Morphological analysis and clinical significance of the opening of the third coronary artery

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ABSTRACT

Introduction: The human heart is in most cases vascularized by two coronary arteries, the right coronary artery (RCA) and the left coronary artery. The supernumerary coronary artery, which arises independently from the right aortic sinus and passes through sub-epicardial adipose tissue of the pulmonary conus and anterior side of the right ventricle is called the third coronary artery (TCA).

Methods: This study consisted of 28 formalin-fixed adult human cadaveric hearts. The presence of the TCA was determined. The position of the orifice of the right and excess arteries in relation to the sinotubular junction was determined, and then also the position of the orifice of the excess arteries “on the o’clock level” in relation to the orifice of the RCA. The radius of these orifices and their distance from the orifice of the RCA were measured. The angle between the aorta and TCA, as well as RCA and conus branch, was measured.

Results: A total 11 of specimens had supernumerary arteries. A supernumerary artery was found in two hearts. The angle formed by the aorta with the TCA was 60.09 ± 17.57, while the angle between the aorta and the conus branch had an average value of 89.88 ± 15.92. The orifices of all supernumerary arteries were located below the level of the sinotubular junction. The average diameter of the TCA was 1.49 mm ± 0.41. The average distance between the TCA orifice and the RCA orifice was 2.21 mm ± 1.03. In 45.45% cases, the orifice of TCA was located at the 10 o’clock level.

Conclusion: The present study highlights the presence of the TCA. It may constitute a significant collateral circulation contributing to apical and septal perfusion. Interpretation of signs and symptoms of coronary occlusion should therefore include possible contribution of this vascular channel.

Keywords: Anatomical variations; supernumerary arteries; third coronary artery

INTRODUCTION

The arterial supply of the human heart is provided by the left and right coronary arteries. However, cases of the presence of only one coronary artery originating from the right (1,2) or left aortic sinus (3,4) have been described, which may be associated with congestive heart failure, myocardial infarction, or sudden cardiac death (5).

Supernumerary heart arteries are a common finding. The supernumerary cardiac artery that originates independently from the right aortic sinus and extends through the subepicardial adipose tissue of the pulmonary conus and anterior right ventricle is referred to as the prefundibular artery, conical artery, delicate Vienens’s artery, or third coronary artery (TCA). Its course and vascularization field often coincide with the distribution of the conical branch of the right coronary artery (RCA) (6-10). Although its distribution is relatively unexplored, TCA may supply various parts of the anterior wall of the right ventricle and the interven- tricular septum (11,12).

In some cases, the existence of two excessive arteries (third and fourth) has been reported, which originate independently from the right aortic sinus (1,13,14).

Data on the frequency of excess arteries are quite variable and range from 1.5% and 8% according to Lo et al. (15) and Kurjia et al. (16), up to 62% (1). The reason for this probably lies in ethnic or geographical differences based on genetic background (17).

The presence of the TCA is especially important in conditions of coronary insufficiency, which can be mitigated by its existence, as well as by a collateral blood flow, that is, anastomoses that this artery most often forms with the anterior interventricular branch (13,18,19), but also with the diagonal and circumflex branches, as well as with the branches of the RCA (20-22).
Therefore, in persons with occlusive coronary artery disease, it is necessary to perform selective angiography of the TCA and thus establish its presence and course, as well as the possible presence of anastomoses of this artery with branches of other arteries, which remained unnoticed in standard angiographies of the left and right coronary arteries (23-25).

For the correct performance of selective angiography of the TCA, it is very important to know the size of the orifice of the TCA in the right aortic sinus, as well as its position relative to ostia of the RCA and sinotubular junction (10,26,27), which was the aim of this research.

Furthermore, our goal was to determine the size of the angle between the aorta and the TCA, since this information could prevent its damage during ventriculotomy and other heart surgeries (26,28).

RESULTS

Out of a total of 28 hearts, 11 of them (39.29%) had supernumerary arteries starting from the right sinus of the aorta and extending along the pulmonary cone and the front side of the right ventricle (Figure 1).

Two supernumerary arteries originating from the right aortic sinus were present in two hearts (7.14%), that is, along the third and fourth coronary arteries (FCA) (Figure 2).

The angle formed by the longitudinal axis of the aorta with the longitudinal axis of the TCA was 60.09 ± 17.57, while the angle between the longitudinal axis of the aorta and the conus branch was most often obtuse, with an average value of 89.88 ± 15.92.

The orifices of all supernumerary arteries were located below the level of the sinotubular junction.

The average value of the diameter of the supernumerary arteries orifice was 1.49 mm ± 0.41 (0.84 mm to 2.1 mm). The smallest diameters (0.84 mm and 0.87 mm) were found in two cases of FCA.

The average distance from the supernumerary artery orifice to the orifice of the RCA, in the right aortic sinus, was 2.21 mm ± 1.03 (Graph 1).

METHODS

Twenty-eight formalin-fixed adult human cadaveric hearts, of unknown sex and age, were collected from the Department of Human Anatomy, Faculty of Medicine, University of Sarajevo, over the period of 3 years. The hearts having gross congenital anomalies were excluded. The study was approved by the Local Ethics Committee.

The dissection enabled us to show the coronary arteries, the place of their origin, their course, their way of branching, and their present anastomoses. Hearts were stored for 3–5 days in 10% of formalin. The epicardial and periartrial adipose tissue was removed and coronary arteries and their branches were carefully dissected. In cases where the TCA was found, the aorta was opened along its length at the level of the posterior sinus in order to gain insight into the left and right aortic sinuses and the presence of an appropriate coronary orifice.

The position of the orifice of the right and excess arteries in relation to the sinotubular junction was determined, and then also the position of the orifice of the excess arteries “on the o’clock level” in relation to the orifice of the RCA. The radius of these orifices and their distance from the orifice of the RCA was measured. A digital sliding caliper (Black and Decker, USA) with a measuring range of 0-200 mm was used to measure the aforementioned parameters.

The angle between the aorta and the TCA, as well as the angle between the RCA and the conus branch, was measured using a manual goniometer (GPM Model 117, Switzerland). The angle between the aorta and the TCA was measured by placing the center of the goniometer at the junction of the aorta and the TCA, the fixed arm of the goniometer along the longitudinal axis of the aorta, and the movable arm of the goniometer along the longitudinal axis of the TCA. When measuring the angle between the RCA and the conus branch, the Center of the goniometer is placed at their junction, the fixed arm of the goniometer parallel to the longitudinal axis of RCA, and the movable arm of the goniometer parallel to the longitudinal axis of conus branch. Finally, photographs were made with a high-resolution digital camera.

The obtained data were analyzed using descriptive statistics. The results are presented in form of mean values, maximum and minimum values, standard deviation, and percentages of representation.
The orifices of all supernumerary arteries were located in the front, to the left, and below the orifice of the RCA (Figures 3 and 4).

When the orifice of the RCA was set at the 12 o’clock level, it was determined that the orifices of supernumerary arteries were located at 10 o’clock (45.45%), 11 o’clock (36.36%), and 9 o’clock (18.18%) (Figure 5 and Graph 2).

**DISCUSSION**

Considering the clinical importance of the presence of the TCA, numerous authors, both morphologists and clinicians have been interested in this research field. Data on the frequency of the TCA are quite variable in relation to ethnicity, which speaks in favor of a genetic predisposition (17,29,30).

The frequency of the TCA varies depending on the method used for its detection and ranges from 8% and 12% (16,18) on selective coronary angiograms, 17%, 22%, and 29.7% (31-33) on CT coronary angiograms, and 34.8%, 36.8%, and even 68% on dissection preparations of human hearts (26,34,35).

In our study, the frequency of occurrence of the TCA was 39.9%, which coincides with the results of other researchers who used the dissection method as the main research tool, as we did. Wide variation in the prevalence of this artery reported by various authors suggests ethnic variability which may have a genetic basis or it could be due to the inability to selectively cannulate TCA on conventional angiography (10,29,36).

The lowest frequency of TCA on coronary angiograms can be explained by the fact that the TCA often remains undetected. Thus, it is necessary to perform selective coronary angiography of this artery in patients with coronary disease, considering its contribution to perfusion, as well as the importance of collateral blood flow through this artery (3,25,37). In this context, it is also important to determine the size and position of the opening of the supernumerary arteries in the right aortic sinus (10,17).

In our study, the orifices of all 13 supernumerary coronary arteries were localized in the right aortic sinus below...
the level of the sinotubular junction, which significantly deviates from the results obtained by Sankari et al. (38), Joshi (39), Manju et al. (40) who found that the location of these orifices was not only below, but also above and at the level of the sinotubular junction.

Data on the localization of the TCA orifice in relation to the RCA orifice are also quite variable. Apsara (41) states that in 98% of cases, the orifice of the TCA is to the left and at the same level as the orifice of the RCA. Stankovic and Jesic (26) found that the TCA orifice is always to the left and above, with a distance of 1.7 ± 0.6 mm from the opening of the RCA (interval 1.2-7 mm), while Maric et al. (17) recorded that it is at the same level and to the left of the RCA opening, from which it is 1–2 mm away. Our results show that the orifice of the supernumerary heart arteries was in all cases located in front, to the left, and below the orifice of the RCA, from which it was 2.21 ± 1.03 mm away, mostly localized at the 10 o’clock level (45.45%), while the rest was located at the 11 and 9 o’clock levels. These results are consistent with the study by Miyazaki and Kato (34), who found that the RCA openings were located at 8, 9, and 10 o’clock. In a large study conducted on 550 human hearts, Yadukul et al. (42) the most frequent localization of the TCA orifice was at 10 o’clock (83.15%), but also at 9, 8, and 7 o’clock.

The area of perfusion of the TCA is variable and may be more extensive than usual in some individuals. About 10% of clinical malpractice is due the ignorance of the anatomical variations (43). The size of the coronary arteries typically determines the treatment options in the management of coronary artery disease since small arteries may cause anastomotic difficulties during bypass grafting and can influence the outcome of procedures such as stenting and balloon angioplasty. The possibility of large TCA and myocardial bridges over it should be thought of during various surgical procedures to avoid tissue damage. Given that the data on the localization of the orifice of the supernumerary cardiac arteries in the right aortic sinus are quite heterogeneous, it is our opinion that this research should be continued on a larger sample and that it is important to determine the most common orifice localization in relation to the sinotubular junction, as well as to the RCA should. This would be of great help to interventional cardiologists for a successful performance of TCA selective coronary angiography.

CONCLUSION

The TCA participates in the perfusion of apical and septal areas by anastomosing with branches of the left anterior descending artery. Hence, the potential presence of the TCA should always be taken into account during diagnostic and therapeutic interventions. The possibility of the existence of a large TCA should not be neglected during various surgical procedures to avoid tissue damage.

COMPETING INTERESTS

There are no conflicts of interest to declare by any of the authors of this study.

REFERENCES


