

Regional Differences in the Diameter of Coronary Sinus among Black Kenyans

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Abstract

Background: Dimensions of the coronary sinus are important in the design of cannulation devices used in cardiac resynchronization therapy and percutaneous mitral valve annuloplasty. Gender and population variations may account for the failure rate of these procedures. Cardiac conditions requiring these procedures are common in black African populations. There are, however, hardly any studies on the regions of coronary sinus in these populations.

Objective: To describe the regional diameters of coronary sinus among black Kenyans.

Study design: Descriptive cross-sectional study.

Materials and Methods: Coronary sinuses of 74 cadaveric hearts from black adult Kenyans (43 males and 31 females) were examined at Department of Human Anatomy, University of Nairobi, Kenya. Samples were classified into male and female and weighed. The coronary sinus was identified and cleaned to expose its entire extent. The length was divided into 3 segments; proximal, middle and distal. The circumference at the middle of each segment was obtained by measuring using a nylon string. This was divided by π (3.14) to obtain the regional diameters. Data was analyzed using SPSS version 17. Sex comparison was established using student's t test and Pearson's correlation test was used to determine association between the diameters and heart weight. These were considered significant at a p-value of ≤ 0.05 . Data were presented using scatter plots and tables.

Results: The diameters at proximal, middle and distal segments were 8.67 ± 0.52 mm, 6.93 ± 0.77 mm and 5.83 ± 0.80 mm respectively. These correlated positively with weight of the heart. Females had significantly larger diameters.

Conclusion: Diameters of coronary sinus show regional differences. They decrease distally, are larger in females and show positive correlation with weight of the heart. These features should be considered during design of and insertion of cardiac devices through the coronary sinus.

Key words:

Coronary sinus; Diameter; Proximal; Middle; Distal

Introduction

The coronary sinus (CS), the main venous drainage of heart, is an important access route for instruments used in different heart procedures such as arrhythmia ablation, biventricular pacing and deployment of various cardiac devices, percutaneous mitral annuloplasty, retrograde cardioplegia perfusion and cardiac resynchronization therapy, *inter alia* [1-4]. Knowledge of CS diameters is important to minimize failure rate [5], complications [6] and enhance operative success [7] during these procedures. These diameters show individual, gender and population variations [8,9]. Accordingly, there is need for population specific data to inform the design and procedure detail of cardiac devices. There are, however, few data on diameters of coronary sinus among black populations of Africa. Further, even globally, reports on diameter of various regions of CS are scanty. Heart diseases are increasing in Sub-Saharan African

including Kenya [10,11]. This study, therefore, measured diameters of the proximal, middle and distal CS in a black Kenyan population.

Materials and Methods

This study was carried out at the Department of Human Anatomy, University of Nairobi on eighty nine cadaveric heart specimen (51 males and 38 females) obtained from adult black Kenyans were used. Ethical approval was granted by the Kenyatta National Hospital-University of Nairobi- Ethics and Research Committee before commencement of the study. The chest cavity was opened through costal cartilages incisions. The sternum was removed and pericardium incised longitudinally to expose the heart. Harvesting of the heart was done by dividing the great vessels 2cm from the superior extent of the heart's base. Heart specimens with any observable congenital defects, valvular vegetations and obvious cardiomegaly (above 450g) were excluded from the study. The hearts were categorized according to sex and weighed in grams using an electronic weighing balance SF-400©. The beginning of the CS was determined at the point where GCV is joined by oblique vein of Marshall (Figure 1).

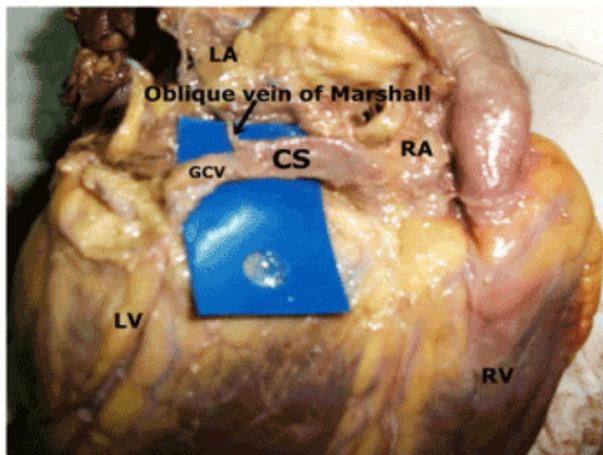


Figure 1: Photograph of heart showing the coronary sinus in the left atrio-ventricular groove. Note that the coronary sinus is formed by the confluence of great cardiac vein (GCV) and oblique vein of Marshall. LA-left atrium, LV-left ventricle, RA-right atrium, RV-right ventricle

The CS was divided into 3 equal segments (proximal, middle and distal) based on its length (Figure 2). The external circumference at the middle of each segment was obtained by measuring using a nylon string. This was divided by pie (3.14) to obtain the regional diameters. For all parameters, three measurements to the nearest one millimeter were done for each and the averages were recorded.

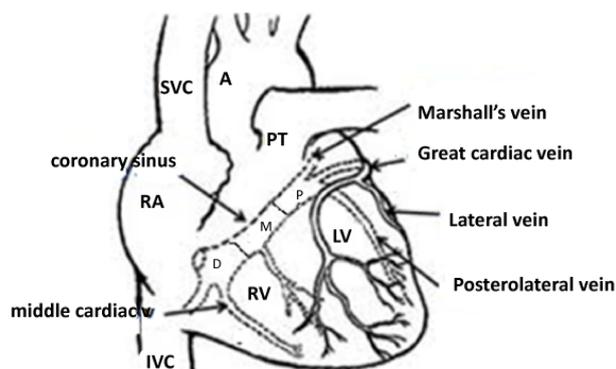


Figure 2: Drawing of the heart showing division of the coronary sinus into segments. (P-proximal, M-middle and D- distal, A- aorta, SVC-superior vena cava, IVC-inferior vena cava, RA- right atrium, RV-right ventricle, PT- pulmonary trunk)

Morphometric data were recorded in datasheets, tabulated and analyzed using SPSS® (Statistical package for social science) software (Version 17.0, Chicago, Illinois) and Microsoft Office Excel, 2007 (Microsoft Corporation). Measurements were expressed in means and standard deviations. Association between various morphometric parameters was established using Pearson's correlation test. The diameters were standardized by dividing them with weight of heart. Using student's unpaired t-test, the standardized values obtained were

used to compare sex differences. A p-value of ≤ 0.05 was considered significant at 95% confidence interval. Tables scatter plots and were used for data presentation.

Results

Of the 89 hearts, fifteen were excluded from the study due to difficulty in identification of oblique vein of Marshall (7), observable pathologies of heart valves (4) and cardiomegaly, that is $>450g$ (4). Seventy four hearts were therefore studied. In all cases, the CS was windsock-shaped originating at the point of confluence of great cardiac vein (GCV) and oblique vein of Marshall to terminate at the postero-inferior aspect of right atrium. It coursed within the left atrio-ventricular (AV) groove and varied in morphometry depending on the region and sex.

The mean diameter of the proximal CS was 8.67 ± 0.52 mm (range 7.32-10.19 mm); 8.52 ± 0.51 mm (range 7.64-10.19 mm) in males and 8.48 ± 0.49 mm (range 6-15 mm) in females ($p=0.006$). The diameter at the middle segment of the CS was 6.93 ± 0.77 mm (range 4.66-8.92mm); 6.98 ± 0.82 mm (range 4.46-8.92 mm) and 6.85 ± 0.70 mm (range 5.10-8.28 mm) in males and females respectively ($p=0.473$). The mean diameter at the distal segment was 5.83 ± 0.80 mm (range 3.50-7.96 mm); 5.87 ± 0.92 mm (range 3.50-7.96 mm) in males and 5.77 ± 0.65 mm (range 4.14-7.01 mm) in females ($p=0.607$) (Table 1). The differences in all the regions were statistically significant ($p=0.00$). The model values for the diameter at proximal and middle segments were 8.92mm and 7.32mm respectively in both genders while the modal diameter of the distal segment was 6.05mm (5.73mm in females and 6.37mm in males).

For sex comparison, standardization using heart weights revealed that the diameters at proximal, middle and distal segments were 0.032, 0.026 and 0.022 respectively in females and 0.027, 0.021 and 0.018 respectively in males. Females had larger diameters. The difference in all the regions was however, not statistically significant ($p=0.067$, 0.187 and 0.575 respectively).

In females, a positive correlation was noted between the diameters at middle and distal segments and weight of hearts ($r=0.034$, $p=0.854$; $r=0.150$, $p=0.422$ respectively) while a negative correlation was noted for the diameter at the proximal segment ($r=-0.049$, $p=0.792$). In the males, the three diameters; proximal, middle and distal, showed positive correlation with heart weights ($r=0.244$, $p=0.114$; $r=0.048$, $p=0.761$ and $r=0.061$, $p=0.698$ respectively) (Figure 3).

Discussion

The coronary sinus (CS) was complete in all cases, consistent with literature reports that absence or the unroofed variants are rare [12-14]. Accordingly, diameter of all three segments was measured. The mean diameter of proximal CS was 5.83mm. This was lower than 9.3mm reported in study among the British where formalin-fixed cadaveric specimens were also used [15]. This shows that the diameter at this region varies in different populations although the different methodologies used in the two studies may contribute to this variation. That is, use of vernier calipers to get diameters as opposed to use of a ruler to obtain the circumference then divided by pie (3.14). This implies that CS devices should be designed to suit a specific population to avoid damaging the CS wall.

In the middle segment, the diameter was 6.93 mm, comparable to 7.6 ± 2 mm reported by Doig et al. [16] while at the proximal end, the

diameter was 8.67 mm, comparable to 8.1 mm [16] and 7.4 mm [17] (Table 2). Diameters at middle and proximal segments do not appear to show significant inter-population variation suggesting that different populations may use devices of similar diameter at middle and proximal CS segments without serious outcomes.

There are few studies which have measured diameter of CS at the three segments [18]. A remarkable finding of the current study is that CS diameters show regional variation, decreasing from the proximal to distal segments in all subjects. This is consistent with literature reports which suggest that veins increase in diameter as they move from their source to their termination [9]. The increase in diameter of the CS towards its ostium (proximal end) as observed in the present study is attributable to increase in volume of blood since more tributaries empty into the CS as it courses towards the right atrium. Pertinent to this suggestion is the observation that inferior vena cava increases towards the heart [19]. Therefore, for safe cannulation, we suggest use of devices with a conical profile to match the varying diameter of the CS. The devices should have a narrow initial segment to fit in the distal CS and a broad terminal segment to fit at its intended proximal position [9].

Despite knowing the mean regional diameters, the mode of diameters is important in order to design devices that may be applicable in most subjects. The mode values for diameters at proximal, middle and distal end in the current study were 8.92 mm, 7.32 mm and 6.05 mm respectively suggesting that the cannulation devices of approximately these dimensions may be safely used in most of the adults in this population.

In the current study, the absolute diameters were larger in males than in females but only at the proximal end where this difference was statistically significant. Blendea et al. [20] reported similar findings of larger diameters in males. Standardization using weight of hearts showed that females have significantly larger diameters. These differences may be related with CS blood flow. Differences related to gender may have important practical implications during CS cannulation.

Silver and Rowley [21] described a significant difference in CS volume between hearts with weights heavier or lighter than 400g. These authors failed to correlate these weights with the CS diameter. In the current study, diameters at middle and distal segments in females increase with weight of heart while in males, a positive correlation was noted for all diameters with weight. This suggests that dimensions of the CS are influenced by weight of heart with those having heavier hearts also having larger sinuses. This further explains the findings of Silver and Rowley [21] that the increase in CS volume with heart weight may lead to increase in CS diameters.

Limitations

Use of cadaveric specimen fixed in formalin may have affected the dimensions of the CS diameters. The measurements were taken manually and this affects the accuracy. The study failed to correlate the diameters with age of heart.

Conclusion

Diameters of coronary sinus show regional differences. They decrease distally, are larger in females and show positive correlation with weight of the heart. These features should be considered during design of and insertion of cardiac devices through the coronary sinus.

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