morphological descriptive type of survey was conducted in the anatomy department at Sir Salimullah Medical College (SSMC), Dhaka, Bangladesh, and from 2009 to 2010.

Participation characteristics

Normal adult human hearts were reportedly achieved from the department of forensic medicine of Sir Salimullah Medical College (SSMC) and Dhaka Medical College (DMC), Dhaka. Formalin-fixed normal adult human hearts of both genders are divided into group A (41 males), and group B (19 females).

Any specimens having an evident anomaly, such as a putrefied heart, a poisoned heart, anomalies that could impact its topography, or calcifications, were excluded from the study. Ethical approval was obtained from the Medical Research and Ethical Committee (MREC) of Sir Salimullah medical college and hospital (SSMC&H).

Methods of dissection

Dissection of the dead body was performed according to standard autopsy techniques. The specimen was collected within 12-36 hours of death. After cleaning the heart specimens further, they were preserved in 10% formal saline.

The age of heart samples ranging from 20 to 70 years was gathered from the DMC and SSMC departments of forensic medicine's record book. The obtained specimens were split into the following categories based on gender: Group A consists of forty-one males ($n=41$), while Group B consists of nineteen females ($n=19$). To open the tricuspid valve, a scalpel knife was used to cut from the right atrium to the apex of the right ventricle via the ventricle's lateral or acute edge. The inside of the heart was cleaned, and blood clots were removed. The second cut was made along the front side of the heart, immediately to the left of the intra-ventricular groove, from the ventricle's apex to the annulus. The length of each papillary muscle was measured from its connection to the ventricular wall to its apex at the level of chordal attachment using a simple divider.

Using the same divider, the breadth of each papillary muscle was measured at the mid-level of the muscle. The divider was put on the metric scale, and the measurement was given in millimeters. The data were collected in a methodical manner on the data collection sheet. As a result, the data was analyzed to determine the mean, standard deviation, and percentage values. Each muscle's morphology was studied in the following ways: (Figure 1 & Figure 2)

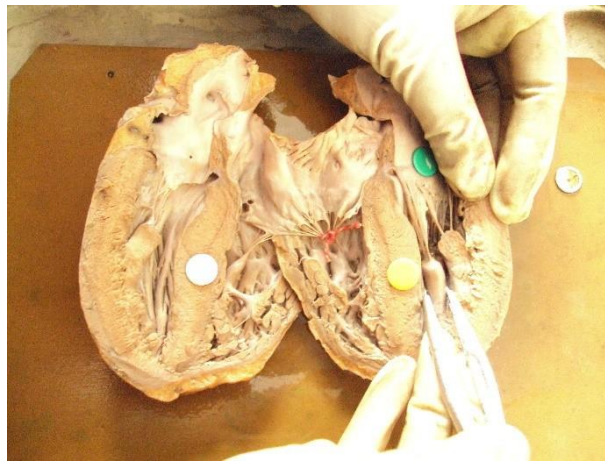


Figure 1: Length of anterior, posterior, and septal papillary muscles

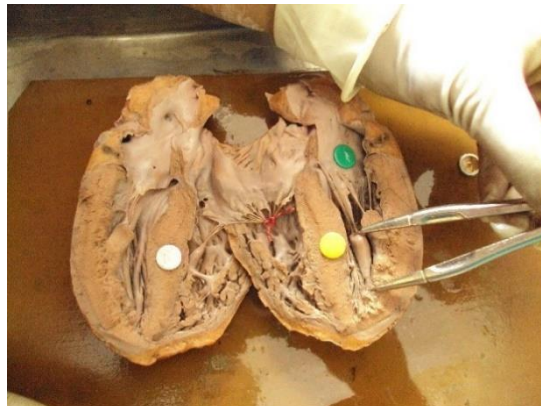


Figure 2: Breadth of the anterior, posterior, and septal papillary muscles

Statistical analysis

The morphological values were analyzed using the statistical package for social science (SPSS-17), unpaired student's t-test, and Chi-square test. An unpaired t-test was done to see the significance between the two groups in relation to sex. Results were considered statistically significant when P-value was <0.05 .

Results

Sixty human cadaveric heart specimens were carefully examined, with observations as below: Morphological dimensions of the length of the anterior papillary muscle in group A (n=41) were (17.27 ± 4.30) mm, and in group B (n=19) was (16.98 ± 3.07) mm, the posterior papillary had (14.04 ± 3.78) mm and (13.81 ± 2.47) mm in group A and group B and septal papillary was in group A, (7.35 ± 2.78) mm and in group B was (6.73 ± 1.94) mm accordingly. The lengths of the anterior, posterior, and septal papillary muscles differed insignificantly between the two groups, according to statistical analysis (Fig. 3).

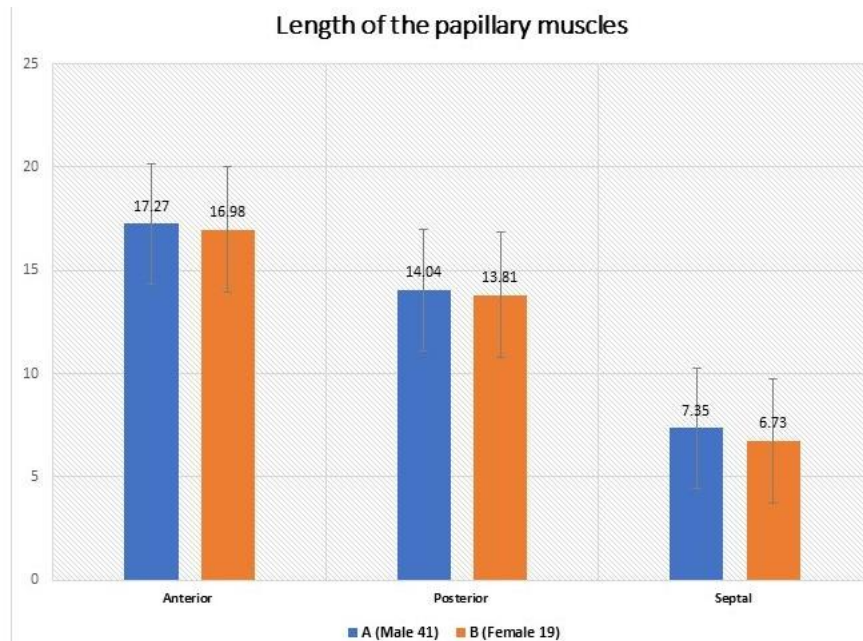


Figure 3: Bar diagram shows lengths of the anterior, posterior, and septal papillary muscles

Fig. 4 showed the mean breadth of anterior papillary muscle (5.75 ± 1.24) mm and (5.94 ± 1.76) mm, posterior papillary has (5.02 ± 1.09) mm and (4.77 ± 0.80) mm and the septal papillary was (3.97 ± 0.81) mm and (3.86 ± 0.38) mm in group A (n=41) and group B (n=19) respectively. Statistical observations revealed that the values were inconsequential in the two groups in respect of the breadth of the anterior, posterior, and septal papillary muscles (Fig. 4)

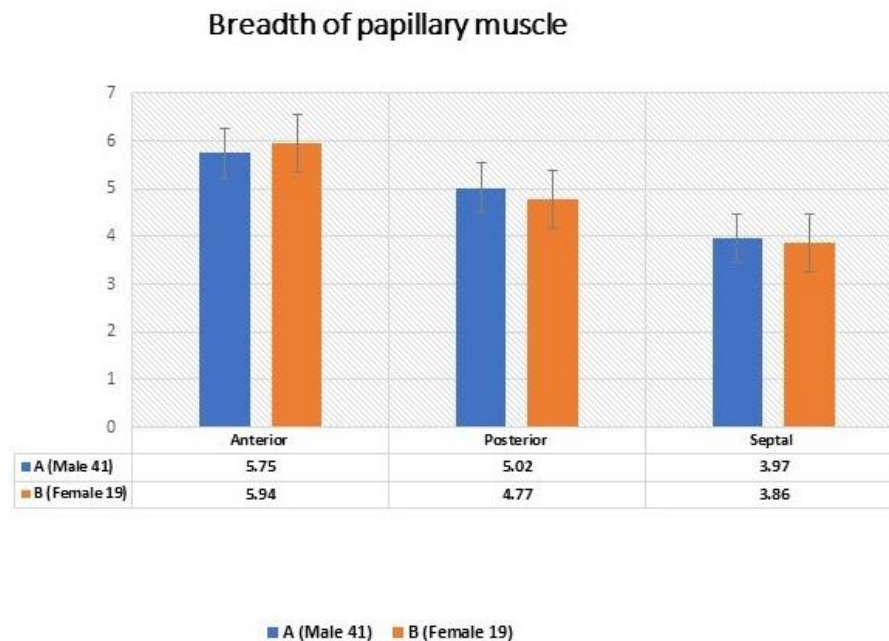


Figure 4: Bar diagram shows breadth of the anterior, posterior, and septal papillary muscles

Discussion

Length of anterior, posterior, and septal papillary muscles

The papillary muscles are clinically significant because they play an important role in right ventricle contraction by pushing the tricuspid annulus towards the apex, causing the long axis to shorten and the chamber to become spherical for blood ejection. The current study observed the length and breadth of the papillary muscles in the right ventricle. Males had longer papillary muscles in the anterior, posterior, and septal areas than females.

Sinha et al. (2021), discovered that the thickness of the anterior, posterior, and septal papillary of the right ventricle was 1.27 ± 0.45 cm, 1.36 ± 0.52 cm, and 0.92 ± 0.54 cm respectively. The mean length of the papillary muscle (both anterior and posterior) in the left ventricle was longer in numerous heart specimens when compared to other heart specimens of the right ventricle. The comparison of the latest research with Manisha's study is generally similar because the current study demonstrated a greater length of the three papillary muscles of the right ventricle (Sinha et al., 2021).

Kavitha et al. (2018) and Marius et al. (2018) measured the anterior 14.89 (4.19) mm, posterior 14.86 (4.05) mm, and septal muscle 10.27 (3.28) mm of the right ventricle. This study explained the length as well, which is identical to the current study (Kavitha et al., 2018; Marius et al., 2018).

A study of 96 formalin-fixed human hearts showed that the mean height of the anterior papillary muscle was 1.49 cm, while the posterior papillary muscle was 1.05 cm (Theodoros Xanthos I et al. (2011). Several other studies mentioned that the length was greater in the anterior, posterior, and septal muscles, respectively, which was similar to the current study (Ekin O Aktas, 2004; Gerola et al., 2001; Nigri et al., 2001; et al., 2014; Saksena et al., 1986).

Breadth of anterior, posterior, and septal papillary muscles

According to the current study, the anterior papillary in females was the thickest than the male group and the other two posterior and septal papillary muscles were the thickest in males in the right ventricle. According to one study, the right anterior papillary muscle measured 4.66 mm (1.60), the posterior papillary muscle measured 4.96 mm (1.71), and the septal papillary muscle measured 3.25 mm (1.15) (Kavitha et al., 2018). Manisha et al., (2020), perceived that the thickness of the right ventricle varies from 0.40 to 1.70 cm with a mean thickness of 1.17 ± 0.31 cm (Sinha et al., 2021).

Gerola LR (2001), specified that the breadth of the anterior, posterior, and septal papillary muscles was 1.2 ± 0.3 cm, 0.7 ± 0.2 cm, and 1.2 ± 0.3 cm, respectively (Gerola et al., 2001). Nigri GR (2001) stated that the mean breadth of the anterior papillary was 1.1 cm (Nigri et al., 2001). Priya et al., (2014) indicated that the breadth of the anterior papillary muscle was 4.04 ± 1.53 mm (Priya et al., 2014). According to Harsha (2014), the mean width of the anterior papillary muscle was 0.8 cm; the posterior papillary was 0.6 cm range and the septal papillary muscle (R & R, 2014). Another study was done by Saksena et al., (1985) mentioned the width of the papillary muscle was 0.5 to 1.5 cm (Saksena et al., 1986). A possible explanation for such disparities is that all research was done in distinct geographic areas and demographics. Begum (1996) studied the breadth of papillary muscles in both genders. The breadth of anterior papillary muscle, posterior papillary, and septal papillary muscle were (5.73 ± 1.12) mm, (3.50 ± 1.17) mm, and (2.19 ± 1.45) mm in males respectively, and (5.20 ± 1.43) mm, (3.84 ± 1.41) mm and (2.02 ± 1.75) mm in females accordingly. The current study found only a minor difference from this study (Begum et al., 2006).

The main similarity between the current survey and the previously mentioned studies was that the majority of the studies were done on formalin-fixed postmortem samples. However, differences were discovered as a result of the majority of the studies being conducted in western countries, at different times, geographical variations, health status, and different dissection methodologies. Modern surgical procedures that are using morphological differences in papillary muscles include rheumatoid papillotomy and commissurotomy, leaflet resection in advanced myxomatous lesions, excision of infective vegetation, transfer and rotation of leaflet segments in traumatic conditions, and correction of papillary rupture-induced tricuspid regurgitation.

The tricuspid valve is complicated by congenital malformations such as Ebstein's deformity, dysplasia, and hypertrophy because the tendinous chords and papillary muscles are remarkably short and thick. As a result, understanding the anatomical differences between the papillary muscles is even more important for

cardiothoracic surgery. A detailed assessment of the heart valve and its complexity is required to achieve this goal.

The current study provides valuable information about baseline data on variations in papillary muscles of the right ventricle in the Bangladeshi population of both sexes, and it helps to provide a definite outlay for administration as well as additional information to clinicians, cardiologists, anatomists, and physiologists to help them decide the diagnosis and management of various diseases. Multi-center studies with larger sample size, on the other hand, are required to perform data on the anatomical characteristics of normal hearts.

Limitations of the study

The specimens were formalin soaked, so shrinkage might be causing changes in the values of the length and breadth of the papillary muscle. During my study period, a small amount of female viscera was obtained during my study period.

Ethical statement

Ethical approval was not required for this type of study.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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