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Original Research Article

Angiographic anatomy of the coronary sinus venous system in adult Kashmiri population

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ABSTRACT

Background: Knowledge of the coronary sinus venous anatomy is an important factor because of its relevance in electrophysiological procedures such as chronic resynchronisation therapy, mapping and ablation of arrhythmias. The advent of advanced invasive and interventional cardiac treatment and management tools for common disorders like heart failure has made understanding of coronary sinus anatomy necessary. The aim was to study the angiographic anatomy of coronary sinus and its tributaries in adult Kashmiri population and provide anatomical basis for cannulation of coronary sinus and its tributaries.
Methods: Authors analysed the levophase angiogram of 150 subjects undergoing routine coronary angiography in the right anterior oblique and left anterior oblique view with the necessary caudal or cranial angulations.
Results: The coronary sinus was formed by the union of GCV+LMV in 93.3% of subjects and by the union of GCV+PLV in 6.7% of subjects. The GCV and the MCV were the most consistent tributaries present in all the subjects. The mean length of CS was 71.70±9.7 mm when it was formed by GCV+LMV and 70.18±14.98 mm in case of GCV+PLV. The diameter of the CS ostium was 8.48±1.21mm. The mean diameter of GCV was 2.90±1.24 mm, MCV was 2.76±1.08 mm, LMV was 2.23±0.51 mm and the PLV was 2.25±0.53 mm. The opening angle of GCV was obtuse in all the cases, MCV drained at an acute angle in 62% subjects and LMV draining angle was acute in 31.33% cases. The valve of the CS was present in 32.7% subjects and absent in 67.3% subjects. The tortuosity was absent in 75.3%. The distance between CS ostium and the ostium of the vein ideal for lead implantation was between 10-40 mm in 76% subjects.
Conclusions: The basic knowledge of coronary sinus and its tributaries play a significant role during electrophysiological procedures. The data obtained from the study can be utilised by interventional cardiologist for cannulation of coronary sinus in Kashmiri population.

Keywords: Coronary sinus, Great cardiac vein, Left marginal vein, Middle cardiac vein, Posterior vein of left ventricle

INTRODUCTION

The main physiological function of the coronary veins is to return deoxygenated blood from the myocardium to the chambers of the heart. The majority of the blood flow enters the coronary sinus, which drains into the right atrium. There is high variability in the anatomy of the human coronary venous system. The heart is drained by the coronary sinus and its tributaries, anterior cardiac veins and the smallest cardiac venous system (thebesian

veins). The coronary venous system is not affected by atherosclerotic disease and its dense meshwork with numerous interconnections allows blood to return to the heart via numerous pathways. Tori1 was the first to describe the coronary venogram in 1952. The coronary venous system is important in many electrophysiological procedures, including arrhythmia ablation, biventricular pacing, and for deployment of an array of cardiac devices.[2-4]

Coronary sinus anatomy

The majority of cardiac veins drain into the wide coronary sinus. The length of the coronary sinus varies from 3.0-5.5cms and is dependent on the site of the drainage of the posterolateral vein.[5] The sinus opens into the right atrium between the opening of the inferior vena cava and the right atrioventricular orifice, the opening is guarded by an endocardial fold (semilunar valve of the coronary sinus / thebesian valve). The valve may vary in size or be completely absent.[6]. It is clinically important because it is often an obstruction to catheters in 20% of patients.[7] The coronary sinus ostium is 5-15 mm in diameter and is located on the posterior interatrial septum anterior to the eustachian ridge and valve and posterior to the tricuspid annulus.[8] The most common use of the cardiac venous system is the placement of left sided pacing leads in cardiac resynchronization therapy. A pacing lead is delivered through the right atrium into the coronary sinus ostium. A thorough understanding of the location, tortuosity, size and branching angles of human venous anatomy is important for designing devices in order to obtain optimal pacing positions in different individuals. The recording of local electrograms from within the coronary venous system can indicate various arrhythmias, which can be considered as potential ablation target sites for left-sided accessory pathways.[9-11] The coronary sinus has also been used to deliver ablation therapy.[12-15]

Tributaries of coronary sinus:

Anterior interventricular vein and the great cardiac vein

The anterior interventricular vein ascends in the anterior inter ventricular groove parallel to the left anterior descending coronary artery continues as the great cardiac vein runs along the left atrioventricular groove parallel to the left circumflex coronary artery terminating into the coronary sinus. It is the most anterior vein seen in the right anterior oblique projection (RAO). It receives tributaries from the left atrium and both ventricles including the large left marginal vein, along the lateral border of the heart and the posterior left ventricular branch (also known as the posterolateral branch). Defibrillation coils have been implanted within the coronary venous system, specifically within the anterior interventricular and middle cardiac veins. Placement of the coils within the venous system was found to lower defibrillation thresholds significantly.[16,17]

The lateral veins

The veins on the free wall of the left ventricle are commonly known as the lateral veins, the left marginal veins, or the obtuse marginal veins. The lateral veins most often provide the optimal pacing position for left-sided pacing leads.[18] It is also important to understand the anatomy of the nearby left phrenic nerve as phrenic nerve stimulation is one of the known complications associated with left-sided pacing and has been reported to occur in up to two-fifths of patients undergoing cardiac resynchronization therapy.[19]

Posterior vein of the left ventricle

The posterior vein of the left ventricle is found on the diaphragmatic surface of the left ventricle a little to the left of middle cardiac vein. It drains the lateral and diaphragmatic walls of the left ventricle and opens into the centre of the coronary sinus but sometimes opens into the great cardiac vein. The posterior vein of left ventricle is the ideal vein to attempt cannulation because it drains the free wall of the left ventricle.

Middle cardiac vein (posterior interventricular vein)

The middle cardiac vein begins at the cardiac apex and runs back in the posterior inter ventricular groove to end in the coronary sinus near its atrial end. It is also known as the posterior inter-ventricular vein. The middle cardiac vein is also one of the most consistently present cardiac veins. The middle cardiac vein has been used for the placement of defibrillation coils.

The small cardiac vein

The small cardiac vein lies in the posterior atrioventricular groove between the right atrium and ventricle and opens into the coronary sinus near its atrial end. The small cardiac vein is not always present in the human cardiac venous system.[20,21]

Oblique vein of the left atrium

The oblique vein of the left atrium descends obliquely on the back of the left atrium to join the coronary sinus near its end. This vein is an embryological remnant of the left superior venacava. The vein of Marshall runs along the posterior aspect of left atrium towards the left superior pulmonary vein and is present opposite the junction of the great cardiac vein and the posterolateral vein.[22]

Anterior cardiac veins

The anterior cardiac veins drain the anterior part of the right ventricle. Usually two or three, ascend in subepicardial tissue to cross the right part of the atrioventricular groove, passing deep or superficial to the right coronary artery. The anterior cardiac veins carry

deoxygenated blood from the right ventricle directly into the right atrium.

Smallest cardiac veins (Thebesian venous system)

The small cardiac veins are composed of small venous branches and drain the subendocardium. The smaller cardiac venous system or thebesian vessels are typically less than 0.5 mm in diameter and originate from the inner layers of the myocardium These vessels are responsible for draining one-quarter of the deoxygenated blood used up by myocardium and drain directly into their respective heart chamber.[21,23]

The aims and objectives were to study the angiographic anatomy of coronary sinus and its tributaries in adult Kashmiri population and to provide anatomical basis for cannulation of coronary sinus and its tributaries.

METHODS

This study was conducted in the postgraduate department of anatomy in collaboration with angiographic centre of cardiology department, government medical college srinagar. A prestructural proforma was used to collect the relevant data. Informed consent was taken. Ethical clearance was obtained. The subjects included in this study were all of kashmiri ethnicity.

Coronary angiography was performed with Judkins technique via the radial and femoral route using a 5fr TIG catheter. Venogram was analyzed in the levophase after injection of contrast in the coronary artery ostia. Coronary sinus visualization was observed 8-12 cycles after contrast injection. A non-ionic contrast agent with low osmolarity was used.

Under the supervision of experienced Interventional Cardiologists, the levophase angiogram of the patients was analysed undergoing routine coronary angiography in the right anterior oblique (RAO) view and left anterior oblique (LAO) view with the necessary caudal or cranial angulations. A total of 150 subjects were studied.

The formation of coronary sinus, its length (mms), diameter of the coronary sinus ostium (mms), the number, dimensions, angulation and position of the coronary sinus and of its tributaries were studied. Patients allergic to radiographic contrast and the subjects who did not gave proper consent were excluded from the study.

RESULTS

A total of 150 subjects were included in the study, among them102 were male and 48 were female subjects. The mean age for females was 56.4±10.22 years (range 40-89 years) and the mean age of males was 56.1±10.83 years (range 30-89 years). The following parameters were studied.

Formation of coronary sinus

In 140 subjects the coronary sinus was formed by the union of great cardiac vein with left marginal vein (93.3%). In 10 subjects (6.7%) it was formed by the union of great cardiac vein and the posterior vein of left ventricle.

Tributaries of coronary sinus

The great cardiac vein and the middle cardiac vein were the most consistently present veins. They were present in 100% of subjects. Left marginal vein was present in 93.3% of subjects followed by posterior vein of left ventricle that was present in 86% of the subjects. The small cardiac vein was visible in 20% of the subjects and the oblique vein of left atrium was present in none.

Table 1: Tributaries of coronary sinus.

Tributaries of coronary sinus	Present in cases	
	Number	Percentage
Great cardiac vein	150	100.0%
Left marginal vein	140	93.3%
Posterior vein of left ventricle	129	86.0%
Middle cardiac vein	150	100.0%
Small cardiac vein	30	20.0%
Oblique vein of left atrium	0	0.0%

Table 2: Formation of Coronary sinus.

CS Length (mm)	Formation of CS	
	GCV + LMV	GCV + PLV
No. of subjects	140	10
Mean	71.70	70.18
Std. Deviation	9.714	14.988
Minimum	48.21	48.22
Maximum	99.00	87.00
Std. Error of Mean	0.821	4.740

Length of coronary sinus

In the present study, the mean length was 71.70±9.71 mm (range from 48.21-99 mm) where the coronary sinus was formed by the union of great cardiac vein and left marginal vein (140 subjects). While as in the 10 subjects in whom the coronary sinus was formed by the union of great cardiac vein and posterior vein of left ventricle, the mean length of coronary sinus was 70.18±14.98 mm (range from 48.22-87 mm).

Diameter of coronary sinus ostium

The mean diameter of the ostium in the transverse direction was 8.48±1.21 mm (range 5.00-11.20 mm).

Diameter of coronary sinus tributaries

The mean diameter of great cardiac vein was 2.90±0.61 mm (range 1.24-5 mm), middle cardiac vein was 2.76±0.69 mm (range 1.08-5mm), left marginal vein was 2.23±0.51mm (range 1.24-4.50mm) and posterior vein of left ventricle was 2.25±0.53mm (1-3.80mm).

Table 3: Dimensions of coronary sinus tributaries.

Statistics	GCV Diameter mm	LMV Diameter mm	PLV Diameter mm	MCV Diameter mm
No. of subjects	150	150	150	150
Mean	2.90	2.23	2.25	2.76
SD	0.613	0.519	0.534	0.695
Minimum	1.24	1.24	1.00	1.08
Maximum	5.00	4.50	3.80	5.00
SE	0.050	0.042	0.044	0.057

Opening angle of major tributaries

Great cardiac vein drained at an obtuse angle with the coronary sinus with mean angle of 114.69° (range 90°-144°). In 62% subjects middle cardiac vein drained at an acute angle (<90°) and in 38% subjects it drained at an angle ≥90°. Left marginal vein drained at an acute angle in 31.33% subjects and in 68.67% subjects, it drained at an angle ≥90°.

Table 4: Valves of coronary sinus.

Coronary Sinus Valve	Frequency	Percent
Present	49	32.7
Absent	101	67.3
Total	150	100.0

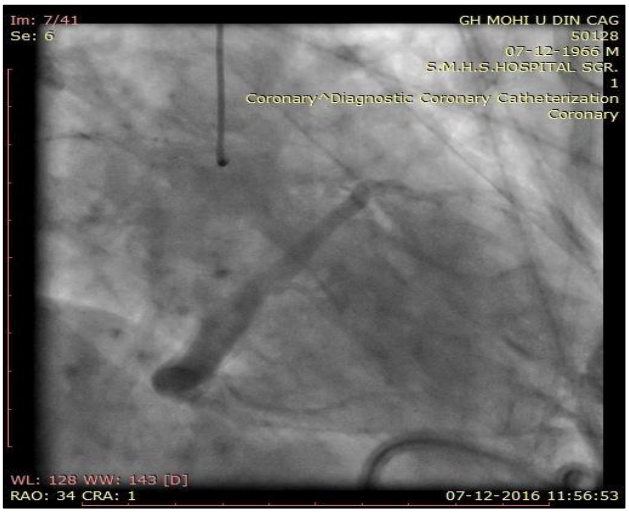

Figure 1: Angiographic RAO: 34 CRA: 1 view of the coronary venous system of the heart showing Anterior interventricular vein (AIV), Great cardiac vein (GCV), Left marginal vein (LMV), Posterior Vein of Left ventricle (PVLV), middle cardiac vein (MCV).

Valve of coronary sinus

The valve of coronary sinus was present in 49 subjects (32.7%) and absent in 101 subjects (67.3%).

Figure 2: Angiographic RAO: 39 CRA: 1 view of the coronary venous system of the heart showing Tortuosity in posterior vein of left ventricle.

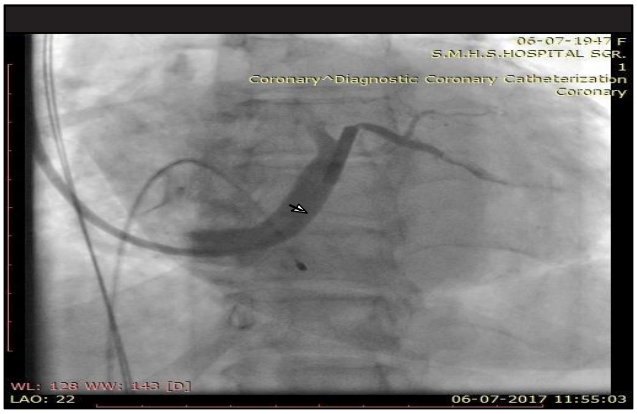

Figure 3: A case of CRT showing lead in the coronary sinus.

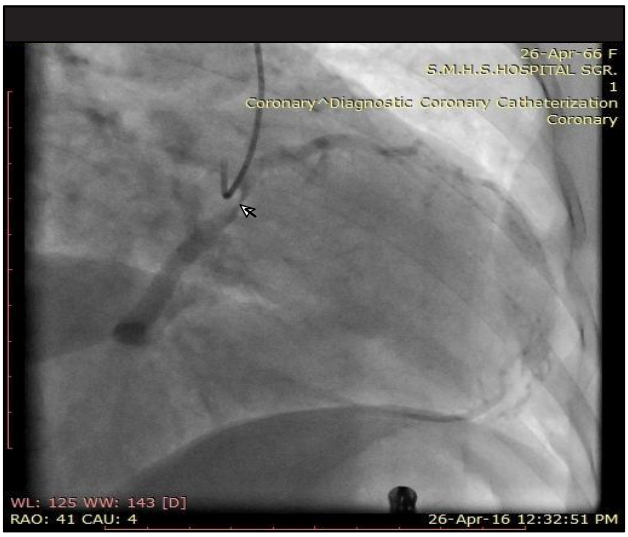

Figure 4: Angiographic RAO: 41 CAU: 4 view Showing stenosed coronary sinus.

DISCUSSION

The venous phase of the coronary angiography was used to examine the anatomy of the venous system of the heart. The posterior vein of the left ventricle or lateral veins are usually the first choice for lead placement. These veins show variation in their position, presence, size, and angulation and thus provide multiple options for the implanter. The posterolateral vein is the ideal vein to attempt cannulation as it drains the free wall of the left ventricle. In case of difficult coronary sinus anatomy lateral tributaries of the anterior interventricular vein and middle cardiac vein can be used to pace the left ventricular free wall.[24] In the present study we made an attempt to understand the basic angiographic anatomy of the coronary sinus and its tributaries.

The present study was conducted on 150 subjects out of whom 102 were males with the mean age of 56.1±10.83 years (range 30-89years), and 48 females with the mean age of 56.4±10.22 years (range 40-89 years).

Formation of coronary sinus

In the present study we have observed the formation of the coronary sinus by the union of great cardiac vein with the left marginal vein in 93.3 % (140 subjects) and by the union of great cardiac vein with the posterior vein of left ventricle in 6.7% (10 subjects). However, author don't observe great cardiac vein directly ending into the right atrium. A study conducted by Manoranjitham R noted the formation of coronary sinus under the following types.[25]

Type I: when the great cardiac vein joins with left marginal vein to form coronary sinus (present in 93.33% of our specimens).

Type II: when the great cardiac vein joins with posterior vein of left ventricle to form the coronary sinus (present in 3.33% of our specimens).

Type III: when the great cardiac vein joins with oblique vein of left atrium to form coronary sinus (present in 3.33% of our specimens).

Type IV: when the great cardiac vein does not end in the coronary sinus and ends directly into right atrium or into anterior cardiac vein (not found in present study).

Tributaries of coronary sinus

In the present study the great cardiac vein and the middle cardiac vein were the two most consistently present tributaries of coronary sinus and were observed in all subjects (100%). The great cardiac vein has been reported to vary considerably in its course. Great cardiac vein and middle cardiac vein were also present in all cases in a study conducted by Gillard et al.[26] In the present study left marginal vein was present in 93.3% of the subjects. In a study conducted by Ortale J et al, left marginal vein was present in 97% specimen.[27] Posterior vein of left ventricle was observed in 86% of subjects in current study, while as it was found in 95% in a study conducted by Jongbloed.[22] In the present study small cardiac vein was observed in 20% of the subjects.

Length of coronary sinus

Observations of the present study revealed the mean length of coronary sinus 71.70±9.71mm (GCV+LMV), 70.18±14.98mm (GCV +PLV). It was however lower than 108.9±18 mm in the Swiss Plass et al, and higher than 39.5 mm Beryl SO et al, and within the reported range of 62.8 mm-86.5 mm Doig et al, and Lee et al.[28,30,31] The wide differences between the findings of these studies may be explained by differences in the nature of specimen and methodology used, in vivo measurements using computed tomography (CT), angiography as opposed to formalin fixed cadaveric specimens. It is evident that despite the methodological differences, CS length varies with population. For instance, using imaging, Doig et al, reported a length of 62.8 mm by angiography in a Canadian study while Plass et al, reported a length of 108.9mm by computed tomography (CT) in a Swiss population. This population variation could be attributed to differences in stature which may affect the size of heart and its vessels.[28,30]

Diameter of coronary sinus

In the present study the diameter of the coronary sinus ostium was found to be 8.48±1.21 mm (range 5.00-11.20 mm). In a similar study conducted by Gilard M et al, the mean diameter of CS ostium was 6.30±1.9 mm (3.1-15.1mm).[26] Sun JP et al in their study found that the ostial diameter was 9.9±2.4 mm (5-19 mm).[32] Present results

are found to be within the range of various published data.[13, 26, 32]

Diameter of coronary sinus tributaries: In the present study we measure the diameter of the tributaries of coronary sinus namely great cardiac vein, left marginal vein, posterior vein of left ventricle and middle cardiac vein. Our findings are consistent and in range with the previous studies done by Gilard M et al, and Ortale J et al.[26,27] The importance of measuring the diameters of these tributaries is to find a vein that is suitable for lead implantation.

Table 5: Diameter of coronary sinus tributaries.

	Present study (Angiographic)	Ortale J [29](Cadaveric)	Gilard M [28](Angiographic)
GCV	1.24-5 mm (2.90±0.61 mm)	1.2-6.3mm (3.9±1.1 mm)	1.32-6.7mm (3.55±1.24 mm)
LMV	1.24-4.50 mm (2.23±0.51 mm)	0.8-4.5mm (2.3±0.8 mm)	
PLV	1-3.80 mm (2.25±0.53 mm)	1.0-5.5mm (2.4±1.1 mm)	0.3-6 mm (2.25±1.2 mm)
MCV	1.08-5 mm (2.76±0.69 mm)	2.1-5.3mm (3.6±0.8 mm)	0.7-6 mm (2.62±1.26 mm)

Valve of coronary sinus

In the present study the valve of coronary sinus was visualized in 32.7% (49 subjects) and absent in 67.3 %(101subjects). A similar angiographic study conducted by Gokhroo RK et al, found no valves in 51% cases, valves in anterior, middle and posterior veins in 22% and thebesian valves and valve of vieussens in 27%. Manoranjitham R.[27,33] in his study of 30 cadaveric hearts found the presence of valve in 93.33%(28 specimen) and it was semilunar in shape.[27,33] In one specimen there was a network of fibers in the ostium of coronary sinus and in one study valve was absent.

Opening angle of major tributaries

In the present study, the draining angle of great cardiac vein was obtuse in all the subjects, Ankolekarvrinda H et al in their cadaveric study have found the same.[34] In 62% subjects the middle cardiac vein drained at an acute angle and in 38% subjects the draining angle was ≥90°in the current study. Gilard M et al, described middle cardiac vein joining the coronary sinus perpendicularly near its ostium after a consistent 60-90° angle.[26] Ankolekarvrinda H et al, in their cadaveric study found that in 26(47.27%) cases middle cardiac vein drained from right angle, 25(45.45%) cases drained forming obtuse angle and in 4(7.27%) cases drained forming an acute angle to coronary sinus.[34] In the current study, the left marginal vein drained at an acute angle in 31.33% subjects and in 68.67% subjects, left marginal vein drained at an angle ≥90º.

Gilard M et al, found the angle of junction between left posterior vein and coronary sinus was acute (<90°) in 43% of cases.[26] This acute angulation might create technical difficulties in the insertion of a permanent pacing lead. The findings of the present study regarding the draining angles of various tributaries into coronary sinus were concordant with the published data in the literature.[5,26]

Number of lateral branches

The number of visible lateral branches on angiography ranged between 1 in 18.7% subjects, 2 in 73.3% subjects and 3 in 8% subjects. Gokhroo RK et al, in their study found total no lateral branches <2 in 34%, 2 in 39% and >2 in 27% cases.[33] The presence of the lateral branches provides various options for proper lead implantation while performing various electrophysiological procedures.

Tortuousity of Vein that is ideal for lead implantation: Gokhroo RK et al, observed in their study that <2/absent curves was present in 65% subjects, 2 curves in 30% and >2 curves in 5%.[33] In present study no curve was observed in 75.3% subjects, 1 curve in 20% subjects and 2 curves in 4.7%. The distance between the CS ostium and the ostium of the vein ideal for lead implantation was found to be <10 mm in 4% subjects, in-between 10-40mm in 76% subjects and >40 mm in 20% subjects. Thus, in majority of subjects the ideal vein for implantation was available.

CONCLUSION

In conclusion, the present study describes the basic anatomy of the coronary sinus venous drainage with focus on specific anatomical aspects that are encountered in invasive and interventional setting in a sample of Kashmiri population. The anatomy of coronary sinus and its tributaries are important parameters for the interventional cardiologists and for clinical research. The recognition of the venous tributaries with respect to their distribution, dimensions, angulations and tortuosity will enable the development of lead positioning tailored to each individual patient.

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REFERENCES

1. Tori G. Radiological visualization of the coronary sinus and coronary veins. Acta Radiol. 1952;36: 405-15.
2. Alonso C, Leclercq C, d'Allonnes FR, Pavin D, Victor F, Mabo P, et al. Six year experience of transvenous left ventricular lead implantation for permanent biventricular pacing in patients with advanced heart failure: technical aspects. Heart 2001;86:405-10.
3. Gerber TC, Kantor B, Keelan PC, Hayes DL, Schwartz RS, Holmes DR. The coronary venous System: an alternate portal to the myocardium for diagnostic and therapeutic procedures in invasive cardiology. Curr Interv Cardiol Rep. 2000;2:27-37.
4. Grzybiak M. Morphology of the coronary sinus and contemporary cardiac electrophysiology. Folia Morphol (Warsz). 1996;55:272-3.
5. Ludinghausen MV. Clinical anatomy of cardiac veins, Vv. cardiacae. Surg Radiol Anat. 1987;9: 159-68.
6. Felle P, Bannigan JG. Anatomy of the valve of the coronary sinus (Thebesian valve). Clin Anatomy. 1994;7(1):10-2.
7. Strohmer B. Valve of Vieussens: an obstacle for left ventricular lead placement. Can J Cardiol. 2008;24(9):e63.
8. Ludinghausen M, Ohmachi N, Boot C. Myocardial coverage of the coronary sinus and related veins. Clin Anat. 1992;5:1-15.
9. Silver MA, Rowley NE. The functional anatomy of the human coronary sinus. American Heart J. 1988;1;115(5):1080-4.
10. Cappato R, Schlüter M, Weiss C, Willems S, Meinertz T, Kuck K. Mapping of the coronary sinus and great cardiac vein using a 2-french electrode catheter and a right femoral approach. J Cardiovascular Electrophysiol. 1997;8(4):371-6.
11. Stellbrink C, Diem B, Schauerte P, Ziegert K, Hanrath P. Transcoronary venous radiofrequency catheter ablation of ventricular tachycardia. J Cardiovascular Electrophysiol. 1997;8(8):916-21.
12. Fisher JD, Brodman R, Kim SG, Matos JA, Brodman LE, Wallerson D, et al. Attempted nonsurgical electrical ablation of accessory pathways via the coronary sinus in the Wolff-Parkinson-White syndrome. J Am Coll Cardiol. 1984;1;4(4):685-94.
13. Haissaguerre M, Gaita F, Fischer B, Egloff P, Lemetayer P, Warin JF. Radiofrequency catheter ablation of left lateral accessory pathways via the coronary sinus. Circul. 1992;86(5):1464-8.
14. Gaita F, Paperini L, Riccardi R, Ferraro A. Cryothermic ablation within the coronary sinus of an epicardial posterolateral pathway. J Cardiovascular Electrophysiol. 2002;13(11):1160-3.
15. Haïssaguerre M, Hocini M, Takahashi Y, O'neill MD, Pernat A. Impact of catheter ablation of the coronary sinus on paroxysmal or persistent atrial fibrillation. J Cardiovascular Electrophysiol. 2007;18(4):378-86.
16. Dosdall DJ, Rothe DE, Brandon TA, Sweeney JD. Effect of rapid biphasic shock subpulse switching on ventricular defibrillation thresholds. J Cardiovascular Electrophysiol. 2004;15(7):802-8.
17. Huang J, Walcott GP, Killingsworth CR, Smith WM, Kenknight BH, Ideker RE. Effect of electrode location in great cardiac vein on the ventricular defibrillation threshold. Pacing Clin Electrophysiol. 2002;25(1):42-8.
18. Rossillo A, Verma A, Saad EB, Corrado A, Gasparini G, Marrouche NF, et al. Impact of coronary sinus lead position on biventricular pacing: mortality and echocardiographic evaluation during long-term follow-up. J Cardiovascular Electrophysiol. 2004;15(10):1120-5.
19. Biffi M, Moschini C, Bertini M, Saporito D, Ziacchi M, Diemberger I, et al. Phrenic stimulation: a challenge for cardiac resynchronization therapy. Circul Arrhythmia Electrophysiol. 2009;1;2(4):402-10.
20. Jongbloed MR, Lamb HJ, Bax JJ, Schuijf JD, Roos A, v Wall EE, et al. Noninvasive visualization of the cardiac venous system using multislice computed tomography. J Am Coll Cardiol. 2005;45(5):749-53.
21. Ludinghausen M. The venous drainage of the human myocardium. Adv Anatomy Embryol Cell Biol. 2003;168:1-104.
22. Pinkosz CM, Urbanowicz Z. Analysis of the course and the ostium of the oblique vein of the left atrium. Folia Morphol (Warsz). 2000;59:163-6.
23. Loukas M, Bilinsky S, Bilinsky E, El-Sedfy A, Anderson RH. Cardiac veins: a review of the literature. Clin Anatomy Off J Am Assoc Clin Anatomists Brit Assoc Clin Anatomists. 2009;22(1):129-45.
24. Habib A, Lachman N, Christensen KN, Asirvatham SJ. The anatomy of the coronary sinus venous system for the cardiac electrophysiologist. Europace. 2009;(11-5):v15-21.
25. Manoranjitham R, Shalini R, Gosai SR, Varman RC. Morphological study of coronary sinus in human cadaveric hearts. Int J Anat Res. 2015;3(3):1415-8.
26. Gilard M, Mansourati J, Etienne Y, Larlet JM, Truong B, Boschat J, et al. Angiographic anatomy of the coronary sinus and its tributaries. Pacing Clin Electrophysiol. 1998;21:2280-4.
27. Ortale JR, Gabriel EA, Iost C, Marquez CQ. The anatomy of the coronary sinus and its tributaries. Surg Radiol Anatomy. 2001;23(1):15-21.
28. Plass A, Valenta I, Gaemperli O, Kaufmann P, Alkadhi H, Zund G, et al. Assessment of coronary sinus anatomy between normal and insufficient mitral valves by multi-slice computer tomography for mitral annuloplasty device implantations. Europ J Cardio-Thoracic Surg. 2008;33:583-9.
29. Ominde BS, Olabu B, Ogeng'o JA. Length of coronary sinus in a black Kenyan population:

correlation with heart length. Anatomy J Africa. 2015;4(1):488-95.
30. Doig JC, Saito J, Harris L, Downar E. Coronary sinus morphology in patients with atrioventricular junctional reentry tachycardia and other supraventricular tachyarrhythmia. Circulation. 1995;92:436-41.
31. Lee MS, Atman PS, Ninh D, Daniel B, James F, Prediman KS, et al. Coronary Sinus is Dilated and Outwardly Displaced in Patients with Mitral Regurgitation. Catheterization Cardiovascul Interventions. 2006;67:490-4.
32. Sun JP, Yang XS, Lam YY, Garcia MJ, Yu CM. Evaluation of coronary venous anatomy by multislice computed Tomography. World J Cardiovasc Surg. 2012;291-5.
33. Gokhroo RK, Bisht DS, Padmanabhan D, Gupta S. Coronary sinus anatomy: Ajmer Working Group Classification. J Invasive Cardiol. 2014;26(2):71-4.
34. Ankolekar VH, Quadros LS, D'souza AS. Morphometric and morphological variations of coronary venous system and itstributaries-An anatomical study. J Pharm Biomed Sci. 2013;34: 1663-9.

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