Anatomical Study of the Right Coronary Artery and the Posterior Interventricular Artery in Dissected Hearts in Northeast Brazil

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ABSTRACT

Introduction: the right coronary artery (RCA) normally emerges from the right aortic sinus, travels through the coronary sulcus and curves towards the crux cordis of the heart, where it usually branches into the posterior interventricular artery (PIA), that irrigates the posterior part of the interventricular septum and the apex of the heart and determines the coronary arterial dominance.

Purpose: to analyze the coronary arterial dominance and RCA and PIA morphometry in hearts of Northeast Brazil.

Methods: 50 human hearts from the Anatomy Laboratory of the Federal University of Ceará were analyzed. The hearts were categorized according to coronary arterial dominance. The diameters of the beginning and end of the RCA were measured. PIA was divided in three parts and its diameters in the beginning and middle were measured, such as its full length. The results were statistically analyzed by Student t-test and one-way analysis of variance (ANOVA), significance $p<0.05$.

Results: the mean diameters of RCA were 3.80 ± 0.71 mm in the beginning and 3.12 ± 0.49 mm in the end, just before it branches into PIA. The diameter of the RCA is bigger in its origin than in its end ($p<0.001$). The mean length of the PIA was found to be 54.52 ± 5.18 mm. The mean diameters of the PIA were 2.46 ± 0.69 mm in the origin, 2.27 ± 0.66 mm in the first third, 2.06 ± 0.59 mm in the second third, and 1.84 ± 0.56 mm in the last third. The diameters of PIA were bigger in the first and in the second thirds compared to the third one ($p=0.007$ and $p<0.001$, respectively). In addition, 95.7% of the analyzed hearts were right dominants.

Conclusion: there is a major right dominance with largest diameter in the initial slice of RCA and PIA compared to the final segment. This knowledge contributes to the management of coronary diseases in these vessels.

Keywords: Anatomy; Coronary circulation; Coronary Vessels; Right coronary artery; Posterior interventricular artery.

Introduction

The heart human has its own arterial supply provided by the coronary arteries[1]. The origins of the right (RCA) and left (LCA) coronary arteries are located in the sinuses of the aortic valve in the ascending aorta[2,3]. The RCA and LCA supply the myocardium and epicardium of the heart[1,2].

Embryologically, they develop from the sinusoids, the *in situ* vascular endothelial network and the coronary buds on the aortic sinuses[4]. Alterations in these elements can lead to an intense variation of anatomic and morphometric parameters between the population, such as size, length and branches emission, which also determines coronary arterial dominance[5,6].

The RCA usually emerges from the right aortic sinus, travels through the coronary sulcus and gives off a right marginal branch, running towards the apex of the heart, before proceeding towards the crux cordis of the heart, where it usually branches into the posterior interventricular artery (PIA)[1,3]. The PIA irrigates the posterior third of the interventricular septum, part of the posterolateral wall of the right and left ventricles and the apex of the heart[7].

Arising from the left aortic sinus, the LCA traverses the coronary sulcus for a short distance before dividing into two or three branches[7]. The anterior interventricular branch (AIB) of the LCA runs towards the apex and it usually gives off a diagonal branch. The circumflex branch (CX) of the LCA gives off a left marginal branch and then terminates on the posterior face before reaching the crux cordis of the heart[1,8]. The branches of LCA supply majority of the sternocostal walls of heart and margin of left ventricle[8].

The coronary arterial dominance is defined by the artery that issues the PIA. Estimates are that 70 to 80% of the population is right heart dominant with the PIA originating from the RCA. Approximately 5 to 10% of the population is left heart dominant with the PIA originating from the CX, and about 10 to 20% is codominant with the PIA originating from CX and RCA[9].

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Thus, these variations can lead to several impacts on pathological situations and their management, alike surgical and hemodynamic procedures. The aim of this study is to analyze the RCA and PIA morphometry and coronary arterial dominance in dissected hearts of Northeast Brazil.

Materials and Methods

This study included 50 cadaveric hearts from the Anatomy Laboratory of the Federal University of Ceará, Fortaleza, Brazil. Infant and damaged hearts were excluded from this study and sexual dimorphism was not considered. The hearts were preserved in glycerin with a technique developed in the laboratory.

All the cadaveric hearts selected to this study had the RCA and PIA embedded in subepicardial fatty tissue, thus the vascular anatomy in these hearts was completely preserved, ensuring the visualization of the original morphological characteristics of the arteries. After the selection of the hearts suitable for the study, were categorized depending on the coronary artery dominance.

The diameters in the origin and in the end of the RCA were measured. PIA was divided in three parts and its diameters in the origin and in the middle of each third were measured, such as its full length. All measurements were made with the help of a vernier caliper with a minimum count of 0.01 mm.

The statistical analysis was performed with the statistical software GraphPad Prism version 6.00 for Windows, California USA. The results were statistically analyzed by Student t-test and one-way analysis of variance (ANOVA) with Tukey's *post-hoc*. Values of $p<0.05$ were considered significant. All values were represented as mean ± standard deviation. This anatomical study was performed after the agreement of the ethical committee (number: 15006918.0.0000.5054) of the Faculty of Medicine, Federal University of Ceará, Fortaleza, Ceará, Brazil.

Results

The results of the morphometric analysis in dissected hearts of Northeast Brazil showed that the mean diameter of the RCA was 3.80±0.71 mm with range between 2.65 to 5.21 mm in the beginning. As for the diameter in the end of this artery, just before it branches into PIA, the average diameter was 3.12±0.49 mm with range between 2.15 to 4.20 mm. The caliber of the RCA is statically greater in its origin than in its end ($p=0.0001$).

Table 1. Measurements of the average diameter of the RCA in the origin and end of the artery.

RCA diameter (mm)			
RCA segment	**Minimum**	**Maximum**	**Mean**
Beginning	2.65	5.21	3.80±0.71
End	2.15	4.20	3.12±0.49

Legend: RCA- right coronary artery.

The average length of the PIA was 54.52±5.18 mm, with values between 46.62 to 66.33 mm. The mean diameter of the PIA in its origin was 2.46±0.69 mm with range between 1.21 to 4.20 mm.

Table 2. Measurements of the average diameter of the PIA in the origin, first, second and last third.

PIA diameter (mm)			
RCA segment	**Minimum**	**Maximum**	**Mean**
Beginning	1.21	4.20	2.46±0.69
First Third	1.37	4.46	2.27±0.66
Second Third	1.02	3.8	2.06±0.59
Last Third	0.73	3.61	1.84±0.56

Legend: RCA- right coronary artery; PIA- posterior interventricular artery.

About the measure in the first third, it was obtained mean diameter of 2.27±0.66 mm, range 1.37 to 4.46 mm. In the second third, the measure showed an average of 2.06±0.59 mm, range 1.02 to 3.84 mm. As for the diameter in the last third, it was identified mean diameter of 1.84±0.56 mm, with range between 0.73 to 3.61 mm. Therefore, the diameters of PIA were statically greater in the first and in the second thirds compared to the last one ($p=0.007$ and $p=0.0001$, respectively). In addition, 95.7% of the analyzed hearts were right dominants.

Discussion

The present study revealed that the external diameter of the first segment of RCA ranged from 2.65 to 5.21 mm with a mean of 3.80 ± 0.71 mm; while the external diameter of RCA at a distance of 1 cm distal to the cardiac crux ranged from 2.15 to 4.20 mm with a mean of 3.12 ± 0.49 mm. The mean diameter at the origin and the end of the RCA were smaller than that found in Vietnamese[10] and Lebanese[11], but were similar what founded in Colombians[12] and Iraqis[13]. In addition, the average length of the RCA found in the literature was quite variable, reaching around 12 cm[4,10,11].

It is important know that SA node artery it originates from RCA (mainly in right heart dominance) or circumflex artery (CX) or even by both of them (in cases with 2 SA node arteries)[14]. In this way, any obstruction in RCA decreases the blood supply in nodal arteries that reflects in high probability of an arrhythmia[10] requiring an intervention. Therefore, we hypothesized that a larger diameter of this vessel (RCA) comprises a protective factor against cardiovascular events and arrhythmias related to the SA node ischemia.

Knowing the size of a patient's coronary arteries is very important and necessary because of its direct impact on percutaneous coronary interventions (example: angioplasty and coronary artery bypass graft surgery)[13]. Regarding the sample, the data were not divided and compared according to sex, however, the literature did not show a statistical difference between

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the sexes' diameters in several evaluated pieces of the RCA by computed tomography angiography in subjects without coronary atherosclerosis[15].

Considering the PIA founds, the beginning diameter in this population (mean=2.46±0.69 mm) was bigger than in Iraquis (mean=1.9 ± 0.4 mm)[13] and Colombians (mean=2,04 ± 0,46 mm)[12], but smaller than in Lebanese (mean=3,3 ± 0,4 mm)[11]. The average length of the PIA was 54.52±5.18 mm, practically the same as that found in the literature (54.5 ± 10.1mm)[13].

The understanding of coronary arterial dominance is relevant due know the main blood supply to the heart and it can be classified by the termination of RCA[14]. There are three possibilities: left dominance (when RCA does not reach the crux, which one the AV node and diaphragmatic wall of the left ventricle are supplied by LCX), right dominance (when RCA reaches or surpasses the crux, which one the SA and AV nodes are supplied by RCA) or balanced[8,10]. Considering the sample investigated in this research, 97% have right dominance, this high number of cases with this dominance corroborates international studies[11,16,17,18,19,20,21]. Nerantzis *et al.* (1996)[16], explain that proximal lesion of the RCA in right artery dominance can be associated with extensive posterolateral ischaemia and mitral dysfunction and should be of practical importance when considering angioplasty or bypass surgery.

However, in contrast to our finding, other studies performed out in Brazil reported minor RCA dominance. Falci *et al.* (1993)[22] reported RCA dominance in 72% of specimens. In a second study by Falci et al. (1996)[23] on the anatomic pattern of circulation carried out in two different groups: group I formed by 119 anatomical specimens taken from individuals whose cause of death was non-cardiac and group II formed by 150 live individuals with sintomatic coronary disease, on pre-operative management. In group I was found 68% and group II was found 59% of RCA dominance, respectively. Ortale *et al.* (2005)[24] reported RCA dominance in 60% of hearts. In 2009, again Abuchaim *et al.* (2009)[25] reported RCA dominance in 72% of cases. This difference may arise due to different selection of patients, since Brazil is a country with continental territorial dimensions, with people of different races.

As with any study, certain design limitations are inherent. Data regarding age and ethnicity were not evaluated. As well as it was not possible to verify coronary artery disease. Diagnosing the presence of atherosclerotic disease is important to understand whether coronary stenosis is an anatomic or acquired change. A method with good accuracy for this diagnosis *in vivo* is the quantitative flow ratio[26]. However, given the ethnic variability of the Brazilian population, and the understanding that the sample was obtained from hearts without structural damage on ectoscopy, we can infer that the sample may reflect the morphometric profile of adults in the region, especially considering the low standard deviation. Furthermore, we emphasize the importance of the results as an initial basis, which must be confirmed through *in vivo* studies.

Conclusion

The right coronary dominance and the length of PIA were corroborated by literature. There are differences in the values founded for the diameter of the RCA and PIA of the study in relation to populations from other countries. However, in general, the results are close to previously divulgated. In view of anatomical differences, we emphasize the importance of studies with the local population for a better understanding of the possibility of extrapolation of results as a proposition of estimated values for professionals who perform interventions in these coronary arteries.

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