Original Article

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Anatomy Section

Morphological and Morphometric Study of Coronary Sinus in Human Cadaveric Hearts in Gujarat Region, India: A Cross-sectional Study

DAXA P KANJIYA[1], MEHUL R TANDEL[2], KULDEEP N SUTHAR[3]

ABSTRACT

Introduction: The major vein draining blood from the heart is the Coronary Sinus (CS). Its significance in facilitating numerous cardiac treatments such as biventricular pacing, and the placement of a variety of cardiac devices has made the CS a therapeutically essential structure. The development of advanced invasive and interventional cardiac procedures requires a thorough understanding of CS anatomy.

Aim: To determine the location, shape, length, and width of the CS together with its left atrial muscular coverage in hearts of formalin-fixed cadavers.

Materials and Methods: The present study was a cross-sectional study in which data was collected from 90 adult human cadaveric hearts preserved with formalin from both sexes. Forty cadaveric heart was obtained from Department of Anatomy, Pramukhswami Medical College, Karamsad and 50 from Dr. ND Desai Medical College and Hospital, Nadiad, Gujarat, India and study was conducted from August 2020 to July 2022. External Lengths (EL) of CS were measured using thread and Vernier Calliper at different levels (EL1-From the entry of oblique vein into CS and EL2-From the point of union of the great cardiac vein and left marginal vein upto its termination). CS width was measured: at the beginning, at the point where Middle Cardiac Vein (MCV) enters, and at the point where it terminates in the right atrium. CS walls were examined to see whether the muscles of the left atrium covered them or not. Using Statistical Package for the Social Sciences (SPSS) software, a descriptive analysis was conducted to determine the range, mean, and standard deviation.

Results: In all 90 (100%) hearts, CS was found in the posterior atrioventricular sulcus. Tubular-shaped CS was found in 80 (88.9%) hearts, while 10 (11.1%) hearts had funnel-shaped CS. The EL1 of the CS was 43.75±4.68 mm and EL2 was 40.19±5.62 mm. The width of the CS was 6.71±1.47 mm at the beginning, 8.49±1.89 mm at the entrance point of MCV, the maximum width at termination in the right atrium was 8.14±2.16 mm and the minimum width was 5.16±1.70 mm. Muscles of the left atrium covered CS in all cases.

Conclusion: The CS has a variable location, shape, length, and width despite being a constant component of the heart's venous system. Its importance in giving access to various cardiac procedures has made it a clinically significant structure. The baseline data of this study can help the cardiologists performing various cardiac procedures in the Gujarat population.

Keywords: Anatomy, Cardiologist, Heart atria, Oblique vein

INTRODUCTION

The literature has several descriptions of the coronary artery system. The coronary venous system, however, has received little attention [1]. The CS is a wide venous channel located in the posterior part of the atrioventricular groove which receives a majority of cardiac veins of the heart. About 60% of the venous blood from the heart is drained by CS. The length of CS ranges from 3.0-5.5 cm [2,3]. The Oblique Vein of the Left Atrium (OVLA) (oblique vein of Marshall) and the great cardiac vein unite to form the CS [4]. The CS terminates between the opening of the inferior vena cava and the right atrioventricular orifice into the right atrium; which is guarded by a semilunar valve (an endocardial fold) [5]. It is an important structure, as it provides access to different cardiac treatments such as biventricular pacing, arrhythmia ablation [6,7]. Additionally, procedures like; percutaneous mitral annuloplasty, retrograde cardioplegia delivery, targeted medication delivery, and the implantation of a CS reducer in refractory angina are all performed through the CS [2,8]. With the development of many advanced invasive and interventional cardiac procedures to treat problems like heart failure and arrhythmias, it is important to understand the morphology of CS [9,10].

In India, data regarding the morphology and morphometry of CS is available for the North Indian and South Indian populations [11-15]. Hence, the purpose of the current study was to observe various morphological and morphometric parameters of CS in formalin-fixed cadaveric hearts in Gujarat population of Western India.

MATERIALS AND METHODS

This cross-sectional cadaveric study was conducted in the Department of Anatomy, Pramukhswami Medical College Karamsad, and Dr. ND Desai Medical College and Hospital Nadiad, Gujarat, India from August 2020 to July 2022. The study was conducted after approval of Institutional Ethics Committee (IEC). Approval No: IEC/HMPCMCE/2020/EX.30/12/2022).

Inclusion criteria: A total of 90 human formalin-fixed cadaveric hearts of either sex (age range: 20-80 years) were included in the study.

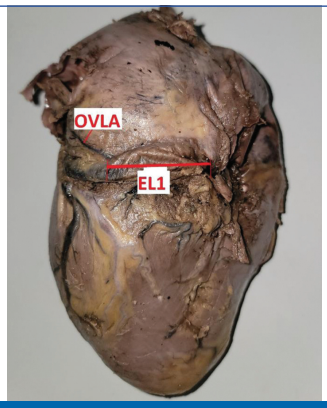
Exclusion criteria: Hearts having significant pathology, postsurgical evidence or congenital defects were excluded from the study.

After removing the fat from the posterior atrioventricular groove, the CS was identified. The entire CS was cleaned properly through careful dissection. After observing CS, measurements were obtained with a vernier caliper and threads. To measure the dimensions of the coronary ostium, the interior of right atrium was exposed by dissection.

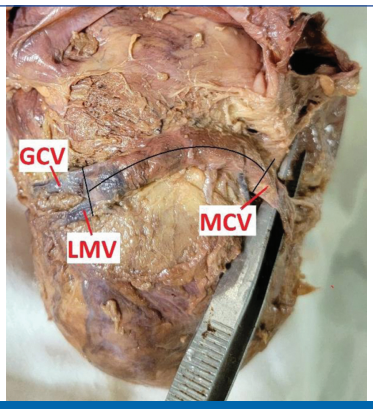
Measurements of the Coronary Sinus (CS)

After identifying the presence of CS, its exact location was identified. The CS was categorised into different shapes such as tubular, conical, funnel, or any other [16]. A thread was used to measure the EL. One point was marked on the thread at the site where the OVLA entered the CS, then the thread was positioned along the length of the CS, and the other point was marked at the site where

CS terminated into the right atrium. The thread was then stretched out on a level surface, and a digital vernier caliper was used to measure the distance between the two points. This reading was noted and recorded as EL1 [Table/Fig-1]. If the OVLA was absent; then the point of union of the great cardiac vein and left marginal vein was used as the landmark and this length was recorded as EL2 [Table/Fig-2].



[Table/Fig-1]: External Length (EL) 1 of Coronary Sinus (CS): From Oblique Vein of the Left Atrium to termination into right atrium.
OVLA: Oblique vein of left atrium



[Table/Fig-2]: External Length (EL) 2 of Coronary Sinus (CS): From union of the great cardiac vein and left marginal vein to termination in the right atrium.
GCV: Great cardiac vein; LMV: Left marginal vein; MCV: Middle cardiac vein

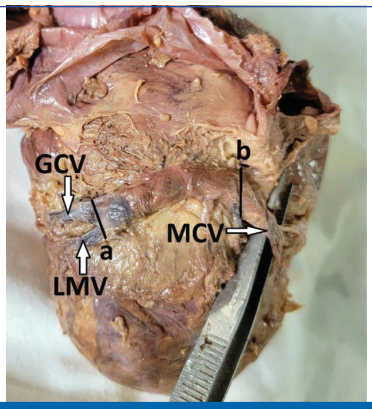
With the use of a divider and a vernier caliper, the width of the CS was measured at three points: first at the beginning, second at the point where the MCV enters the CS, and third at the site where it opens in the right atrium (coronary ostium) [Table/Fig-3,4]. At the coronary ostium, the minimum and maximum widths were measured and documented separately [Table/Fig-4]. The minimum width was measured between the free border of the valve and opposing margin of the coronary ostium, and the maximum width was determined by taking a measurement parallel to the free border of the valve (excluding the valve). A careful inspection of the walls of CS was done to identify whether it was covered by the left atrial muscles or not. If muscle covering was found, then the extent of the covering was noted, whether it was one-third, one-third to two-thirds, or more than two-thirds of the length of CS.

STATISTICAL ANALYSIS

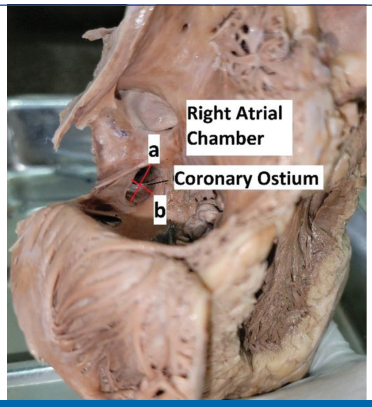
Data were entered in EPI INFO 7. Continuous variables were expressed with mean and standard deviation while categorical variable was presented with percentages.

RESULTS

The CS was present in all 90 (100%) hearts and all were located in the posterior part of atrioventricular groove. Tubular-shaped CS was found in 80 (88.9%) hearts while in 10 (11.1%) hearts had funnel-shaped. EL1 of CS was 43.75±4.68 mm while EL2 was 40.19±5.62 [Table/Fig-5]. The width of CS at the beginning and at the point of



[Table/Fig-3]: Width of Coronary Sinus (CS): a: At beginning; and b: At the point of entry of MCV.
GCV: Great cardiac vein; LMV: Left marginal vein; MCV: Middle cardiac vein



[Table/Fig-4]: Width of Coronary Sinus (CS) at termination in right atrium (Coronary Ostium).
a: Maximum diameter of coronary ostium; b: Minimum diameter of coronary ostium

entry of MCV was 6.71±1.47 mm and 8.49±1.89 mm, respectively [Table/Fig-6]. In all hearts (100%), the CS was covered by <two-thirds muscles of the left atrium.

Variables	No. of specimens	Minimum (mm)	Maximum (mm)	Mean±SD (mm)
External Length (EL) 1 (From oblique vein of left atrium to termination into right atrium)	51	37.48	58.10	43.75±4.68
External Length (EL) 2 (From union of great cardiac vein and left marginal vein to termination in right atrium)	39	33.60	63.55	40.19±5.62
EL (Total)	90	33.60	63.55	42.2±5.35

[Table/Fig-5]: Length of the Coronary Sinus (CS) (n=90).

Variables	Minimum (mm)	Maximum (mm)	Mean±SD (mm)
At beginning	3.40	11.69	6.71±1.47
At the point of entry of MCV	3.24	15.23	8.49±1.89
At termination in right atrium (Coronary Ostium): Maximum	4.21	13.48	8.14±2.16
At termination in right atrium (Coronary Ostium): Minimum	2.34	10.94	5.16±1.70

[Table/Fig-6]: Width of Coronary Sinus (CS) (n=90).

DISCUSSION

The left atrial and Left Ventricular (LV) epicardium are both accessible through the CS. For detection and treatment of arrhythmias, a wide range of diagnostic and mapping procedures are carried out through CS. Interest in the anatomy of the coronary venous system is rising due to modifications of CS geometry by cardiac resynchronisation treatment and percutaneous mitral valve replacement operations [17,18].

Bergman RA et al., and Kawashima T et al., had reported variations related to the absence of the CS [19,20]. But in this study, all cases had a complete CS, which was consistent with observations mentioned by other authors that absence variations are uncommon [2,12,13,21,22].

The shapes of CS observed by various authors are compared in [Table/Fig-7]; which indicates that different populations may have different shapes of CS [11,22-25]. In the present study of the Gujarat population, tubular-shaped CS was found among 88.9% of hearts while 11.1% of the CS was funnel-shaped.

S. no.	Authors publication year	Shape of Coronary Sinus (CS)	%	Population
1	El-Maasarany S et al., [23] (2005)	Cylindrical	80	British
		Funnel	20	
2	Ballesteros LE et al., [24] (2010)	Cylindrical	67.6	Colombian
		Funnel	23.5	
		Flattened	8.9	
3	Karagoz A et al., [25] (2013)	Windsock	56.2	Turkish
		Tubular	43.8	
4	Ominde BS et al., [22] (2015)	Windsock	100	Kenyan
5	Zabina B et al., [11] (2017)	Tubular/cylindrical	82	North Indian
		Funnel	18	
6	Present study (2023)	Tubular	88.9	Gujarat-Indian
		Funnel	11.1	

[Table/Fig-7]: Shape of the Coronary Sinus (CS) in different population [11,22-25].

[Table/Fig-8] shows a comparison of the length of CS in different populations reported by different authors [2,11-15,18,22-24,26]. In this study, EL1 was measured from the point where OVLA entered CS upto the point where CS pierces the wall of RA which was 43.75±4.68 mm. Zabina B et al., Suma HY et al., Chawre HK et al., and Ominde BS et al., used similar landmark [11,13,18,22]. The present study measurement was in agreement with their results. In this research, EL2 was considered as the length from the union of the great cardiac vein and left marginal vein to termination in the right atrium, which was 40.19±5.62 mm. In the study by Zabina B et al., they considered this measurement as an EL3 (33.81±8.7 mm) which was slightly lower than the measurements of this study [11]. But Manorajitham R et al., had reported a higher length (54.98±12.2 mm) of the CS with this landmark [15]. The average length of CS reported by Habib A et al., was 30-55 mm, by Chawre HK et al., was 29.82 mm and Ballesteros LE et al., reported the length between 25.96±6.34 mm [2,18,24]. This variation in the length of the CS could be due to variations in the size of the heart and the shape of the CS.

In the present study, the width of CS at the beginning and at the point of entry of MCV was 6.71 mm and 8.49 mm, respectively, which was lower than reported by Zabina B et al., (4.25 mm at the beginning while 6.98 mm at the entry of MCV) [11]. At the termination in the right atrium; the maximum width of CS was 8.14 mm and the minimum was 5.16 mm in this study. While at the same site, Zabina B et al., reported a maximum width of 9.61 mm and minimum width of 5.79 mm, Manoranjitham R et al., stated the mean width of 9.35+3.24 mm and a mean height of 7 mm (5-9 mm) and a mean breadth of 12 mm (7-16 mm) was reported by El-Maasarany S et al., in their study [11,15,23]. The difference between the width may be due to different sample sizes and populations. In all hearts (100%), the CS was covered by less than two-third of the muscles of the left atrium in the present study, while Zubina B et al., reported 96% of hearts CS was covered by muscles of left atrium [11].

To get the best possible results in the future, sophisticated radiological methods like Multi Slice Computed Tomography (MSCT) may be used to conduct further anatomical research. For this reason, it is imperative that one must learn more about the structure and function of the CS.

S. no.	Authors publication year	Place of study	Length	
			Mean (mm)	Range (mm)
1	El-Maasarany S et al., 2005 [23]	London, UK	48.4±5.2	NA
2	Habib A et al., 2009 [2]	USA	NA	30-55
3	Ballesteros LE et al., 2010 [24]	Columbia	25.96±6.34	NA
4	Ankolekar VH et al., 2013 [12]	Karnataka, South India	28	20-38
5	Suma HY et al., 2013 [13]	Puducherry, South India	NA	20-55
6	Kavimani and Jebkani CF, 2014 [14]	Chennai, South India	28	20-38
7	Manoranjitham R et al., 2015 [15]	Tamil nadu, South India	54.98±12.2	NA
8	Loch WB et al., 2015 [26]	Poland	NA	15-50
9	Ominde BS et al., 2015 [22]	Nairobi, Kenya	39.55±5.32	20-53
10	Chawre HK et al., 2015 [18]	Madhya Pradesh, Central India	29.82	19.03-54.32
11	Zabina B et al., 2017 [11]	Punjab, North India	**EL (Total)** 38.22±8.6	20.5-58.78
			EL1 38.45±8.3	20.50-57.12
			EL3 33.81±8.7	21.35-40.72
12	Present study-2023	Gujarat, Western India	**EL (Total)** 42.2±5.35	33.60-63.55
			EL1 43.75±4.68	37.48-58.10
			EL2 40.19±5.62	33.60-63.55

[Table/Fig-8]: Comparisons of length of the Coronary Sinus (CS) in different population [2,11-15,18,22-24,26].
NA: Data not available

Limitation(s)

Because of the lack of information on the variations in CS morphology between men and women and between different ages, no conclusion can be drawn regarding the prevalence of CS in one gender over another.

CONCLUSION(S)

Through its role in providing access to modern interventional procedures such as cardiac catheterisation, biventricular pacing, arrhythmia ablation, and the implantation of cardiac pacemakers, the CS is now begun to get more attention. The selection of the appropriate devices for cannulation procedures also depends on the morphology of the CS. The baseline data of this study can help cardiologists for performing various cardiac procedures.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Anatomy, Pramukhswami Medical College, Bhaikaka University, Karamsad, Anand, Gujarat, India.
2. Associate Professor, Department of Anatomy, Pramukhswami Medical College, Bhaikaka University, Karamsad, Anand, Gujarat, India.
3. Associate Professor, Department of Anatomy, GMERS Medical College, Dharpur, Patan, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Daxa P Kanjiya,
Assistant Professor, Department of Anatomy, Pramukhswami Medical College,
Shree Krishna Hospital, Anand Sojitra Road, Karamsad, Anand-388325,
Gujarat, India.
E-mail: daxa.kanjiya@gmail.com

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