


The artery of Mouchet: blood supply of the septomarginal trabecula in 50 human hearts

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SUMMARY

The septomarginal trabecula is a muscular structure which transmits the right branch of the atrioventricular bundle. It is usually supplied by a branch from the second anterior septal artery. Anastomoses between the right and left coronary arteries may happen on the septomarginal trabecula. They are of great significance in order to prevent ischemia during a myocardial infarction. Surgeries such as Konno's and Ross' procedures implies in knowledge of these vessels anatomy. The coronary arteries of 50 human hearts were injected with latex and subsequently dissected with the purpose of identifying the arterial branch that supplied the septomarginal trabecula. The trabecular branch arose from the second anterior septal artery in 38% of cases, and the branch arose from the first anterior septal artery in 26%. One of the hearts had its septomarginal trabecula supplied by the conus arteriosus artery literature. Anastomoses between the right and left coronary arteries were found inside the septomarginal trabecula. The right branch of the atrioventricular bundle is subject to a great number of clinical conditions and is often manipulated during surgery, thus, the study of the septal branches of the coronary arteries and the trabecular branch is essential.

KEYWORDS: Heart/anatomy & histology. Coronary circulation. Heart ventricles/anatomia & histologia.

INTRODUCTION

The septomarginal trabecula (ST) was originally described by Leonardo Da Vinci in 1573 as a fleshy pons inside the right ventricle which originated from the interventricular septum wall and reached the right ventricular anterior wall, either ending on this wall or at the base of the anterior papillary muscle. Da Vinci named it as “arcuate trabecula”^{1,2}.

The ST is described in modern literature as an extremely important myocardial projection that rises from the septal wall of the right ventricle below to the pulmonary orifice and reaches the anterior papillary muscle³⁻⁵. Its function was believed to prevent over distension of the right ventricle, although nowadays it is stated that the ST is responsible to transmit the right branch of the atrioventricular bundle to the right

ventricle, and consequently, the electric impulse^{2,3,5,6}.

The interventricular septum is supplied by septal branches of the anterior interventricular artery and septal branches of the posterior interventricular artery. The ST is usually supplied by the second anterior septal branch of the anterior interventricular artery, although this disposition is prone to vary^{5,7-12}. The anterior interventricular artery is a branch of the left coronary artery, while the posterior interventricular artery is a branch of the right coronary artery^{3,5,6}.

Considerations regarding the blood supply of the ST and study of the vascular aspects of the interventricular septum can be of fundamental importance to myocardial revascularization, visualization of those vessels in imaging exams and understanding

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circulatory phenomenon of myocardial hypertrophy^{12,13}. Furthermore, pathologies of ischemic nature can compromise the ST and consequently the right branch of the atrioventricular bundle⁴.

This study aims to perform macroscopic analysis of the septal branches of the right and left coronary arteries on human hearts, emphasizing the blood supply of the ST.

MATERIALS AND METHODS

The coronary arteries of 50 fresh human hearts were injected with latex (green for the right coronary artery and red for the left coronary artery) and fixed in a solution of 3% formaldehyde, 3% absolute alcohol, and 2% ethylene glycol. The causa mortis of the donors was unrelated to the cardiovascular system and the hearts were free of damage. The present study was conducted at the Anatomy Laboratory of the Rio de Janeiro University and the Morphology Department of the Fluminense Federal University.

The right coronary artery and its main branches (conus arteriosus artery, sinoatrial nodal artery, marginal arteries, posterior interventricular artery, and the atrioventricular nodal branch) as well as the left coronary artery and its main branches (circumflex artery, anterior interventricular artery, diagonal branches) were carefully dissected.

With the help of a surgical microscope, the anterior septal branches of the anterior interventricular artery were dissected. Collateral branches of the right coronary artery that anastomosed with the anterior septal branches were also dissected. The number of anterior septal branches and which branch gave the ST supply was observed and measured with the aid of a digital caliper.

The left coronary artery was divided in three segments according to the ventricular area: superior, middle and inferior.

Descriptive statistics (mean and standard deviation) were analyzed with GraphPad Prism 6 software. All pictures were taken with a Sony Alpha ILCE-3000K (20.1 Megapixels).

RESULTS

The number of anterior septal branches ranged from six to fifteen. All hearts had at least one arterial branch to the ST.

In 26% of cases (13 hearts), the blood supply came from the first anterior septal artery. In 38% (19 hearts),

the artery arose from the second anterior septal artery. Seven hearts (14%) had the ST supplied by a branch from the third anterior septal artery. Abnormally, the artery that supplied the ST arose in one case from the conus arteriosus artery (Figure 1). Other results are summarized in Table 1.

Two branches of the trabecular artery were found in 21 cases (42%). In 20 cases (40%) there was one branch. In 5 cases (10%) there were three branches. In 3 cases (6%), four branches. Only one case (5%) possessed five branches inside the ST, which was not previously described in the literature. The results are summarized in Table 2.

The vessels reached the ST through three different patterns: the first pattern was the usual sub-endocardic disposition; the second pattern was through an intramuscular disposition, beneath the center of the ST; and the third pattern was also with an intramuscular disposition, although it was beneath the inferior

FIGURE 1

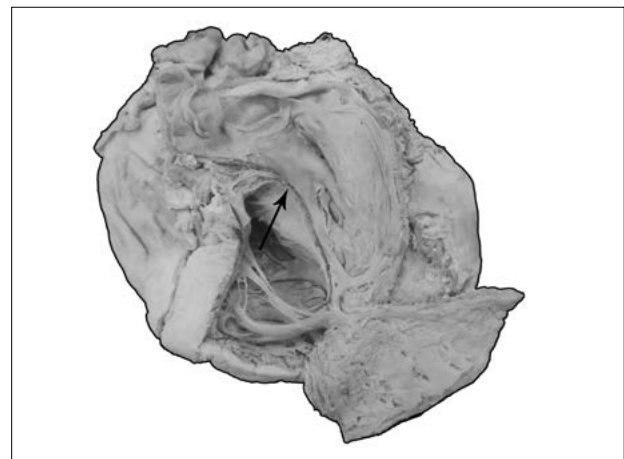


TABLE 1. ORIGIN OF THE TRABECULAR ARTERY.

Origin	Number of cases	%
1st anterior septal	13	26%
2nd anterior septal	19	38%
3rd anterior septal	07	14%
4th anterior septal	01	2%
5th anterior septal	03	6%
6th anterior septal	01	2%
7th anterior septal	02	4%
2nd and 6th anterior septal	01	2%
Left coronary artery	01	2%
1st anterior septal with Right coronary branches	01	2%
Conus arteriosus artery	01	2%
TOTAL	50	100%

TABLE 2. NUMBER OF BRANCHES INSIDE THE ST.

Number of branches	Number of cases	%
01	20	40%
02	21	42%
03	05	10%
04	03	6%
05	01	2%
TOTAL	50	100%

surface of the ST. 58% of the sample had the pattern 1, 34% had the pattern 2, while 6% had the third pattern. One of the cases (2%) had two ST branches, one of them presented the pattern 1 and the other branch possessed the pattern 2.

The ventricular area ranged from 65 to 100 mm, with a mean of 85 mm. Thus, the three segments (superior, middle and inferior) had a mean of 28.3 mm. In 38 hearts (76%), the ST supply came from the middle segment. In 9 hearts (18%) it came from the superior segment. In only three cases (6%), the branches for the ST blood supply came from the inferior segment.

The length of the ST branch in different hearts varied from 10 to 68 mm.

DISCUSSION

The ST is classified as a trabecula of second order by Sappey¹⁴, Cunningham¹⁵, Llorca¹⁶, and Testut and Latarjet⁵. It can be seen at the ninth week of fetal age, together with the anterior papillary muscle⁴.

Dewitt¹⁷ observed the disposition and arrangement of the conduction system in mammals' hearts and concluded that there is a constant presence and distribution of the right branch of the atrioventricular bundle and its relation to the ST in all studied hearts.

The blood supply of the anterior pillar is target to only a few anatomical variations, as stated by Winckler¹⁸ and Llorca¹⁶ although both authors emphasizes the fact that the anterior interventricular artery gives origin to a dozen of branches that penetrates the ventral portion of the interventricular septum. Cunningham¹⁵, Schlesinger et al.¹⁹, and Testut and Latarjet⁵ also support this description.

These vessels have a well-defined vascular territory. The anterior septal arteries that arise from the superior third of the anterior interventricular artery possess a descending and posterior trajectory, while the vessels that originates from the middle third have a horizontal trajectory, and the arteries that arise from the inferior third have an ascending and poste-

rior, slightly recurrent trajectories^{5,15,16,20}. Those vessels, according to Schlesinger et al.¹⁹, Farrer-Brown and Rowles²¹, and Hadziselimović²², runs to the interventricular septum and forms anastomosis with posterior septal arteries.

Usually, the second anterior septal artery reaches the base of the anterior papillary muscle on the right ventricle and gives origin to a small branch that penetrates the ST, although this branch can originate from the first, third or fourth anterior septal arteries^{7-11,16,18,23}. Names such as "artere du pilier anterieu du ventricule droit de Mouchet"^{5,6,10}, "ramus limbi dextri de Gross"^{5,23}, "anterior pilar artery"⁶ "ramus trabeculae supra-marginalis"¹⁸, "artere de la branche droite du faisceau de His"¹⁸ have been used to refer to the trabecular branch of the second anterior septal artery.

Our results showed that the "trabecular artery" can arise in rare cases from the fifth, sixth, and seventh anterior septal arteries, as well as directly from the right coronary artery, from the conus arteriosus artery, or even from two anterior septal arteries (second and sixth), facts never reported in the literature.

Testut and Latarjet⁵ stated that in rare cases, the first and third anterior septal arteries would be responsible for the ST supply, in contraposition, our results showed that in 26% it arose from the first and in 14% it came from the third.

The anterior septal branches would be also responsible for the most part of the IVS blood supply, together with the ST, the right branch of the atrioventricular bundle, and the Purkinje fibers, due to the low pressure values of the right ventricle²⁴.

Hadziselimović²² studied 71 human hearts (from neonatal to 81 years old and of both sexes) and his results showed that intramyocardic anastomosis were found in all portions of the heart, particularly on the interventricular septum and adjacent areas.

Moscovici²⁵ in a study of 80 human hearts also stated the presence of intercoronary anastomosis on the interventricular septum, and their importance regarding the subendocardic plexus. The author also gives importance to the vessels that reach the papillary muscles through their implantation on the ventricular wall, as these vessels use the fleshy trabeculas and myocardia pons to reach them, according to his results, those arteries would also provide intercoronary anastomoses.

Despite the presence of the anterior septal arteries, Correia²³ reported the presence of smaller branches from the anterior interventricular artery that penetrated the ST at different locations, thus, the author

proposed that the ST blood supply should be classified as segmental.

In a study of 651 human hearts, Schlesinger et al.¹⁹ found that in 50% of his sample had an artery rising from the right coronary sinus, together with the right coronary artery: the “conus artery”, as he named. The territory supplied by this vessel, according to the author, was the superior portion of the interventricular septum, close to the supraventricular crest, although this territory can also extend itself to larger portions of the septum, thus, its role is fundamental regarding collateral circulation in cases where the right and left coronary arteries are obstructed. Furthermore, the author reported six large arteries that penetrated the interventricular septum (branches of the anterior interventricular artery) with an intimate trajectory with the right margin of the IVS's endocardium.

Schlesinger et al.¹⁹ also stated that some of the anterior interventricular artery branches - especially the ones next to the cardiac apex - diverted their usual trajectory in order to supply or anastomose with nutritious branches of large trabeculas or large myocardic bands (such as the supramarginal crest). Regarding the anastomotic branches, the author states that their origins can be from the anterior interventricular artery, the circumflex artery or the right coronary artery. The branches of the anterior interventricular artery usually have 70 to 800 mm of length, according to Schlesinger et al.¹⁹,

A study by Zapedowski²⁶ showed that the territory supplied by posterior septal branches would receive collateral vessels from the right and left coronary arteries, thus, again, proving that the anastomosis on the interventricular septum and the papillary muscles can play a large role in pathophysiological and morphological changes.

Hadziselimovic et al.²⁷ investigated 200 human hearts through coronariography and dissections. Their results displayed the role of the many anastomoses between the collateral and terminal branches of both coronary arteries in respect to coronary artery diseases.

A study conducted by Melo et al.²⁸ showed that the human heart possess 7 anterior septal branches on average, although some hearts displayed less than 5 branches, while others possessed 13 branches, in contrast with a study performed by Hosseinpour et al.²⁹ which had the presence of 4 anterior septal branches, on average.

In 2% of cases, the ST blood supply originated from an anastomosis between the first anterior septal artery and branches of the right coronary artery. There are no descriptions regarding this variation in the literature, although Campbell⁷ stated the existence of anastomoses between the right and left coronary arteries in 20% of his specimens. According to the author, those anastomoses could reduce the consequences of ischemia on the right branch of the atrioventricular bundle in cases of anterior septal arteries obstruction. Likewise, a great number of authors reiterate the clinical significances of those anastomoses^{19,24,25,27}.

Pino and Prates^{1,30} stated that the origin of the trabecular artery was mainly from the superior segment of the sternocostal face, in contraposition, our results showed that this vessel often came from the middle segment. Furthermore, the authors did not found arteries arising from the inferior segment.

The present work showed the presence of one to five arteries inside the ST. In 21 hearts (42% of cases), it was found 2 arteries inside the trabecula, in accordance to the results of Mouchet^{10,11}, Correia²³, and Pino and Prates^{1,30}. Other authors such as Lascano³¹ and Truex and Conpenhaver³² described the presence of one main branch accompanied by smaller vessels. Furthermore, Pino and Prates^{1,30} found four arteries inside the ST, whereas the results of the present study showed a ST with five arteries on its inside, a fact never reported in the literature.

As previously stated, the vessels that supplied the ST reached the band in three different patterns, although a review of the literature only showed the description of the subendocardic pattern^{1,8-11,16,18,30,33}. In the present study, it was found two new patterns: an intramuscular pattern in which the vessel ran through inside the ST (34% of cases) and another intramuscular pattern in which the artery ran through the inferior margin of the trabecula (6% of cases).

The mean distance between the origin of the coronary vessels and the trabecular branch of Pino and Prates^{1,30} studies had similar results to ours, although the authors only found branches from the first five anterior septal arteries.

A study performed by Possatti et al.¹² in 40 hearts showed that the ST blood supply came from a branch of the first anterior septal branch in 52.5% of cases, from the second in 42.5% of cases and from the third in 5% of cases, in accordance to Pino and Prates¹. This is not in accordance with the results found in

the present study, as the second anterior septal artery was the main responsible for the ST blood supply (38% of cases) and the first anterior septal artery was responsible in 26% of cases.

According to Hosseinpour et al.²⁹ there are slight differences among the pattern and trajectory of the anterior septal branches in normal hearts in comparison to congenitally malformed hearts, especially with hearts that had ventricular septal defects.

Clinical features of the ST and its blood supply involves the fact that it is deeply related to the atrioventricular bundle. Due to this anatomy, removal of this structure in order to treat low defects on the interventricular septum may cause dynamic changes and disruption of the conduction system⁴. Furthermore, variations on the length and girth of the ST may cause surgical difficulty⁴.

Knowledge of the anterior septal branches anatomy is significant to operations such as Ross procedure, Konno procedure (correction of Fallot's tetralogy), resection of obstructive muscular subaortic stenosis, and enlargement of restrictive ventricular septal defects, as they require incisions on the upper portion of the interventricular septum^{28,29}. Injury of these vessels can cause myocardial damage and arrhythmia, due to its relation with the ST and right branch of the atrioventricular bundle, in rare cases, iatrogenic injuries can cause sudden death²⁹.

Aortic stenosis associated with myocardial bridges has shown disappearance of the ASB during systole and their reappearance during diastole¹². The anterior septal branches are also clinically relevant to angioplasties, as it was shown that those branches can be used to myocardial revascularization if their diameter was at least 2 mm wide¹².

RESUMO

A trabécula septomarginal é uma estrutura muscular que transmite o ramo direito do feixe atrioventricular. É usualmente suprida por um ramo da segunda artéria septal anterior. Anastomoses entre as artérias coronárias direita e esquerda podem ocorrer na trabécula. São de grande importância especialmente na prevenção de isquemia durante um infarto do miocárdio. Procedimentos cirúrgicos como o de Konno's e Ross implicam conhecimento anatômico desses vasos. As artérias coronárias de 50 corações humanos foram injetadas com látex e dissecadas com o propósito de identificar o ramo arterial que supria a trabécula septomarginal. Em somente 38% dos casos o ramo foi proveniente da segunda artéria septal anterior, enquanto que em 26% dos casos a artéria se originou da primeira artéria septal anterior. Um dos corações teve a trabécula septomarginal suprida por um ramo originário da artéria do cone arterioso. Além disso, foram encontradas anastomoses entre as artérias coronárias no interior da trabécula septomarginal. Em suma, o ramo direito do feixe atrioventricular está sujeito a inúmeras condições clínicas e é alvo de manuseio em cirurgias, logo, o estudo dos ramos septais das artérias coronárias, em especial o ramo trabecular é essencial.

PALAVRAS-CHAVE: Coração/anatomia e histologia. Circulação coronária. Ventriculos do coração/anatomia e histologia.

CONCLUSIONS

In summary, the ST is usually supplied by branch from the anterior interventricular artery. Our work showed that the first and second anterior septal branches have an important role regarding this vascular supply, since they originated the trabecular artery in most cases. The conus arteriosus artery can exceptionally provide the ST blood supply, as well as anastomotic branches between the right and left coronary arteries, facts never reported in the literature.

We believe this work has added to the literature new findings regarding the interventricular septum, ST and right branch of the atrioventricular bundle blood supply.

The increasing rates of coronary artery diseases, the constant advances in imaging exams and surgical procedures implies in a more detailed study of the distribution, branching pattern and anastomoses of coronary vessels.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interests.

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