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Variations of Coronary Venous Anatomy with Implications for Cardiac Interventions

Vandana Dave[1], Simmi Mehra[2], Ram Prakash Busar[3], Manish Singh Ahuja[4]

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Author's Affiliation: [1]PhD Scholar, Department of Anatomy, Mahatma Gandhi Medical College, Mahatma Gandhi University of Medical Sciences and Technology, RIICO Industrial Area, Sitapura, Jaipur, Rajasthan 302022, India. [2]Professor, Department of Anatomy, Dr DY Patil Medical College, Mumbai, Maharashtra 400706, India. [3]Professor, Department of Anatomy, Mahatma Gandhi Medical College, Jaipur, Rajasthan 302022, India. [4]Professor, Department of Anatomy, Armed Forces Medical College, Pune, Maharashtra 411040, India.

Corresponding Author: Vandana Dave, PhD Scholar, Department of Anatomy, Mahatma Gandhi Medical College, Mahatma Gandhi University of Medical Sciences and Technology, RIICO Industrial Area, Sitapura, Jaipur, Rajasthan 302022, India.

E-mail: daveveenu@gmail.com

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Abstract

Introduction: The Coronary veins are used as a conduit in various invasive cardiological procedures for arrhythmias and heart failure. The present study aims to study variations in anatomy of coronary sinus and its tributaries.

Materials and Methods: The study was conducted on 110 formalin fixed cadaveric hearts. The coronary sinus was observed for its length, formation, tributaries, Thebesian valve and Vieussens valve. The transverse and craniocaudal diameter of coronary sinus ostium were measured.

Results: The Coronary Sinus (CS) was classified into five types according to the formation by joining of tributaries. Type I CS was most common and observed in 52 (47.3%) specimens, which was formed by joining of great cardiac vein (GCV) and Oblique vein of left atrium (OBV). The mean length of CS was found as 26.09 ± 9.25 mm with range of 10.52 – 49.02 mm. In the first four types of CS, Type III CS presented maximum length of 29.94 ± 9.29 mm. The mean transverse and mean craniocaudal diameter of CSO were observed as 8.26 ± 3.13 mm and 10.18 ± 4.30 mm respectively. The Vieussens valve and Thebesian valve were present in 59 (53.63%) and 91 (82.72%) heart specimens. GCV and middle cardiac vein were present in all specimens with no variation in their course and drainage.

Conclusion: Knowledge of variations in the CS and its tributaries are helpful in biventricular pacing and various invasive cardiac procedures.

Keywords: Coronary sinus; Coronary sinus ostium; Thebesian valve; Vieussens valve.

Introduction

The coronary venous system has become more important with the recent advances in the electrophysiology and invasive cardiac procedures. The coronary sinus is clinically important through its role in providing access for different cardiac procedures like mapping and ablation of atrioventricular accessory pathways, the retrograde perfusion of thrombolysis[1,2], bypass coronary artery stenosis[3], and delivery of stem cells to infarcted myocardium.[4] Transvenous implantation of a pacing lead in an appropriate coronary vein on the left ventricle is done through the coronary sinus.[5,6] Hence, knowledge of the normal anatomy and variations of coronary venous system is imperative for successful outcome of invasive cardiac surgeries.

Coronary Sinus (CS) is the largest vein of heart. The CS lies in the posterior part of atrioventricular groove and has a length of about 2–3 cm. It drains most of the venous return of heart and opens into the right atrium. The Coronary Sinus Ostium (CSO) is covered by an endocardial fold known as Thebesian Valve (TV). CS receives major tributaries of heart. These are great cardiac vein (GCV), oblique vein of left atrium (OBV), posterior vein of left ventricle

(PVL), middle cardiac vein (MCV) and small cardiac vein (SMV).[7] The valve present at the termination of GCV is known as Vieussens valve (Vv).

The studies on coronary venous system are scarce than the coronary arterial system as coronary venous system has not been given much importance in comparison to the coronary arteries. CS is used for retro perfusion in patients in whom the coronary arterial system is not acquiescent for revascularization. Variations in the coronary venous system are common cause of difficulty in accessing the suitable tributary for the biventricular lead placement.[8] Knowledge of the variations of coronary veins is helpful for the selection of patient suitable for invasive cardiac procedure and to avoid complications which can improve the treatment outcome. Therefore, the present study was aimed to study the normal anatomy and variations of coronary venous system.

Materials and Methods

This study was conducted on 110 formalin fixed adult human cadaveric hearts of both sexes from age of 22 to 87 years. The study was conducted in the Department of Anatomy, Mahatma Gandhi Medical College, Jaipur. The approval from the institute ethics committee was obtained before start of the study. Hearts with any pathology or macroscopic anomalies were excluded from the study.

The coronary sinus and its tributaries were traced by removing the epicardium and subepicardial fat. Variations in these tributaries were noted. The CS was opened longitudinally along its free wall to note the presence of Vieussens valve which is located at the termination of GCV. The formation of CS was noted according to the tributaries draining into the left end of CS. The right atrium was opened along the sulcus terminalis and thoroughly washed to remove blood clots. The length of CS was measured from its beginning point at the formation of CS which also marks the termination of GCV to the CS ostium. The presence or absence of Thebesian valve was noted. The transverse and craniocaudal diameter of CS ostium were measured. All the measurements were done by using the digital vernier callipers with 0.1 mm precision. These observations were tabulated. All qualitative data were expressed as numbers and percentage. Mean, range and standard deviation of all quantitative data were calculated.

Results

Formation of coronary sinus

A total of 110 hearts were studied. The tributaries forming CS were observed. According to the formation, five types of coronary sinus were noted, (Fig. 1 and 2). The Type I CS was most common and observed in 52 (47.3%) heart specimens, followed by Type III CS which was seen in 41 (37.3%) hearts. The Type V CS was observed only in one (0.9%) heart specimen, (Table 1).

Fig. 1: Heart specimens showing formatio of coronary sinus (CS). Type I GCV (great cardiac vein) with OBV (Oblique vein of left atrium), Type II - GCV with PVL (posterior vein of left ventricle), Type III - GCV with LMV (left marginal vein); MCV - Middle cardiac vein; SMV - Small cardiac vein.

Length of coronary sinus

The length of CS was measured. The mean length was found as 26.09 ± 9.25 mm with range of 10.52–49.02 mm. Type V CS was observed in only one heart, it presented a length of 39.2 mm. The mean length was also noted for different types of CS with range, (Table 2).

Table 1: Formation of coronary sinus

Sl. No.	Type of CS	Veins forming CS	No. of heart specimens	(%)
1.	Type I	GCV with OBV	52	47.3%
2.	Type II	GCV with PVL	10	9%
3.	Type III	GCV with LMV	41	37.3%
4.	Type IV	GCV with OBV and PVL	6	5.4%
5.	Type V	GCV with PLSVC	1	0.9%

CS = Coronary sinus; GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

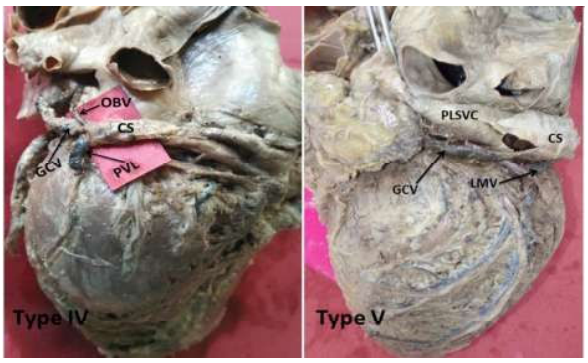

Fig. 2: Heart specimens showing formation of coronary sinus (CS). Type IV - GCV (Great cardiac vein) with OBV (oblique vein of left atrium and PVI, (Posterior vein of left ventricle), Type V = GCV with persistent left superior vena cave (PLSVC); LMV = Left marginal; vein

Diameter of coronary sinus ostium

The average transverse diameter of CSO was measured as 8.26 ± 3.13 mm (range 2.59 – 15.60 mm) and the average craniocaudal diameter of CSO was 10.18 ± 4.3 mm (range 3.10 – 18.9 mm). The average transverse and craniocaudal diameter of CSO were also measured for different types of CS, (Table 3).

Vieussens valve and Thebesian valve

Thebesian valve was observed in 91 (82.72%) heart specimens and Vieussens valve was present in 59 (53.63%) heart specimens. The presence or absence of Thebesian and Vieussens valve were also noted for different types of CS, (Table 3).

Tributaries of coronary sinus

The great cardiac vein and middle cardiac vein were observed as most common tributaries of coronary sinus and were present in all heart specimens. The small cardiac vein and middle cardiac vein formed a common channel just before draining into the coronary sinus in 12 heart specimens. Posterior vein of left ventricle (PVL) was observed as most variable tributary. PVL was present in 59 hearts. One PVL was seen in 20 heart specimens. Two and three PVL were observed in 16 and 13 hearts respectively and four and six PVL (Fig. 3) were observed in 9 and 1 hearts respectively. All the tributaries presented a normal course and drainage (Table 4).

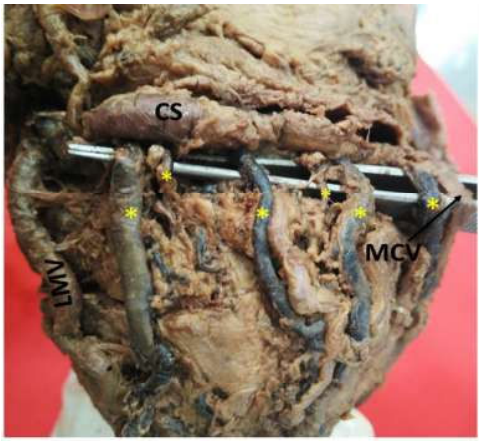

Fig. 3: Posterior surface of heart showing six posterior vein of left ventricle (*) draining into coronary sinus (CS). LMV = Left marginal vein; MCV = Middle cardiac vein.

Table 2: Length of coronary sinus

Sl. No.	Type of CS	Mean length of CS with standard deviation (mm)	Range (mm)
1.	Type I (GCV with OBV)	24.06 ± 8.22	11.91 – 45.9
2.	Type II (GCV with PVL)	19.15 ± 7.66	10.52 – 31.74
3.	Type III (GCV with LMV)	29.94 ± 9.29	13.89 – 49.02
4.	Type IV (GCV with OBV and PVL)	26.78 ± 9.18	20.6 – 45.01
5.	Type V (GCV with PLSVC)	39.2 mm	–

CS = Coronary sinus; GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

Table 3: Diameter of coronary sinus ostium (CSO) and presence or absence of Thebesian valve (TV) and Vieussens valve (Vv) in different type of coronary sinus (CS)

Sl. No.	Type of CS	Diameter of CSO (mm)		Number of hearts with TV present	Number of hearts with Vv present
		Transverse	Craniocaudal		
1.	Type I (GCV with OBV)	8.17 ± 2.83	10.54 ± 4.04	47	29
2.	Type II (GCV with PVL)	8.05 ± 3.10	9.15 ± 5.4	7	6
3.	Type III (GCV with LMV)	8.12 ± 3.50	10.14 ± 4.55	33	20
4.	Type IV (GCV with OBV and PVL)	9.26 ± 2.54	8.33 ± 2.81	4	4
5.	Type V (GCV with PLSVC)	14.79	14.38	0	0

GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

Table 4: Tributaries of coronary sinus (CS)

Sl. No	Tributary of CS	Present in number of heart specimens	Percentage (%)
1.	Great cardiac vein	110	100
2.	Middle cardiac vein	110	100
3.	Oblique vein of left atrium	68	61.81
4.	Small cardiac vein	58	52.72
5.	Left marginal vein	77	70
6.	Posterior vein of left ventricle	59	53.63

Table 5: Comparison of occurrence of Thebesian valve and Vieussens valve

Sl. No	Authors	Number of total hearts	Number of hearts with TV present (%)	Number of hearts with Vv present (%)
1.	Mak et al.[24]	75	73	-
2.	Karaca et al.[21]	52	67	75
3.	Maasarany et al.[25]	40	87.5	100
4.	Randhawa et al.[17]	50	64	60
6.	Present study	110	82.72	53.63

TV = Thebesian valve; Vv = Vieussens valve.

Table 6: Comparison of frequency of coronary veins

Authors	Mlynarski et al.[29]	Malago et al.[30]	Berhan et al.[9]	Ortale et al.[11]	Sharma et al.[28]	Mazur et al.[31]	Present study
Study method	64-slice CT	64-slice CT	Dual source CT	Cadaveric	Cadaveric	Cadaveric	Cadaveric
Sample size	199	301	339	32	30	200	110
CS	100%	100%	100%	100%	100%	100%	100%
GCV	-	100%	100%	100%	100%	100%	100%
MCV	100%	100%	100%	100%	100%	100%	100%
OBV	-	10.9%	10.6%	43%	30%	71%	61.81%
PVL	62.3%	82%	87%	100%	90%	63.5%	53.63%
SMV	-	18.9%	20%	54%	60%	74%	52.72%
LMV	80.4%	84%	87.9%	97%	100%	39.5%	70%

CS = Coronary sinus; GCV = Great cardiac vein; MCV = Middle cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; SMV = Small cardiac vein; LMV = Left marginal vein.

Discussion

The Coronary Sinus (CS) and its tributaries are commonly used in treatment modalities for heart failure and arrhythmias.[1] The cardiac resynchronization therapy is a technique which restores the synchronization between right and left ventricle by implantation of a pacing lead in one of the tributaries of CS.[9] The knowledge of coronary venous anatomy is important to increase the success rate and treatment outcome of these procedures. Failure rate of these invasive cardiac procedures has been documented as 5–12% even with experienced hand.[10]

Formation of Coronary sinus

The CS is commonly observed to be formed by joining of GCV and OBV.[11,12] Samoon et al.[13] reported two types of formation of CS by union of GCV with LMV in 93% and union of GCV with PVL in about 7% subjects in the angiographic study of 150 patients. Manoranjitham et al.[14] noted the formation of CS in 30 human cadaveric hearts. They observed three types of CS on basis of its formation. These were formed by union of GCV with LMV in 93.33%, GCV with OBV in 3.33% and GCV with PVL in 3.33%. The present study has reported Five Types of CS which were formed by union of GCV with OBV (47.3%), GCV with PVL (9%), GCV with LMV (37.3%), GCV with both OBV and PVL (5.4%) and GCV with persistent left superior vena cava (0.9%). A previous study has reported different type of CS which was not formed as a continuation of GCV, the GCV was observed as directly draining into the right atrium or anterior cardiac vein.[15,16]

Length of Coronary sinus

The length of CS according to its formation has been documented in very few studies.[13,14,17] The mean length of CS in present study was revealed as 24.06 ± 8.22 mm (GCV + OBV), 19.15 ±7.66 mm (GCV + PVL), 29.94 ± 9.29 mm (GCV + LMV) and 26.78 ± 9.18 mm (GCV + OBV + PVL). The persistent left superior vena cava was observed in only one heart, in which the length of CS was 39.2 mm. Samoon et al.[13] noticed the length of CS as 71.70 ± 9.71 mm (GCV + LMV) and 70.18 ± 14.98 mm (GCV + PVL), which is different from our observations. Manoranjitham et al.[14] reported the mean length of CS as 54.98 ± 12.2 mm (GCV + LMV), 53.06 mm (GCV + PVL) and 34.52 mm (GCV + OBV). We also observed maximum mean length in CS formed by union of GCV with LMV. Randhawa et al.[17] observed the mean length of CS as 30.2 ± 3.1 mm (GCV + OBV) and 31.7 ± 5.9 mm (GCV + PVL). Ankoleker et al.[18] revealed the mean length of CS as 28 mm and an autopsy study by Bellesteros et al.[19] reported the length as 25.96 mm. These results correspond with our study. Variations in the length of CS may be caused by different size of hearts.

Diameter of Coronary sinus ostium

In the present study, the mean transverse and craniocaudal diameter of CS ostium was observed as 8.26 ± 3.13 mm and 10.18 ± 4.30 mm respectively. Zhivadinovic et al.[20] reported the mean transverse and craniocaudal diameter as 7.67 ± 1.72 mm and 8.1 ± 1.51 mm respectively which is similar to our observation. The mean diameter of CS ostium was ranged from about 8 to 12 mm in different studies.[21,22,23]

Thebesian valve and Vieussens valve

The TV was noticed in 91 specimens which is similar to the previous studies.[21,24,25]A considerable difference was observed in results of cadaveric studies and studies by using different type of imaging techniques. Anh et al.[26] reported TV in 54% hearts studied by using fiberoptic endocardial visualization catheter. The technical limitations in visualization of smaller valves could be a cause of lower prevalence of the valve. Corcoran et al.[27] studied the Vieussens valve in 50 cadaveric hearts and found obstructive Vieussens valve in 46% cases, (Table 5).

Tributaries of Coronary sinus

The GCV and MCV were observed as most consistent tributaries of CS and was present in all specimens, similar to the other studies.[9,11,28,29,30,31] The present study reported 0 to 6 PVL, similar variation in number of PVL was reported by previous studies.[21,32] Gilard et al.[32] observed 0 to 3 PVL and Karaca et al.[21] observed 2 to 6 PVL. Karaca et al.[21] noticed 2 PVL in 11%, 3 PVL in 38%, 4 PVL in 37%, 5 PVL in 11% and 6 PVL in 2% cases. In the present study, 6 PVL were noticed only in one heart specimen, (Table 6).

Conclusion

Invasive cardiac surgeries for cardiac ailments are becoming more common with advancement in electrophysiology. Coronary venous system is commonly used as an access route to the heart. The anatomy and variations of coronary veins described in the present study might be helpful for biventricular pacing, radio frequency ablation and other cardiac interventions. The presence of Vieussens valve, smaller coronary sinus ostium with large Thebesian valve and variable anatomy of inconstant tributaries of coronary sinus need to be negotiated before selection of any interventional cardiac procedure. Stem cell transplantation through the retrograde perfusion and mechanical induction of angiogenesis through coronary veins are the currently investigated research fields which require an accurate knowledge of coronary venous anatomy and its variations.

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