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Anatomy of the supraventricular crest in human hearts

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The supraventricular crest is a fleshy trabecula of the right ventricle that has an important function in guiding the blood flow. However, controversy persists regarding its anatomical constitution. In this study, we aimed to investigate its frequency, formation, termination, morphometry, and relationships with the septomarginal trabecula, septal papillary muscle, right atrioventricular ring, and left posterior semilunar valve of the pulmonary trunk valve. Our material consisted of 50 hearts from adult individuals of both sexes that had been preserved in 10% formalin. They were opened along the arterial cone by means of an incision starting at the pulmonary trunk and ending at the right margin. The supraventricular crest was always present. The marginal (right) extremity was formed by two to six muscle bundles that joined together (88%). On the septal (left) side, the single muscle bundle penetrated the interventricular septum directly (88%) or by means of two or three divisions (12%). It could form a septal band (52%) and could pass over the septal papillary muscle (43.5%) or just below it (34.8%). There was a relationship of muscle fibres between these two structures in 64% of cases. Dissection of the septal band demonstrated continuity with the septomarginal trabecula (46%). In 80% of cases, the crest was connected to the right atrioventricular ring and it participated in its outline directly (64%) or by means of muscle expansions (16%). Its muscle fibres bordered the left semilunar valve of the pulmonary valve in 50% of cases. Regarding morphometry, we observed that the length varied little with increasing weight of the heart (22.6%), but the height and width increased markedly with increasing weight of the heart. (Folia Morphol 2010; 69, 1: 42–46)

Key words: anatomy, human hearts, supraventricular crest, morphology, circulatory system

INTRODUCTION

The supraventricular crest [17] is a third-order fleshy trabecula attached to the anterior wall of the right ventricle along its entire length, and it is located between the right atrioventricular ostium and the ostium of the pulmonary trunk [15]. Although it is well known, Anderson et al. [4] reviewed the specialized literature and demonstrated that there were at least four different structures in the right ventricle that also received this name. On the other hand, Brandt [6] drew attention to the lack of detailed descriptions of this structure in the literature.

Thus, there is still much doubt and controversy about the morphology of the supraventricular crest [5, 10, 13,16].

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We believe that these doubts continue to persist because, as stated by Brandt [6], the concept and limits of the supraventricular crest are not clearly defined. Despite such controversies, an important role relating to guiding the blood flow and emptying the right ventricle is attributed to the crest [6, 9]. It is probably involved in the pathology of congenital cardiac malformations such as the tetralogy of Fallot, common aorticopulmonary trunk [5, 13, 16], congenital infundibular cardiopathies [12], ventricular preexcitation [3, 7], and ventricular septal defects [1]. To contribute towards elucidating the features of the crest, we considered it important to conduct a detailed study on its formation, path, and termination. Furthermore, Kosinski et al. [10] mentioned that the diversity of results in the literature would justify new studies on the supraventricular crest.

We aimed to investigate the following characteristics of the supraventricular crest: frequency, formation, termination, morphometry, and relationships along its path with nearby structures such as the septomarginal trabecula, septal papillary muscle, right atrioventricular ring, and left posterior semilunar valve of the pulmonary trunk valve.

MATERIAL AND METHODS

Our material consisted of 50 hearts weighing between 114.5 and 451.4 g, from adult human individuals (29 males and 21 females) aged between 21 and 84 years. These hearts had been fixed and conserved in 10% formalin and came from the anatomy laboratories of the Federal University of São Paulo and the University of the West of São Paulo State.

We only used hearts that macroscopically did not present any diseases of any nature that might have interfered with our results.

The right ventricle was opened by means of an incision starting at the midpoint of the pulmonary trunk and continuing through the arterial cone of the sternocostal surface to the right margin, parallel to the anterior interventricular sulcus. To facilitate the dissection, we opened a window in the wall of the right ventricle to expose the supraventricular crest better, in the specimens for which this was necessary. We then began the dissection by following the right margin to the interventricular septum, removing the endocardium that surrounded the crest, and thus exposing the muscle bundles.

The supraventricular crest was measured using a Mitsutoyo digital pachymeter. Three width and three height measurements were made: one at each extremity of the parietal part of the crest and the other at the midpoint. From these three values for each of these dimensions we took the arithmetic mean. Length measurements were made directly using the digital pachymeter between the extremities of the parietal part of the crest.

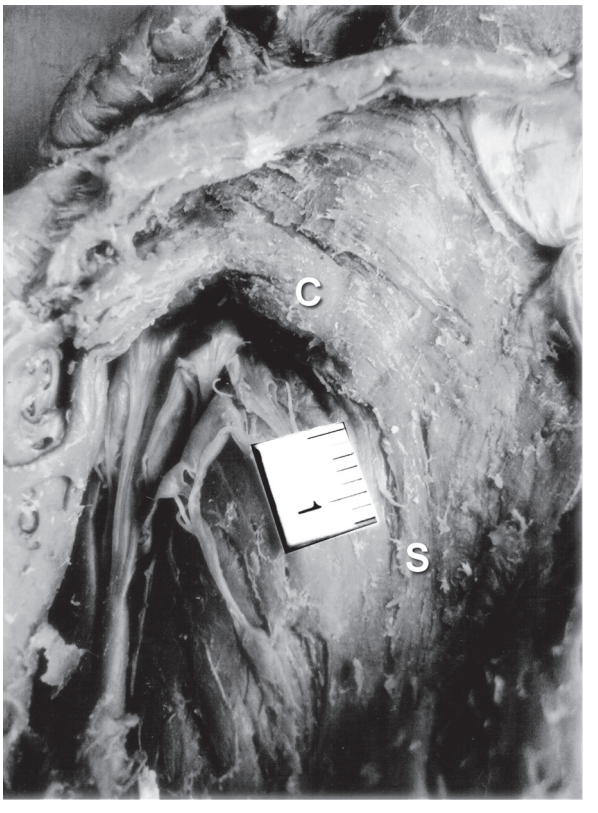

Figure 1. Continuity to the muscle bundle of the supraventricular crest (C) with the interventricular septum (S).

We took the parietal part of the supraventricular crest to be the muscle segment of the anterior wall between the right atrioventricular ostium and the pulmonary trunk valve.

RESULTS

The supraventricular crest was present in all of the 50 right ventricles examined (100%). Dissection of the crest demonstrated that in most cases (88%) its marginal (right) extremity was formed by muscle bundles joining together. The number of bundles ranged from two to six, and three bundles was the most frequent formation (42%). In one specimen, two of the bundles forming the crest did not merge, thereby forming a dissociated or double supraventricular crest.

On the septal (left) side, the morphology was different. On dissection, the muscle bundle showed evident direct continuity with the interventricular septum (Fig. 1) without presenting divisions (88%) or with two or three divisions (12%). The direction of this bundle could be oblique (34%) or horizontal (48%). This con-

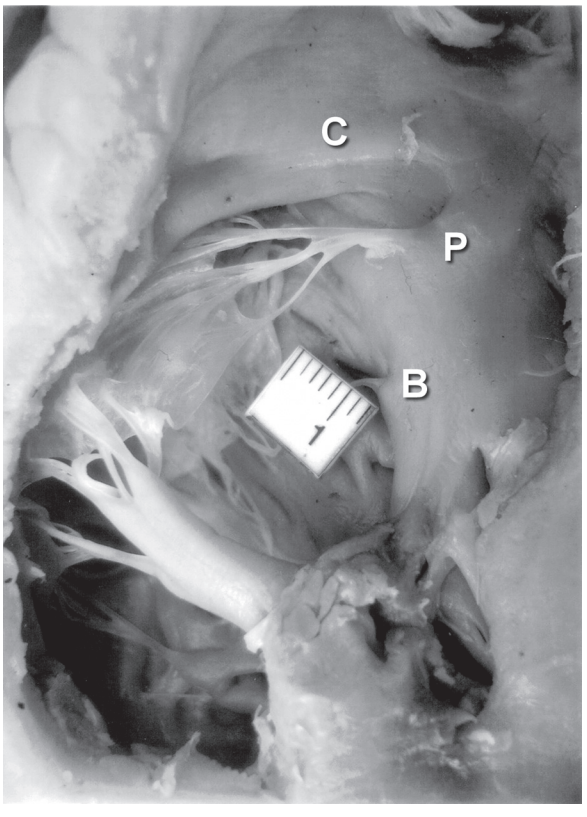

Figure 2. The septal band (B) is the muscle salient in the interventricular septum continuing from the supraventricular crest (C) and travelling above the septal papillary muscle (P).

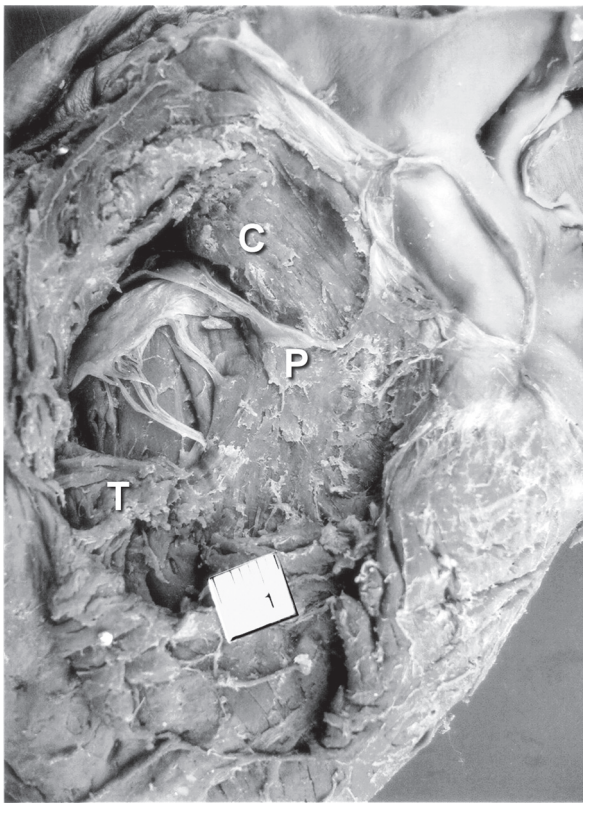

Figure 3. Direct participation of the muscle bundle of the supraventricular crest (C) in the formation of the septal papillary muscle (P) and the septomarginal trabecula (T).

tinuity of the muscle bundle with the interventricular septum, known as the septal band (Fig. 2), could form a prominence on the surface of the septum (52%) as a muscle cordon corresponding to a third-order fleshy trabecula. In the other cases (48%) in which there was no prominence in the septum, the continuity was only confirmed by dissection (Fig. 1).

The passage of this bundle to the septum, in the cone region, could occur immediately above the septal papillary muscle (43.5%) (Fig. 2) or just below the septal papillary muscle (34.8%), or could even occur directly, without coming close to the septal papillary muscle (21.7%).

From analysis of the relationship between the septal extremity of the crest and the septal papillary muscle, we observed that 32 of the specimens (64%) (Fig. 3) presented a relationship of muscle fibres between these two structures. This relationship could occur through direct participation of muscle fibres of the crest in forming the septal papillary muscle (25%) or through furnishing a base for inserting the papillary muscle (59.4%). In the remaining cases, the muscle fibres of the crest outlined the papillary muscle (15.6%).

Dissection of the septal band also showed that this structure could present continuity with the septomarginal trabecula (46%) (Fig. 3). In 40 specimens (80%) it was seen that the supraventricular crest was also connected to the right atrioventricular ring, thereby participating directly in its outline (64%) or through muscle expansions (16%). The connections between the crest and the right atrioventricular ring (80%) could occur through full participation in the anterior outline of the ring (18%), partial participation in its path (50%), or participation only at its septal extremity (12%).

We investigated the behaviour of the supraventricular crest in relation to the left semilunar valve of the pulmonary valve and observed that its muscle fibres bordered this cusp in 50% of cases.

Morphometry of the supraventricular crest

We separated the 50 hearts into five groups, in increasing order of weight, and then took mean values for the weight of the heart and the length, height, and width of the crest for each group. We obtained the results shown in Table 1.

Table 1. Mean values of dimensions the supraventricular crest in relation to mean weight of heart

Intervals of hearts groups	Mean weight of heart [g]	Length [mm]	Height [mm]	Width [mm]
114.5–190.0	168	33.5	3.1	4.5
191.0–225.0	210	35.4	3.4	5.6
226.0–262.0	248	36.6	4.3	6.6
263.0–327.0	295	41.0	5.1	7.7
328.0–349.0	383	41.1	6.1	11.3

The length presented little variation with increasing weight (22.6%), but height (96.7%) and width (151%) increased markedly with increasing weight of the heart (128%).

DISCUSSION

Correct identification of the supraventricular crest has given rise to controversy among researchers. Consequently, different interpretations regarding heart malformations such as the tetralogy of Fallot have been reported [5, 13].

The debatable points that we found from reviewing the literature essentially fell into three categories: a) the limits of the supraventricular crest; b) the continuity in the direction of the interventricular septum (septal band); and c) the behaviour of the crest in the transition zone between the parietal component (anterior wall) and the septal component (septal band) in the region of the arterial cone or infundibulum.

Brandt [6] stated that the crest was a muscle bundle that had an origin and insertion; it passed above the septal papillary muscle; its muscle fibres participated in the anterior wall of the infundibulum; and its caudal extremity was divided into two branches (anterior and posterior). The posterior branch remained close to the anterior cusp of the tricuspid valve, while the anterior branch participated in the interventricular septum. An important role relating to emptying the ventricle through rotation of the apex was attributed to the supraventricular crest.

Van Praagh and Van Praagh [16] considered that the parietal component and the septal component were independent and that the septal band contributed towards forming the septal papillary muscle. Goor et al. [8] held the view that these two components were continuous and that the supraventricular crest would be the combination of the parietal band and the septal band. The parietal band would be the muscle bundle located in the anterior wall of the right ventricle, extending from the tricuspid ring to the septum, while the septal band would be its lower continuation, i.e. the muscle bundle along the septum. However, in their study, Goor et al. [8] only considered the segment between the two muscle bundles located between the pulmonary valve and the membranaceous septum.

According to Rosenquist et al. [13], congenital defects of the interventricular septum (tetralogy of Fallot) would be located on the supraventricular crest itself or on the parietal band (intra-crest), between the two segments that make up the supraventricular crest. Embryology was used to justify this interpretation and, according to this, the parietal band would develop in two parts: a lower part located in the interventricular septum and an upper part known as the supraventricular crest. Rosenquist et al. [13] stated that the septal defect of the tetralogy of Fallot would be due to the separation of these two parts during the formation of the supraventricular crest.

In an embryological study, Anderson et al. [2] considered that the supraventricular crest was composed of two parts: a larger part located close to the anterior cusp of the tricuspid and another part in the septum, continuous with the septomarginal trabecula.

Becker et al. [5] considered that the supraventricular crest consisted of two components. The first would be the muscle mass that separates the pulmonary and tricuspid valves (ventricular cone component), while the second parietal component would be along the interventricular septum (septal cone component). The latter could reach as far as the apex. These authors concluded by attributing the discord between authors to the lack of unity of nomenclature regarding the supraventricular crest.

Meredith et al. [11] attempted to establish links between congenital malformations of the heart and the embryology of the supraventricular crest. They concluded that this structure has two continuous parts: the parietal band on the wall of the right ventricle and the septal band along the septum. James [9]

characterized the supraventricular crest as the only connection from the anterior wall of the ventricle to the interventricular septum.

Anderson et al. [3] drew attention to the disorderly use of the term "supraventricular crest" for different muscle bundles located in the region of the cone or infundibulum. They stated that such use was consequently producing errors in interpreting congenital heart malformations and concluded by making an appeal for uniformity of the term by going back to the original concept put forward by Wolff in 1781 [14].

Our dissections demonstrated that this crest was continuous on the interventricular septum and even with the septomarginal trabecula close to the apex. These results were also confirmed by Kosinski et al. [10], who stated that the supraventricular crest continued inferiorly towards the apex by means of the interventricular septum. Thus, as suggested by Anderson et al. [3], it would be better to maintain Wolff's initial concept from 1781 [14], i.e. a muscle bundle between the right atrioventricular ostium and the pulmonary trunk valve. Our dissections clearly showed that the supraventricular crest was anatomically continuous with the septal band on the interventricular septum. Kosinski et al. [10] also came to this same conclusion. Continuity of this muscle bundle with the septomarginal trabecula, already mentioned by Testut and Latarjet [15], is also very frequent (46%). Since we were unable to demonstrate anatomical continuity of the septal band of the supraventricular crest with the septomarginal trabecula in 54% of our adult hearts, we cannot state, like Kosinski et al. [10], that this continuity was considered throughout several groups. In the transition zone known as the cone region, the muscle bundle passes through at the level of the septal papillary muscle, above it (43.5%) or below it (34.8%). We were able to confirm the existence of the connection between the supraventricular crest and the right atrioventricular ring that James [9] had cited, through the full participation of the crest in the outline of the ring (28.1%) or its partial participation (53.1%).

CONCLUSIONS

In conclusion, anatomically, the supraventricular crest of the right ventricle is a continuous muscle bundle from the right margin to its penetration into the interventricular septum. On this course, it passes between the right atrioventricular and pulmonary trunk ostiums. The passage of the supraventricular crest from the anterior wall to the interventricular septum, in the cone region, occurs at the level of the septal papillary muscle. The crest may participate in forming the latter. Its lower extremity in the interventricular septum may be continuous with the septomarginal trabecula in the vicinity of the apex, by means of the septal band. Thus, the name "supraventricular crest" should be kept only for its upper or parietal part.

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