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ANATOMICAL STUDY OF THE ANTERIOR INTERVENTRICULAR SEPTAL BRANCHES AND THEIR RELATIONSHIP WITH THE BLOOD SUPPLY OF THE SEPTOMARGINAL TRABECULA

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ABSTRACT

The aim of this study was to examine the morphological features of the anterior interventricular septal branches that supply blood to the septomarginal trabecula and to correlate the anatomical observations with the angiographic characteristics analyzed by hemodynamic procedures. Forty human hearts were dissected after injecting colored latex into the left coronary artery. The vascularization of the septomarginal trabecula was always derived from the anterior interventricular artery, via the first, second and third anterior interventricular septal branches in 21 hearts (52.5%), 17 hearts (42.5%) and two hearts (5%), respectively, and the distances from the left coronary artery ostium ranged from 22 to 51 mm. The external diameter of these vessels at their origin varied from 1.0 to 2.35 mm and the vessels were analyzed based on specific requirements for surgical and hemodynamic methods of myocardial revascularization. Myocardial bridges were located over or before the origin of the vessels studied.

Key words: Coronariography, coronary arteries, interventricular septal branches, septomarginal trabecula

INTRODUCTION

The interventricular septum plays an essential role in ventricular function since it contains important elements of the cardiac conduction system and comprises a large portion of the myocardium [8,22,23]. This septum is considered to be the most densely vascularized portion of the heart [10], and is perfused mainly by anterior and posterior interventricular septal branches arising from the coronary arteries [22]. Anterior interventricular septal branches emerging from the proximal segments of the left anterior interventricular artery also supply blood to the septomarginal trabecula, which bears the distal portion of the right branch of the atrioventricular bundle.

Despite the large number of studies on the vascularization of the interventricular septum, few reports have focused on the relationship between the anterior interventricular septal branches and the septomarginal trabecula. Vieussens [24] identified an anterior interventricular septal branch, referred to as the "internal coronary artery" that differed from the others in its gross caliber and characteristic course. Brock *et al.* [5] stated that a large interventricular septal branch coursed in the lower margin of the septomarginal trabecula and supplied blood to the anterior papillary muscle of the right ventricle. James and Burch [8] divided the interventricular septum into two areas and noticed that these areas had different blood supplies. The upper portion, which included the atrioventricular node, the atrioventricular bundle and the proximal segments of the two main bundle branches, was supplied by a branch of the right coronary artery. The lower area, which comprised the greater mass of the septum, including most of the two main bundle branches and the Purkinje arborization of the septum, were supplied mainly by anterior interventricular septal branches. Based on these findings, James and Burch [8] stated that occlusion of the left anterior interventricular artery may produce disturbance in heart conduction, depending upon the efficiency and extent of the collateral circulation.

Odesanmi [13] filled the coronary arteries of human hearts with a radio-opaque medium followed by radiography in order to study the arterial vascularization of the interventricular septum in

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normal and hypertrophied hearts. Henriquez-Pino and Prates [7] injected latex into the coronary arteries and recorded the number of anterior interventricular septal branches, the interventricular septal branch that supplied the septomarginal trabecula, the distance between the origin of the branch and the left coronary artery ostium, the length of the branch from its origin up to penetration into the septomarginal trabecula, and the number of arterial branches inside the septomarginal trabecula. Topaz *et al.* [20,22] used coronary angiographies to analyze the anterior interventricular septal branch of greater caliber and length, and its relationship with the vascularization of the interventricular septum, the atrioventricular bundle and the right bundle branch. These authors also demonstrated the possibility of angiographically distinguishing the proximal interventricular septal branches from the diagonal and marginal arteries since the vessels of the interventricular septum moved little during arteriography and were visualized better in the right anterior oblique view. Musso *et al.* [11] examined the blood supply of papillary muscle in the arterial conus by injecting vinyl acetate into the coronary arteries and noted that the anterior interventricular septal branches contributed to the irrigation of the septomarginal trabecula.

Considering the development of new hemodynamic procedures for the diagnosis and treatment of cardiovascular diseases, an improvement in our knowledge of the morphology of the major anterior interventricular septal branch that irrigates the septomarginal trabecula is necessary, particularly in view of recent proposals for the revascularization of this vessel and its visualization on the coronariography. Pichard *et al.* [14] examined the angiographic appearance of the interventricular septal branches and proposed that the compression of these vessels could serve as a marker for hypertrophic obstructive cardiomyopathy. Vemuri *et al.* [23] stated that angioplasty offered an excellent alternative for revascularization of the interventricular septal branches since these vessels are generally not accessible to surgery. In agreement with this, Bedard *et al*. [4] reported technical difficulties during the surgical revascularization of the interventricular septal branch since this vessel was generally not large enough to sustain a graft.

Azuma *et al.* [2] demonstrated that complete occlusion of the first interventricular septal branch was associated with right bundle branch block and eletrocardiographic changes. Sigwart [17] developed a catheter-based technique as a therapeutic option for hypertrophic obstructive cardiomyopathy by injecting absolute ethanol into the first major interventricular septal branch to induce an artificial localized septal infarct. Airoldi *et al.* [1], Mutlak *et al.* [12] and Shamin *et al.* [16] reported that the treatment of hypertrophic obstructive cardiomyopathy by catheter intervention was technically successful, but was also associated with a high incidence of procedure-related right bundle branch block and other conduction disturbances. These recent clinical findings and the possible complications stimulated our interest in a more detailed study of the anterior interventricular septal branch associated with the septomarginal trabecula, as part of an investigation to correlate the morphological and anatomical features with the images obtained from coronariographies.

MATERIAL AND METHODS

Forty hearts from adult male and female cadavers with no macroscopic evidence of coronary disease were obtained from the Department of Morphology of the Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória (EMESCAM). In five hearts, the left coronary artery was infused with blue latex until the vessel was full but not distended. Thirty-five hearts were injected with vinyl acetate. All of the hearts were fixed in 10% formaldehyde solution for at least 24 h prior to dissection of the anterior interventricular artery and its interventricular septal branches, with subsequent identification of the anterior interventricular septal branch that coursed inside the septomarginal trabecula or contributed to its irrigation. The dissection included the careful removal of the anterior wall of the right ventricle to expose the interventricular septum and preserve the septomarginal trabecula.

After dissection, the hearts were numbered and preserved in 10% formaldehyde solution. The following parameters were studied: the origin of the arterial branch relative to the septomarginal trabecula, the distance between the origin of this vessel and the left coronary artery ostium, the proximal angulation with the anterior interventricular artery, and the external diameter of the vessel at its origin and its relationship to the myocardial bridges situated over the anterior interventricular artery. The diameters at the origin of the vessels studied were compared with the specific requirements for surgical and hemodynamic myocardial revascularization (1.5 and 2.0 mm, respectively).

RESULTS

In all cases, the septomarginal trabecula blood supply was derived from anterior interventricular

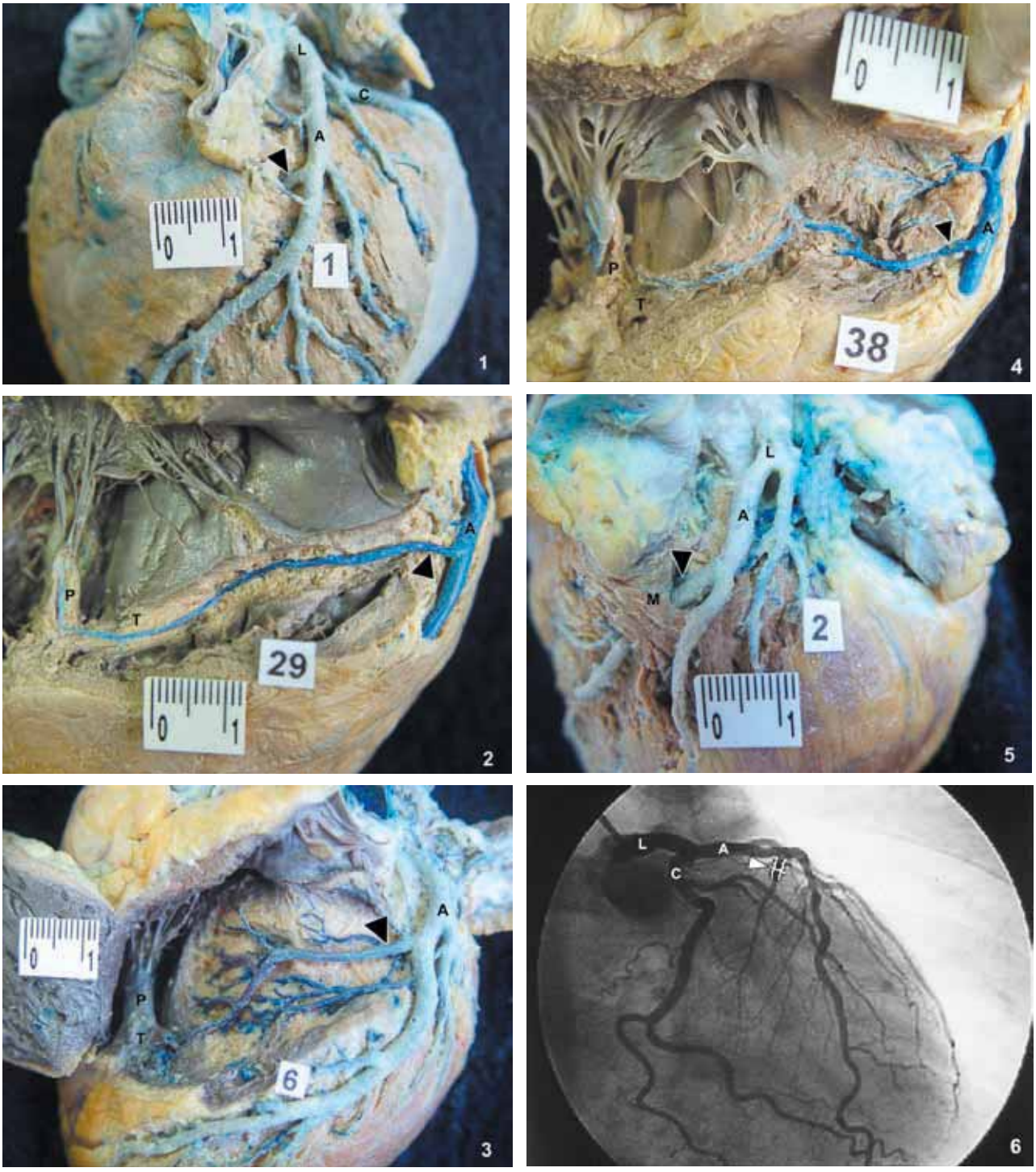

Figure 1. Anterior interventricular septal branch (**arrow**) penetrating the interventricular septum to supply blood to the septomarginal trabecula.
Figures 2 and **3.** First anterior interventricular septal branch on its course through the septomarginal trabecula (**T**), after removal of the anterior wall of the right ventricle. The angulation is larger than 90º.
Figure 4. Second anterior interventricular septal branch irrigating the septomarginal trabecula.
Figure 5. Myocardial bridge (**M**) situated over the origin of the interventricular septal artery branch.
Figure 6. Coronariography showing possibility of measuring the diameter of the interventricular septal branch, in this case 1.85 mm. **A** – anterior interventricular artery, **C** – circunflex artery, **L** – left coronary artery, **P** – anterior papillary muscle.

septal branches that arose from the left anterior interventricular artery. The arterial branch to the septomarginal trabecula issued from the first anterior interventricular septal branch in 21 hearts (52.5%), from the second in 17 hearts (42.5%) and from the third in two hearts (5%).

The first anterior interventricular septal branch irrigated the septomarginal trabecula in 21 hearts, and the distance between the origin of the corresponding interventricular septal branch and the left coronary artery ostium ranged from 22 to 51 mm (mean ± SD of 32.62 ± 8.53 mm). In 17 hearts in which the second interventricular septal branch was directed towards the septomarginal trabecula, the distance varied from 30 to 51 mm (mean: 40.53 ± 7.78 mm). In two hearts in which the blood supply derived from the third interventricular septal branch, the distance varied from 33 to 35 mm (mean: 34 ± 1.41 mm).

The external diameter at the origin of the interventricular septal branch ranged from 1.0 mm to 2.35 mm (mean: 1.62 ± 0.37 mm). In 26 hearts (65%) the diameter was ≥ 1.5 mm, and in 14 hearts (35%) the diameter was < 1.5 mm. In seven hearts (17.5%), this diameter was ≥ 2 mm, while in 33 (82.5%), it was < 2 mm.

The proximal angulation between the anterior interventricular septal branch that supplied the septomarginal trabecula and the anterior interventricular artery was > 90° in 29 hearts (72.5%), ~ 90° in 10 cases (25%), and clearly < 90° in only one specimen (2.5%).

In 29 hearts (72.5%), there were no myocardial bridges associated with the anterior interventricular septal branch. Seven hearts (17.5%) had myocardial bridges located proximal to the origin of the interventricular septal branch studied while in four hearts (10%) these bridges were situated over the origin of this vessel.

DISCUSSION

Although several reports have described the origin of the anterior interventricular septal branch and its extension towards the septomarginal trabecula, few reports have investigated the diameter and angulation of this vessel at its origin. A precise knowledge of these anatomical features is essential for performing hemodynamic interventions.

There is considerable variability in the origin of the arterial branch that extends towards the septomarginal trabecula. Brock *et al.* [5] noted that the interventricular septal branch that coursed inside the septomarginal trabecula was usually the second branch. Baroldi and Scomazzoni [3] described the major interventricular septal branch as being the second branch of the anterior interventricular artery in 57% of their cases and the first in 18%. Eliška and Elišková [6] found a thick interventricular septal branch that issued as the first branch from the left anterior interventicular artery in 58% of the cases studied. In the remaining 42%, the size of the interventricular septal branch did not exceed that of other septal branches, in agreement with the description by James and Burch [8]. In the series evaluated by Henriquez-Pino and Prates [7], the arterial branch to the septomarginal trabecula always derived from the first five interventricular septal branches, and most commonly arose from the second branch in 48%, from the first branch in 22% and from the third in 14% of the cases. According to Sahni and Jit [15], the largest anterior interventricular septal branch was the first branch in 49.7% of male and 59% of female hearts, and the second branch in 6.7% of male and 4.5% of female hearts. In 36.7% of male and 31% of female hearts, the first two branches were of equal length. Topaz *et al.* [20,22] reported that the first anterior interventricular septal branch was usually the largest and longest (40-60 mm) and provided the most important collateral channels of all the septal branches. Musso *et al.* [11] stated that the first, second and third anterior interventricular septal branches also contributed to the irrigation of the septomarginal trabecula by either coursing through the trabecula or by giving off collateral branches. Our findings corroborate with those of Eliška and Elišková [6], Sahni and Jit [15] and Topaz *et al.* [20,22] since in all cases we found a larger branch that was provided mainly by the first interventricular septal branch.

According to Henriquez-Pino and Prates [7], the mean distance between the origin of the interventricular septal branch and the left coronary artery ostium was 32.2 mm when the irrigation of the septomarginal trabecula was provided by the first branch, 35.6 mm when provided by the second branch and 53.9 mm when provided by the third. Our data for the corresponding measurements were 32.62 ± 8.53 mm, 40.53 ± 7.78 mm and 34 ± 1.41 mm, respectively.

Based on angiographies, Kostis *et al.* [9] reported that systolic obliteration and disappearance

of the anterior interventricular septal branches with subsequent diastolic reappearance occurred in aortic stenosis in association with myocardial bridges over the origin of a given vessel in 10% of cases.

Stoney *et al.* [18] stated that the interventricular septal branch was large enough to sustain a graft if the proximal portion was 1.5 mm in diameter, which was the case in 30% of the angiographies reviewed, as reported by Bedard *et al*. [4], compared to our finding of 65%. Topaz *et al.* [19,21] demonstrated that angioplasty provided an excellent method for revascularizing the interventricular septal branches, as long as the vessel diameter was at least 2 mm. Vemuri *et al.* [23] noted that the interventricular septal branch was large enough for hemodynamic interventions in approximately 30% of the patients, whereas in the present study 17.5% of the branches had a diameter > 2 mm and were therefore suitable for angioplasty.

Topaz *et al.* [19,21] encountered certain technical difficulties during angioplasty, particularly in relation to the sharp anatomical angle between the left anterior interventricular artery and the origin of the interventricular septal branch, and the marked tendency of atherosclerotic lesions to affect the ostium and the very proximal portion of this branch. To the best of our knowledge, no other studies have estimated the angulation to allow comparison with our results.

Based on our findings, we conclude that the anterior interventricular septal branch to the septomarginal trabecula is accessible to revascularization if its size meets the procedural requirements. The sharp angulation, a real difficulty during angioplasty, was not a significant factor here. Finally, extreme caution should be exercised in procedures involving the anterior interventricular septal branches, particularly the larger branch, because of its relationship with the right bundle branch.

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