International Journal of Current Research and Review
DOI: 10.7324/IJCRR.2018.10102

Original Article

IJCRR
Section: Healthcare
Sci. Journal
Impact Factor
4.016
ICV: 71.54

Morphology and Morphometry of Venous Drainage System of Heart: A Retrospective Cadaveric Study

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ABSTRACT

Introduction: In recent times the veins of the heart have gained importance as a treatment modality for the ischaemic myocardium and carry great importance in cardiac surgery. This treatment is possible because of the presence of intramyocardial collateral venous circulation Anatomic mapping of the cardiac veins is important to guide transvenous procedures such as biventricular pacing. A detailed knowledge of cardiac venous anatomy is necessary for successful catheterization of the coronary sinus and cardiac veins.

Material & Methods: The dissection of the cardiac veins was carried out on 30 preparations of formalin fixed hearts obtained from cadavers during routine undergraduate teaching. About 10 ml of CAB solution (Cellulose Acetate Butyrite crystals in acetone) was injected into the coronary sinus. The specimens were left overnight and then placed into the 5% formalin solution. The specimen was dissected to expose coronary sinus with its tributaries. Various parameters including length, diameter of coronary sinus and its tributaries and presence of muscle bridges were noted.

Observations: CS was present in all 30 (100%) cases. The mean diameter of CS was calculated as 8.87±1.48mm. The great cardiac vein (GCV) normally drains the left atrium and both ventricles. This pattern was seen in 20 cases (66.6%). Arteriovenous anastomosis between GCV and the right coronary artery and anterior interventricular branch of left coronary artery were observed in 13.3% cases respectively. The present findings are discussed in light of available literature.

Key Words: Arteriovenous anastomosis, Coronary sinus, Great cardiac veins

INTRODUCTION

Variations pertaining to the coronary arterial system have been described throughout the literature. The therapeutic modalities for Coronary Artery Disease (CAD) have also been described vastly. The coronary venous system, by comparison, has been largely neglected[1]. The venous system does, however, have key importance in the application of new technologies and techniques designed for the treatment of cardiovascular disease. Tori [2] was the first to outline some of the larger veins by retrograde injection of contrast material into the catheterized coronary sinus.

Recently the veins of the heart have gained importance as a treatment modality for the ischaemic myocardium[3]. The coronary sinus can be used for retrograde perfusion of the myocardium.[4-8] Presence of intramyocardial collateral venous circulation is the key to this treatment. Projects to protect the myocardium by means of reperfusion were reported to be highly successful in some centers while in others the results were reported to be inconsistent because of the great variability of the cardiac venous system. Apart from this, lack of uniform terminology/classification and incomparability in categorizing the variations of cardiac venous system exists.

This process of venous reperfusion can be managed with arterial blood or nutritive solutions [9-12]. The important function of the venous drainage of the heart is "venous-unity" and a great compensating capacity[13].

There are three main domains in which a thorough understanding of the venous system may lead to potentially useful

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ISSN: 2231-2196 (Print) **ISSN:** 0975-5241 (Online)

Received: 16.04.2018 **Revised:** 29.04.2018 **Accepted:** 12.05.2018

clinical interventions. First is the use of percutaneous techniques to allow retroinfusion of arterialized blood into the coronary veins in patients deemed unsuitable for conventional revascularization. Second, the regional delivery of therapeutic agents such as cardioprotective drugs, cells or gene vectors, is possible [14]. And finally, the use of the coronary venous system as a route of access to the myocardium by the cardiac electrophysiologist [15]. Variability in terms of valves, diameter, angulation, extent of muscular sleeves, proximity to other cardiac structures, and cross-over spatial relationship with branches of coronary arteries have implications for practitioners seeking to make use of the system [16].

Anatomic mapping of the cardiac veins is important to guide transvenous procedure such as biventricular pacing and for deployment of cardiac devices[15-17]. In the current scenario, there are therapeutic options for arrhythmias and for heart failure that use the coronary venous system to access target areas [1]. The epicardial coronary venous system has become the subject of renewed interest in recent years[16].

Coronary sinus cannulation has allowed access to the left atrial and left ventricular (LV) epicardium, enabling a spectrum of diagnostic and mapping maneuvers to aid in the determination of the type of arrhythmia as well as permit the delivery of ablative energy. More recently, the coronary sinus has become the gateway to LV epicardial lead placement to achieve biventricular pacing[15]. Retrograde cardioplegia is done in cardiac surgeries like valve replacement/repair, severe coronary lesions/ occlusion, aortic incompetence, coronary reoperations, coronary grafts and pediatric cardiac surgeries [19]. It is achieved by introducing the cardioplegic drug, potassium chloride through the coronary sinus after passing the catheter beyond the ostium of the coronary sinus. Hence any variation in the veins of the heart is significant [1]. Therefore, an attempt is made to discuss the anatomy and variations of cardiac venous system so that it may help in forming a basis for the treatment of Ischaemic Heart Disease (IHD) and CAD.

MATERIAL AND METHODS

The cross sectional study of anatomical variations in the venous drainage of heart was conducted on 30 adult cadaveric hearts obtained from the department of Anatomy, Govt. Medical College and Hospital, Chandigarh. The study was conducted by following the ethical guidelines for biomedical research on human subject as given in "Declaration of Helsinki" and by Central Ethics Committee on Human Research (CECHR) of ICMR, New Delhi. The opening of coronary sinus was approached through the opening of inferior vena cava and a 18G veinflow was introduced into it. About 10ml of 10% mixture of coloured CAB (Cellulose Acetate Butyrite) crystals in acetone was injected into the coronary sinus. Specimens were left overnight and then placed into 5% formalin solution .The specimens were dissected for the coronary sinus and its tributaries. Length and diameter of coronary sinus were measured. Tributaries of coronary sinus along with their diameter were penned down. The observations were recorded on a Performa (appended). The results were tabulated and analysed statistically using appropriate statistical tests.

Observations

The coronary sinus (CS) was present in all 30 (100%) cases. The mean diameter of CS was calculated as 8.87±1.48mm. The range of the diameter varied from 5.0 to 12mm. In majority of cases (63.3%), the range of the diameter was calculated as 9.0 to 12mm whereas in 36.7% cases, the range was 5.0 to 8.0mm.The most frequent shape of CS was "cylindrical" (93.3%) followed by "flattened" in 6.67% cases.

The mean length of the CS was calculated as 33.76±5.36mm. The minimum length of the coronary sinus was observed as 26.0mm while the maximum was 48.0mm. In 30% cases, the range was calculated as 36 to 40mm; in 23.3% cases, the range was 32 to 34mm and in 10% cases, the range of length was 42 to 48mm as shown in Table 1.

Table 1: Range and mean of the diameter and length of the coronary sinus

	Range of Diameter (mm.)	Number of Cases	Mean Diameter (mm.)	Range of Length (mm.)	Number of Cases	Mean Length (mm.)
Coronary Sinus	Upto 5.0	1	8.87±1.48	26 – 30	11	33.76±5.36
	6.0 to 10.0	26		32 – 34	7	
	>10	3		36 – 40	9	
				42 – 48	3	

Great cardiac vein (GCV)

The great cardiac vein starts at the apex of heart and runs in the anterior interventricular sulcus (AIS) along with anterior interventricular branch of the Left Coronary Artery (LCA) (Fig.2). This pattern was observed in 25 cases (83.3%) in the present study.

In some specimens, variations were observed in the beginning of the GCV. In one case (3.3%), the GCV started at the junction of upper 2/3rd and lower 1/3rd of AIS. In three cases (10%), it started at the middle of AIS and in only one case (Fig 1), the beginning of GCV was at the junction of upper 1/3rd and lower 2/3rd of AIS. Superficial veno-venous anastomosis were observed in 13(42.9%) of hearts in the present study. In these cases, there was a communication seen between the GCV and the left marginal vein LMV, between the GCV, LMV and middle cardiac vein (MCV ; between the left marginal vein (LMV) and the uppermost tributary of the GCV ; between the GCV, middle cardiac vein (MCV) and posterior vein of left ventricle (PVLV) (Fig.2) ; between the GCV and the PVLV.

The GCV, normally, drains the left atrium and both ventricles. This pattern was seen in 20 cases (66.6%). However, in the remaining 10 cases (33.3%), this normal pattern of drainage was not seen and the GCV received most of the tributaries from the left side of the heart as compared to right side. In one case (3.3%), the GCV passed superficial to one of the branches of LCA.

Arterio-venous anastomosis

In four cases (13.3%) 'Arterio-venous' anastomosis were observed between the tributaries of great cardiac vein and branches right coronary artery (RCA); between the GCV and the anterior interventricular branch of the LCA at the upper end of AIS ; between the GCV and the anterior interventricular branch of the LCA at the junction of upper2/3rd and lower1/3rd of AIS and also at the apex of heart. At the upper end of AIS, arteriovenous anastomosis was observed between GCV and one of the branches of LCA in a single case (Fig 3).

Muscle Bridges were observed in four cases. In one case, muscle bridge was seen crossing over the major tributary of GCV from its left side; in the other, the muscle bridges were seen over the GCV and the anterior interventricular branch of the LCA in the upper part of AIS. In another heart, the MCV was covered by a muscle bridge at the middle of posterior interventricular sulcus (Fig.4). In another heart, the CS was covered by a muscle bridge at the site of termination of GCV into the CS.

The mean diameter of GCV was calculated as 3.31±0.72mm. The range of diameter varied from 1.8 to 4.8mm. In majority of cases (53.3%), the range of the diameter varied from 2.8 to 3.4mm, whereas in 36.7% cases, the range of the diameter was 3.8 to 4.8mm and in 10% cases, the range was 1.8 to 2.4mm.

Middle cardiac vein (MCV)

The middle cardiac vein normally starts at the apex of heart and runs in the posterior interventricular sulcus along with posterior interventricular branch of the RCA (Fig 5). This kind of normal pattern was present in 25 cases (83.3%).

In others, the beginning of the middle cardiac vein varied. In one case (3.3 %), the MCV started at the junction of upper 2/3rd and lower 1/3rd of AIS. In three cases (10%), it started at the middle of AIS and in only one case at the junction of upper 1/3rd and lower 2/3rd of AIS. In these cases, communication was seen between the MCV, LMV and the PVLV ; between the tributaries of MCV, LMV and PVLV ; between the MCV and LMV ; between the MCV and right marginal vein (RMV) through a communicating vein ; between the MCV, GCV and PVLV (Fig.2). In one case (3.3%), the MCV received tributaries only from its right side.

Normally, it drains the diaphragmatic surface of both ventricles. This pattern was seen in 26 cases. However, in the remaining 4 cases, this normal pattern of drainage was not seen and the MCV was also receiving tributaries from the anterior surface of ventricles.

The mean diameter of the MCV was calculated as 3.79±1.10mm. The range of diameter varied from 2.0 to 6.0mm. In majority of cases (56.7%), the range of diameter was calculated as 2.0 to 3.0mm. However, in 40% cases, the range of diameter was 4.0 to 5.0mm and 6 mm in 3.3% cases.

Table 2: Range and mean of the diameter of great cardiac, middle cardiac vein and small cardiac vein

GCV			MCV			SCV		
No of Cases	Range (mm)	Mean	No. of cases	Range (mm)	Mean	No. of cases	Range	Mean
3	1.8-2.4	3.31±0.72	17	2.0-3.0	3.79±1.10	8	1.0-1.6	1.81±0.54
16	2.8-3.4		12	4.0-5.0		7	1.8-2.2	
11	>3.8		1	>6		3	2.4-3.0	

The middle cardiac vein diameter is greater than great cardiac vein.

Small cardiac vein (SCV)

The small cardiac vein normally lies posterior in the coronary sulcus between the right atrium and right ventricle and opens into the coronary sinus at its termination into the right atrium. In our study of 30 hearts, the small cardiac vein was present only in 18 cases (60%) and absent in remaining 12 cases (40%).

In all the 18 cases (60%), where the small cardiac vein was present, its location was seen to be normal as described above. In one heart, there was also an "AV anastomosis" seen between the small cardiac vein and the right coronary artery. In another heart, the SCV was receiving the RMV.

The mean diameter of SCV was 1.81±0.54mm. The range of the diameter varied from 1.0 to 3.0mm. In majority of cases (23.3%), the range of the diameter was calculated as 1.6 to 2.0mm. In 20% cases, the range of the diameter was calculated as 1.0 to 1.4mm; in 10% cases, the range was 2.2 to 2.4mm and in 6.6% cases, the range was 2.6 to 3.0mm.

Posterior vein of the left ventricle (PVLV)

The posterior vein of the left ventricle is normally found on the diaphragmatic surface of the left ventricle and a little to the left of the middle cardiac vein(Fig 2). It usually opens into the centre of the coronary sinus but sometimes into the great cardiac vein. The former kind of normal pattern was seen in 27 cases (90%). In the remaining 3 cases (10%), the PVLV joined the left end of CS (near the termination of GCV into the CS). In three cases, there was a communication seen between the PVLV and the tributaries of LMV. In two cases (6.67%), there was a communication seen between PVLV and the tributaries of MCV. In one case (3.3%), there were number of communicating veins seen between the tributaries of PVLV, LMV and MCV. The PVLV was accompanied by a vein on its left side in three cases (10%); accompanied by a vein on its right side in two cases (6.67%) and accompanied by a vein on its either side in three cases (10%).

The mean diameter of PVLV was calculated as 2.84±0.97mm. The range of diameter varied from 1.0 to 2.6mm. In majority of cases (46.7%), the range of diameter was calculated as 2.1 to 3.0 mm. Out of the remaining cases (53.4%), 50% cases were in the range of 1.0 to 2.0mm and the remaining 50% cases were in the range of 3.2 to 5.6mm.

Oblique vein of left atrium (OVLA)

The oblique vein of left atrium descends obliquely on the back of the left atrium and drains into the CS near its atrial end (Fig 6). In our study of 30 hearts, the OVLA was present only in 9 cases (30%), and not observed in the remaining 21 cases (70%).

The above described normal pattern was seen in all the 9 cases (30%).

The mean diameter of OVLA was 1.0±0.41mm. The range of the diameter varied from 0.4 to 1.6mm. In majority of the cases (13.3%), the range of the diameter was calculated as 1.0 to 1.2mm. In 10% cases, the range of the diameter was 0.4 to 0.8mm and 6.6% cases were in the range of 1.4 to 1.6mm.

The Right Marginal Vein opened directly into the right atrium in 11 cases (36.3%) while in two cases (6.67%), it joined the small cardiac vein. In the remaining 13 cases (where it was present), it was difficult to appreciate its termination.

DISCUSSION

Coronary Sinus (CS) is a major vessel which is about 2 to 3 cm long, lying posteriorly in the coronary sulcus (atrioventricular groove) between the left atrium and left ventricle (Fig.2). The sinus opens into the right atrium between the opening of the inferior vena cava (IVC) and the right atrioventricular orifice, and its opening is guarded by an endocardial fold. The incidence of presence of CS was observed by various authors [15,20-28,30]. In the present study, the incidence was 100% which was similar to that observed by various authors[15,20-28,30]. Variations pertaining to the absence of the coronary sinus had been reported Bergman et al, 1988[30] and Kawashima et al, 2003[31]. According to them in such cases, the great cardiac vein drained into the superior vena cava or the left brachiocephalic vein. Several veins, including the middle cardiac converge to empty into the right atrium directly or may reach the right atrium by passing successively into the left superior vena cava, left brachiocephalic vein and the right superior vena cava. Sahinoglu et al,1994 [32] reported a case of persistent left superior vena cava with a double coronary sinus, one superior and one inferior, both emptying into the right atrium. No such anomaly was observed in the present study.

In the present study, the mean diameter of the CS was 8.87±1.48 mm with a range of 5.0 mm-12 mm. None of the other studies[15,21] have mentioned the mean diameter; however the range of the diameter reported by them is almost similar to the present observations. The measurement of the length shows great variability when compared to existing literature. The mean length of the CS was 33.76±5.3mm with range of the diameter varied from 26 to 48 mm in the present study. Whereas Plass et al, 2008[24] and Sun et al, 2012[26] measured the mean length as high as 108.9mm, followed Lee MS as 86.5mm. Some other authors including Ballestros LE et.al, 2010[25] reported it as less as 25.96±6.34 mm. Probably the points to measure the total length varied in different studies.

Table 3: Showing comparison of length and diameter of coronary sinus

S. No	Author's (Year)	No. of cases	Length (mm)		Diameter (mm)	
			Mean	Range	Range	Mean
1.	Mochizuki (1933)	160	-	-	-	-
2.	Ortale et al (1994)	37	-	-	6.0- 12.0	-
3.	El- Massarany Set al (2005)	32	48.4±5.2	-	-	-
4	Lee MS et.al (2006)	-	86.5	-	-	
5.	Plass A et. Al(2008)	50	108.9±18	-	-	-
6	Habib A et al(2009)	-	-	30-55mm	5.0-15.0	
7	Ballesteros LE et.al (2010)	68	25.96±6.34	-	-	-
8.	Sun JP et .al(2012)	-	109	-	-	-
9.	Kavimani and Jebkani (2014)	40	28	20-38	-	-
10	Ominde BS et al., (2015)	74	39.55±5.32	20-53	-	-
11	Mehra L et al., (2016)	40	35.35±4.43	20.89-39.62	-	-
12	Present study (2018)	30	33.76±5.36	26-48	5-12	8.87±1.48

The most common shape of coronary sinus was cylindrical (93.33%) and flattened in 6.67% in the present study (Fig.2), in accordance with other studies[22,25] except Ominde BS et.al, 2015[28] have reported "wind-sock" shape in 100% of cases .

85% of the venous drainage of heart occurs through great, middle, small cardiac veins through coronary sinus to the right atrium. The right marginal vein may join the small cardiac vein or may open in to right atrium directly. Oblique vein of left atrium descends obliquely on the back of left atrium to join CS.[15] (Fig 6). Variations regarding venous drainage were observed similar to other authors[20,21,31,33,34].

The GCV had many variations due to its long course before draining into the right atrium[31]. In the present study, the mean diameter of the GCV was calculated as 3.31±0.72mm which was less than that observed by Ortale et.al,1994[21] (3.9±1.1mm). The great cardiac vein originated at the apex of heart in 25 cases (80%) which was considerably higher than that reported by Ortale et.al, 1994[21] (27%). In one case (3.3%), the origin was at the junction of upper1/3rd and lower 2/3rd of AIS while the origin of GCV was absent in the upper1/3rd as reported by Ortale et.al,1994[21]. In three cases (10%), the origin was at the middle of AIS which was less as reported by [21](16%). In one case (3.3%), the origin of GCV was at the junction of upper 2/3rd and lower 1/3rd of AIS while Ortale.et.al,1994[21] reported 57% cases in which the origin of GCV was in the lower 1/3rd .

The heart is one of the sites in which arteriovenous anastomosis are common feature[21]. Connection between CS and RCA have been described at the crux of the heart. [21,53] . Hadziniselimovic & Secerov, D 1974 [33] observed a higher incidence (39%) and Pejkovic and Krajnc,2004 [34] (6%) of arteriovenous anastomosis. In the present study the AV anastomosis were present in36.6% cases. In four (13.3%) cases AV anastomosis existed between GCV and RCA; whereas similar frequency was observed between GCA and LCA. It is assumed that these anastomosis prevent coagulation of blood in small veins. In cases of arterial occlusion; myocardium can be supplied by retrograde vascularisation. Cardiologists who interpret imaging of the cardiac veins and cardiac surgeons who operate close to the GCV should be aware of such a variation. Venovenous anastomosis are seen at the apex, anterior and posterior aspects similar to other studies.[16,33] communication between GCV, MCV and PVLV have been observed in the present study(Fig.2).

There are not much variations seen in the MCV due to its short course before draining into the right atrium[31]. In the present study, the mean diameter of the MCV was calculated as 3.79±1.10 which was slightly greater than that observed by Ortale[21] (3.6±0.8). The MCV originated at the apex of heart (Fig.5) in 25 cases (80%) as compared to 73% reported by Ortale[21]. In one case (3.3%), the origin was at the junction of upper 1/3rd and lower 2/3rd of AIS while the origin of MCV was absent in the upper 1/3rd of PIS as reported by Ortale[21]. In three cases (10%), the origin was at the middle of AIS while Ortale[21] reported 5% cases in which the origin of MCV was in the middle 1/3rd of posterior interventricular sulcus. In one case (3.3%), the origin of MCV was at the junction of upper 2/3rd and lower 1/3rd of AIS while it was 22% reported by Ortale [21]in the PIS. The mean diameter of middle cardiac vein is greater than great cardiac vein thus its adequate size is useful for inserting a pacing lead [16].

Venovenous anastomosis are seen at the apex , anterior and posterior aspects similar to other studies.[16,33]. Superficial veno-venous anastomosis were observed in 13(42.9%) of hearts in the present study . Hadziselimovich & SecerovD, 1979 [33] observed such anastomosis in 49% hearts.

In the present study, the small cardiac vein was present in 60% cases while its presence was reported in 54% cases by Ortale[21] and 46% cases by Mochizuki[20]. The mean diameter of the SCV was calculated as 1.81±0.54 which was almost similar to that recorded by Ortale[21] (1.8±0.8). The SCV received the RMV in two cases (6.67%).

The PVLV was present in 100% cases. The mean diameter of PVLV was calculated as 2.84±0.97 which was slightly greater than that observed by Ortale[21] (2.4±1.1). In majority of cases, the range of diameter was calculated as 2.1 to 3.0mm while it was 3.0 to 4.0 mm as observed by Mozhizuki[22].

The OVLA was present in only 30% cases while Ortale[21] reported its presence in 43% cases. The mean diameter of OVLA was calculated as 1.0±0.41 which was absolutely same as that observed by Ortale[21].

The left marginal vein was present in 100% cases while Ortale[21] reported it in 97% cases. The mean diameter was calculated as 2.81±0.99 which was greater than that observed by Ortale [21](2.3±0.8).

The right marginal vein was present in 26 cases (86.7%) and Ortale[21] reported its presence in 92% cases. The mean diameter was calculated as 1.71±0.71 which was slightly less as recorded by Ortale[21] (1.8±0.6). The RMV opened directly into the RA in 11 cases (36.3%) while in 2 cases (6.67%), it joined the SCV. In the remaining cases, it was difficult to appreciate its termination. A study [24] has reported right marginal vein draining directly into the right atrium in 51% of cases.

Table 5 shows the number and diameter of the tributary veins of the coronary sinus, while Table 6 summarizes the origin of the anterior and posterior interventricular veins.

Table 4: Comparison of the frequency and diameter of the tributaries of the coronary sinus

Veins	Present study			Ortale et al (1994)[21]			Mochizuki (1933)[20]		
	Cases (30)	Percent age	Diameter (mm.)	Cases (37)	Percent age	Diameter (mm.)	Cases (160)	Percent age	Diameter (mm.)
GCV	30	100	1.8 – 4.8	37	100	1.2 – 6.3	160	100	3.0 – 7.0
MCV	30	100	2.0 – 6.0	37	100	2.1 – 5.3	160	100	2.0 – 8.0
SCV	18	60	1.0 – 3.0	20	54	0.5 – 3.3	74	46	-
PVLV	27	90	1.0 – 2.6	37	100	1.0 – 5.5	-	-	2.0 – 7.0
OVLA	9	30	0.4 – 1.6	16	43	0.4 – 1.8	-	-	-
LMV	30	100	1.0 – 5.0	36	97	0.8 – 4.5	42	26	-
RMV	26	86.7	0.8 – 3.8	34	92	0.5 – 2.9	33	21	-

Table 5: Origin of the great and middle cardiac veins

Origin of the Vein		Present Study		Ortale et al (1994)[21]		Mochizuki (1933)[20]	
		Cases (30)	Percentage	Cases (37)	Percentage	Cases (160)	Percentage
Origin of GCV in the AIS	Superior 1/3rd	1	3.3	-	-	2	1
	Middle 1/3rd	3	10	6	16	25	16
	Inferior 1/3rd	1	3.3	21	57	119	74
	Apex of heart	25	80	10	27	14	9
Origin of MCV in the AIS	Superior 1/3rd	1	3.3	-	-	-	-
	Middle 1/3rd	3	10	-	-	-	-
	Inferior 1/3rd	1	3.3	-	-	-	-
	Apex of heart	25	80	-	-	-	-
Origin of MCV in the PIS	Superior 1/3rd	-	-	-	-	2	1
	Middle 1/3rd	-	-	2	5	25	16
	Inferior 1/3rd	-	-	8	22	120	75
	Apex of heart	25	80	27	73	3	8

Muscle bridges play a role in sclerotic process since intimal hyperplasia of blood vessels is observed proximal to the muscle bridges. Presence of myocardial bridges results in misinterpretation of vessels in coronary angiographic studies.[35,36] Angiographic studies have demonstrated muscle bridges exclusively over anterior interventricular artery.[33] Whereas dissection study conducted by Reyman HC,2008[36] have demonstrated myocardial bridges both over anterior interventricular artery and great cardiac vein. In the present study muscle bridges were observed not only over anterior interventricular artery and great cardiac vein, but over coronary sinus and middle cardiac vein as well (Fig.4).

CONCLUSION

The length and diameter of coronary sinus is helpful in selecting devices of appropriate length for cannulation procedures to protect the ischemic myocardium by perfusion of coronary sinus. Myocardial bridges covering coronary sinus increase chance of development of cardiac arrhythmias. The study provides a baseline data which will be helpful in conventional and interventional studies.

ACKNOWLEDGEMENT

Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors/editors/publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

Conflict of interest: None

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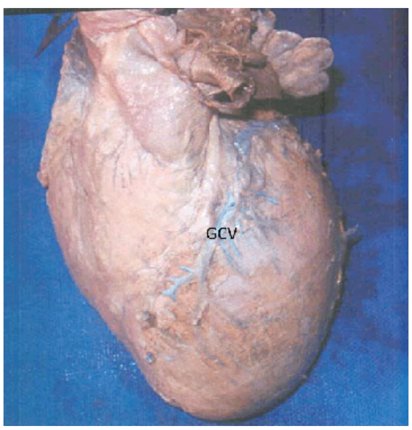

Figure 1: Great cardiac vein (GCV) originating at the middle of anterior interventricular sulcus.

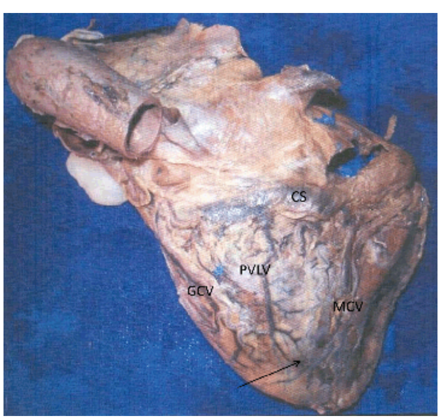

Figure 2: Coronary sinus (CS) is cylindrical in shape. Arrow showing veno-venous anastomosis between great cardiac vein (GCV) , Middle cardiac vein(MCV) and posterior vein of left ventricle(PVLV).

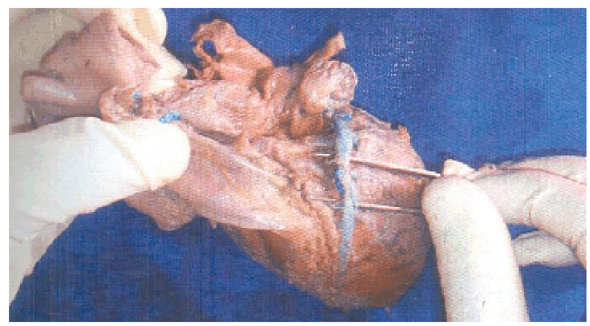

Figure 3: Arteriovenous anastomosis between GCV and anterior ventricular branch of left coronary artery.

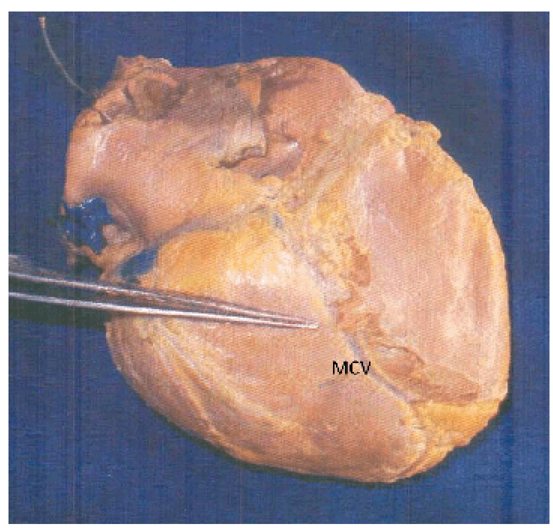

Figure 4: Muscle bridge covering middle of posterior interventricular septum.

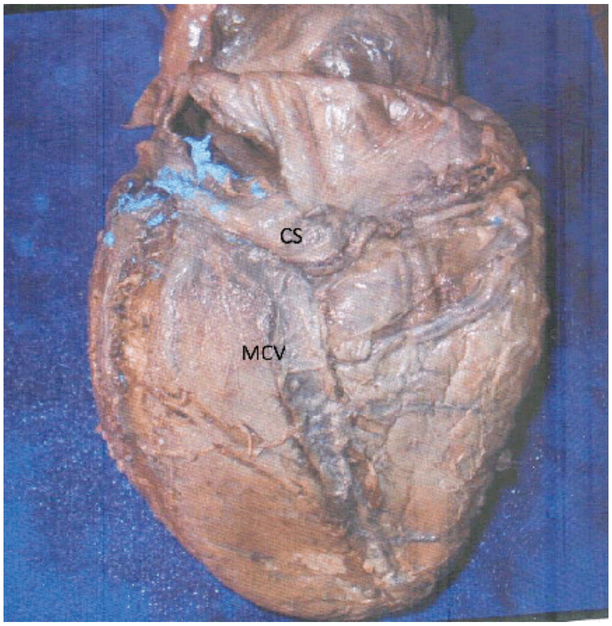

Figure 5: Middle cardiac vein (MCV) originating at the apex of the heart, receiving tributaries from right side.

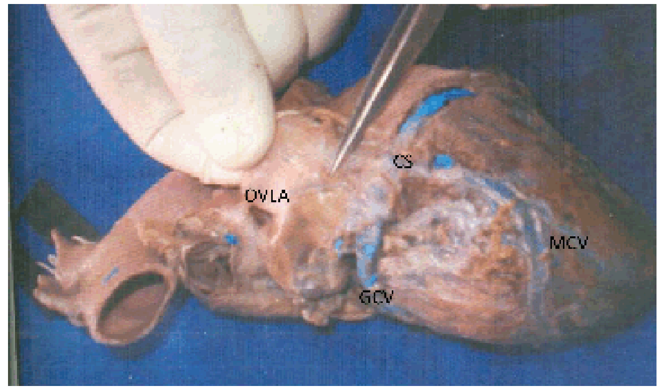

Figure 6: Oblique vein left atrium(OVLA) draining into coronary sinus(CS).