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Positions of septal papillary muscles in human hearts

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Septal papillary muscles, similarly to other papillary muscles, are essential elements of the heart valvular system. Damage to their structure may lead to a considerable life risk.

Of all the papillary muscles, the septal papillary muscles are characterized by the greatest topographical and morphological variability. However, information about these muscles is scarce and fragmentary. The objective of this study was to ascertain their occurrence and the region in which they are placed in the inter-ventricular septum.

One hundred and eleven human hearts were examined. The hearts belonged to the Clinical Anatomy Department of the Medical University of Gdańsk. They were fixed in formalin with ethanol and came from middle-aged and older individuals of both sexes, devoid of pathological changes and birth defects. During the tests, classic anatomical methods were applied.

*The region where the papillary muscles are found covers a sizeable surface of the septum, from the conus arteriosus up to the back angle of the right chamber. Depending on their location the following septal papillary muscles (*musculi papillares septales, *MPS) were singled out: 1) lying on the front wall of the septum (anterior papillares septales), 2) in the central part of the septum (central muscles), and 3) in the posterior section of the septum (posterior papillares septales). A trial to determine the types of MPS was based on this diversity of location. Consequently, five types of MPS were specified: type I: anterior–central (44.1%); type II: anterior (15.3%); type III: anterior–posterior (13.5%); type IV: anterior–central–posterior (24.3%); and type V: uniform (2.75%).*

This study is an attempt to systematize and standardize the terminology of these structures. (Folia Morphol 2010; 69, 2: 101–106)

Key words: human heart, right ventricle, septal papillary muscles

INTRODUCTION

Septal papillary muscles (*musculi papillares septales*, MPS), similarly to other papillary muscles, are essential elements of the heart valvular system. Damage to their structure may lead to a considerable life risk [5, 10].

Two groups of septal papillary muscles were distinguished, i.e. constant and variable. To the first group belongs a muscle of the arterial cone (*m. conti arteriosi or m. subarterialis*, MCA) that always occurs and lies on the most anterior part of the septum. It has been most often regarded as a septal papillary muscle [11, 15]. The second group consists of the remaining septal papillary muscles, which in most cases were called additional muscles (*m. accesorius*) [2, 14], the septum's own muscles

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(*m. papillaris proprius septi,* MPP) [1], or were completely ignored; if they were not developed they were called tendinous chords (*chorda tendinea*) [9].

Of all the papillary muscles, the septal papillary muscles are characterized by the greatest topographical and morphological variability. However, information about these muscles is scarce and fragmentary. The objective of this study was to ascertain their occurrence and the region in which they are placed in the inter-ventricular septum.

MATERIAL AND METHODS

One hundred and eleven human hearts were examined. The hearts belonged to the Clinical Anatomy Department of the Medical University of Gdańsk. They were fixed in formalin with ethanol and came from middle-aged and older individuals of both sexes, devoid of pathological changes and birth defects. During the tests, classic anatomical methods were applied. The right ventricle was cut open with a V-shape incision, approaching from the opening of the pulmonary trunk to the apex of the chamber (along the anterior inter-ventricular groove), and then alongside the edge (right) of the chamber towards the right atrioventricular valve [6]. Figure 1 shows the morphology and topography of the right valvular system in human hearts.

RESULTS

The region where the papillary muscles are found covers a sizeable surface of the septum, from the conus arteriosus up to the back angle of the right chamber. Depending on their location the following septal papillary muscles (*musculi papillares septales,* MPS) were singled out: 1) lying on the front wall of the septum (anterior papillares septales), 2) in the central part of the septum (central muscles), and 3) in the posterior section of the septum (posterior papillares septales). A trial to determine the types of MPS was based on this diversity of location. Consequently, five types of MPS were specified (Table 1).

Type I: anterior–central. Septal papillary muscles or just groups of chordae tendineae emerged from the anterior and central part of the septum. This type dominated in the studied material (41.4%). Muscles or chordae tendineae ran individually or in groups from several regions in the anterior half of the septum. Those ones which ran near the conus arteriosus supplied the front cusp and commissural part of the valve (Fig. 2).

Simultaneously, muscles (chords) projected from more distant regions of the septum, particularly in large numbers from the edge of the muscle 'slat', which is an extension of a crista supraventricularis (Fig. 3).

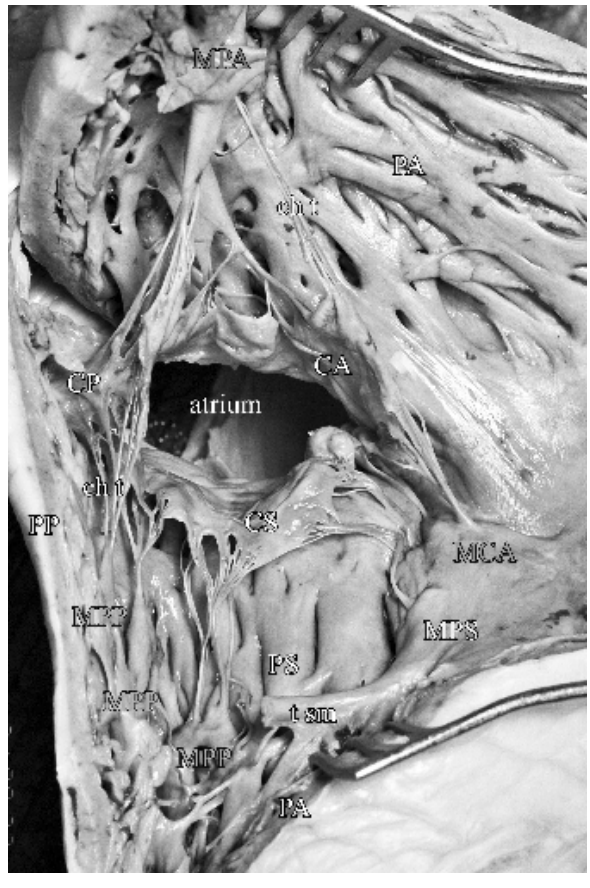

Figure 1. Morphology and topography of valvular system. Anterior wall severed and going upward; MCA — musculus coni arteriosi; MPS — musculus papillaris septalis; MPP — musculus papillaris posterior; MPA — musculus papillaris anterior; CA — cuspis anterior, CS — cuspis septalis; CP — cuspis posterior; t sm — trabecula septomarginalis; ch t — chorda tendineae; PA — paries anterior; PP — paries posterior; PS — paries septalis.

Table 1. Positions of septal papillary muscles in human hearts

Type I		Type II		Type III		Type IV		Type V	
N	%	N	%	N	%	N	%	N	%
49	44.1	17	15.3	15	13.5	27	24.3	3	2.7

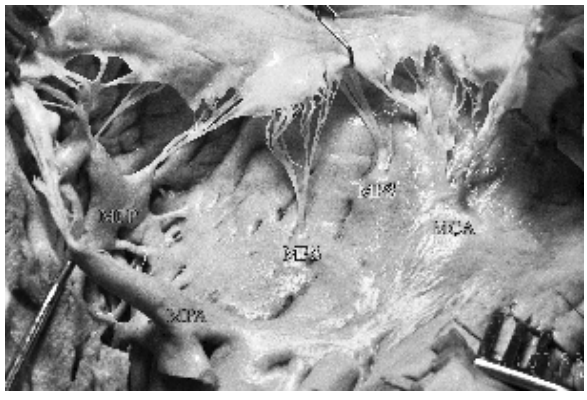

Figure 2. Anterior–central MPS (type I); abbreviations as in Figure 1.

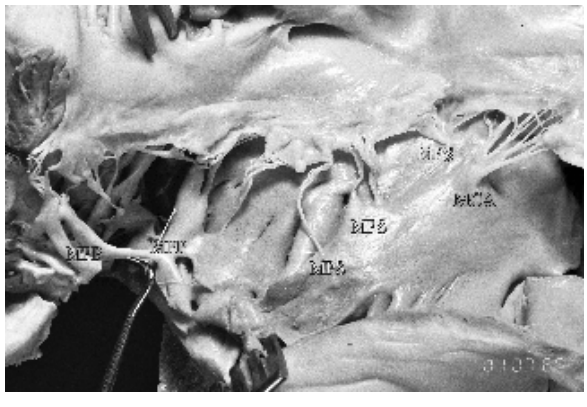

Figure 3. MPS emerging from the edge of the muscle 'slat' (type I); abbreviations as in Figure 1.

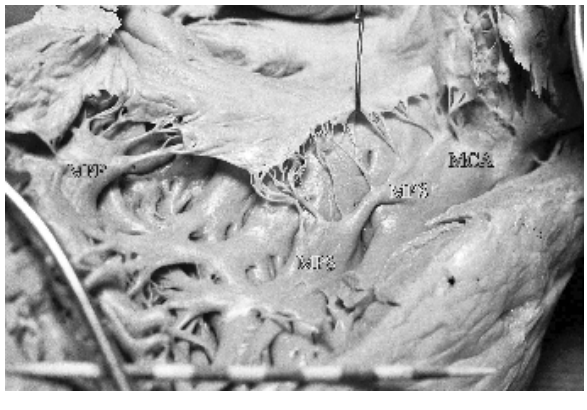

Figure 4. Anterior MPS (type I); abbreviations as in Figure 1.

Tendinous chords emerging from these muscles ran to the frontal, and sometimes to the central part of the septal cusp (Fig. 4). They could be called anterior septal muscles.

As the figures show, MPS also appeared farther, in the central part of the septum (outside the slat),

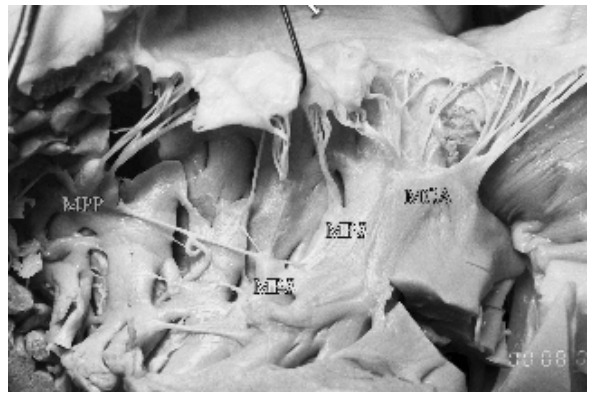

Figure 5. Central cone-shaped MPS (type I); abbreviations as in Figure 1.

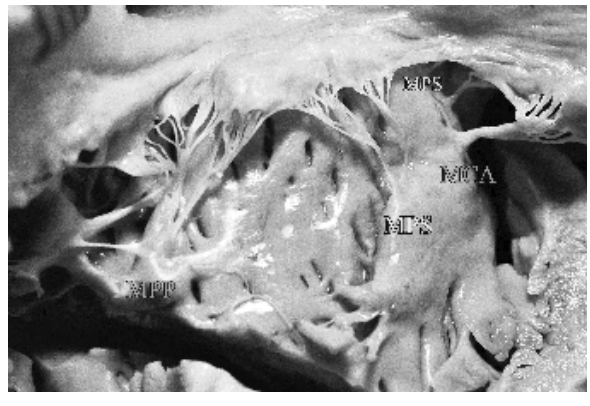

Figure 6. Anterior MPS in close proximity to MCA (type II); abbreviations as in Figure 1.

and in this case they could be called central muscles. These muscles constitute groups of chords running from poorly developed muscles or directly from the septum. The better developed muscles in this category were usually cone shaped (Fig. 5).

Type II: anterior. Muscles or chords ran only from the anterior part of the septum, in close proximity to the arterial cone, or just from the cone itself (15.3%). As in the first type, they could provide the anterior cusp, commissure, and anterior and central part of the septal cusp (Fig. 6).

The chordae tendineae muscles were concentrated particularly close to MCA in one heart only (Fig. 7).

Type III: anterior–posterior. Muscles or chords emerged from both the anterior and posterior parts of the septum (13.5%). The anterior septal papillary muscles traditionally partially provided the front cusp, commissure, anterior, and central part of the septal cusp, whereas the posterior septal papillary muscles provided the posterior part of this cusp. They were positioned in the posterior part of the septum,

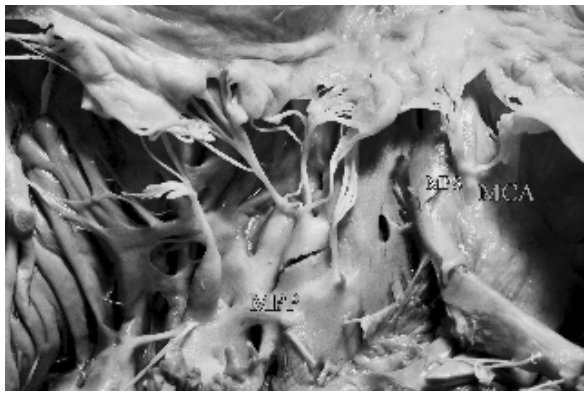

Figure 7. MPS positioned near MCA (type II); abbreviations as in Figure 1.

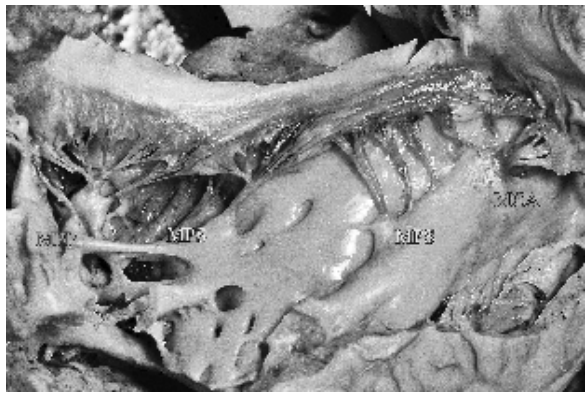

Figure 9. Posterior MPS connected with anterior MPS and MPP (type III); abbreviations as in Figure 1.

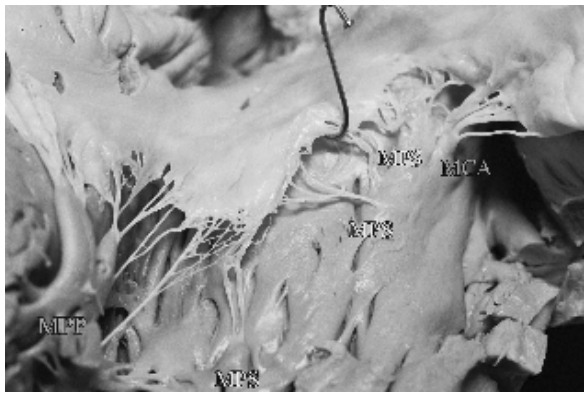

Figure 8. MPS in anterior and posterior part of the septum (type III); abbreviations as in Figure 1.

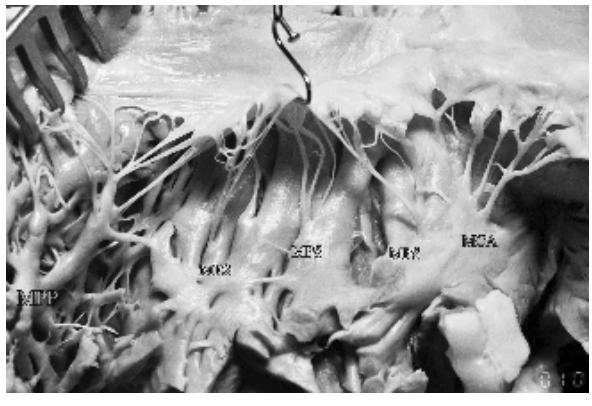

Figure 10. MPS in anterior, central, and posterior part of the septum (type IV); abbreviations as in Figure 1.

which is often their place of occurrence. This posterior muscle definitely appeared farther, often in the posterior wall of the chamber. Only in the case when there was no relationship between posterior MPS and MPP, were the muscles numbered among this particular type. Since MPS are most often reduced to small cones or to chords themselves, they supply only a small section of the cusp. Such sectional provision of the septal cusp is visible mainly in its anterior part. However, the study indicates that it can also be observed in the posterior section as well (Fig. 8).

An interesting example of MPS topography is the human heart in Figure 9. Both topography and morphology of MPS are very similar. Observations of their position indicate that the posterior septal papillary muscles apparently form a transitional stage leading to MPS or MPP. One can clearly see a junction of the muscle base with both the muscle 'slat' (alleged chord) and MPP through the well formed trabecula carnea. One more posterior septal muscle which is not joined with MPP is visible on the septum, under the septal cusp.

Type IV: anterior–central–posterior. Groups of septal muscles or chords themselves projected from three above-mentioned regions of the septum. These types of muscles were present in 24.3% of cases (Fig. 10).

In some other cases, the chords ran to the septal cusp from horizontal "septal" trabeculae carneae or even alleged chords. The latter ran horizontally from the muscle 'slat' towards the back angle of the chamber and the posterior papillary muscle (Fig. 11). Such trabeculae are structures probably functionally connected with the conducting system, which send an impulse towards MPP.

Type V: uniform. Single chords most frequently ran evenly from the septum, emerging from the region of cone muscle up to the posterior papillary muscle; the remaining papillary muscles were placed in the septum as it was in type IV classification. Type V was observed only in 2.7% of cases (Fig. 12).

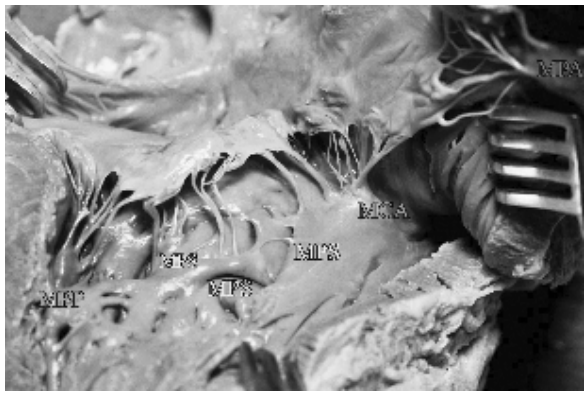

Figure 11. Horizontal septal trabecula carnea (type IV); abbreviations as in Figure 1.

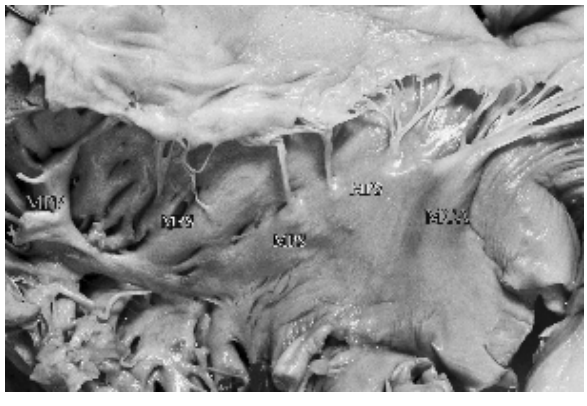

Figure 12. MPS (type V); abbreviations as in Figure 1.

DISCUSSION

Some contemporary authors of anatomy textbooks underestimate the significance of papillary muscles, particularly septal muscles. They do not give any more detailed information about their morphology and topography [7], although they do mention their existence. Some other scientists present essential information; however, they do not indicate these structures in their drawings [16]. Additionally, it must be remembered that papillary muscles belong to the valvular heart system, which ensures its correct functioning [4, 13]. Damage to these structures can lead to a serious life risk [5, 6].

Papillary muscles are a functional whole; however, their great topographical and morphological diversity was observed long ago. If we only take into consideration their position, practically all papillary muscles should be called septal, as in many aspirator species they lay solely in the inter-ventricular septum. In the presented study it is classification types IV and V. For this reason, Musso et al. [8] questioned the legitimacy of the universally used name *m. papillaris septalis.* Hence the assumption that the essential criterion of identity of these muscles is their characteristic position towards the cusps, and provision of these cusps is understandable.

In pictures of the right chamber, as found in many works, small muscles or chordae tendineae in the septum, which provide the septal cusp, can be seen. However, the authors rarely decide to classify them. 'Chordae tendineae', 'additional muscles', or 'the septum's own muscles' are names commonly used. The above terminology rejects their belonging to conus arteriosus, which lies evidently farther, in the anterior of the septum [1, 2, 9, 12, 14, 16]. Regarding the above, it seems relevant to make a division within the muscles generally known as septal muscles into two separate groups, i.e. the muscle of the arterial cone and the group of remaining septal muscles. Within the latter, on account of the large area of their appearance, one should distinguish anterior, central, and posterior groups of MPS. Wenink [15] and later Restivo et al. [11], proposed a shared name for MCA and anterior MPS, i.e. for muscles lying near MCA. According to them, it is a medial papillary complex. The above authors refer to the other muscles as separate septal muscles; however, they do not name them. The remaining muscles in the study are called central and posterior septal muscles. But it must be emphasized that anterior muscles are those adjacent to MCA. A question arises whether chordae tendineae emerging straight from the septum should be treated as muscles. The answer is that they should not, but according to the previously-quoted findings of Bargmann and Doerr [2] or Tandler [14], they are elements derived from primary muscle bundles of walls of cardiac ventricle, which were transformed into the connective tissue. So they are derivatives of muscles which underwent complete or partial involution. Szostakiewicz-Sawicka [13] approaches this problem similarly. According to her, individual chords running from the muscle 'slat', which is an extension of the supraventricular crest, are elements of a big septal muscle the apices of which fused with the septum.

The above considerations reveal a certain vagueness in classification concerning papillary muscles positioned in the septum. It refers mainly to septal and posterior papillary muscles. This study is an attempt to systematize and standardize the terminology of these structures.

Interpretation of the results certainly requires great caution; however, it seems very probable that

the observations in the study can be treated as general tendencies characteristic for other taxonomic groups of aspirators [3].

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