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Anatomy of valves of the coronary venous system and great cardiac vein: implications for interventional cardiology

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Abstract

***Background & Aims*:** The coronary venous system is an emerging field of interest for cardiologists with advancement of the electrophysiological procedures. Transcatheter coronary sinus interventional therapy is a promising method to treat coronary heart diseases. Thebesian valve (TV), Vieussens valve (Vv), and bend of the great cardiac vein (GCV) are commonly encountered obstacles in the passage of catheter. In this study, we aimed to evaluate the factors causing complications and obstruction to coronary venous catheterization.

***Materials & Methods*:** In this cross-sectional observational study, we examined 110 formalin-fixed cadaveric hearts. The height of TV, the transverse and craniocaudal diameter of coronary sinus ostium (CSO), length, diameter, and angle of bend of GCV were measured. The presence or absence of Vv was noted. The morphological characteristics of TV and the percentage of CSO coverage by TV were recorded.

***Results*:** The TV and Vv were observed in 91 (82.7%) and 59 (53.63%) specimens respectively. Remnant (8.2%), semilunar (52.1%), fold (10%), cord (3.6%), and fenestrated (8.2%) morphologies of TV were reported. In 16 (20.5%) hearts, Thebesian valve was covering more than 75% of CSO. Hearts with larger diameter of CSO presented smaller height of TV. The mean length and diameter of GCV were measured as 135.1 ± 31.6 mm and 4.31 ± 1.44 mm respectively. The mean angle of bend of GCV was calculated as 104.1 degrees. The acute angle was observed in 3.6% of specimens.

***Conclusion*:** Knowledge of the obstructive anatomical structures and their variations can be helpful in the optimization of a more suitable invasive technique for invasive cardiology.

***Keywords*:** Coronary sinus, Great cardiac vein, Thebesian valve, Vieussens valve

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Introduction

Coronary sinus (CS) and great cardiac vein (GCV) act as a potential conduit for various invasive cardiological procedures like mapping and ablation of atrioventricular accessory pathway, the retrograde perfusion of thrombolysis, the coronary sinus flow studies, retrograde cardioplegia and cardiac resynchronization therapy (1-3). Bypass coronary artery stenosis and delivery of stem cells to infarcted myocardium through the coronary venous system are still under investigation. A successful CS catheterization depends on the size of coronary sinus ostium (CSO) and the morphology of Thebesian valve (TV) (4). The acute bend of GCV and the Vieussens valve can also obstruct the cannulation of CS (5). Studies by previous researchers mentioned that CS cannulation is not successful in 5 – 10% of patients (6). The causes of failure of CS cannulation were attributed to failure to catheterize the CS in 3.7% of cases (7) and inability to locate CSO in 2.8% of cases (8). The TV is a major cause of obstruction to CS catheterization as it covers the CSO directly. Complications caused by misplacement of the catheter are observed as dissection and perforation of the CS or cardiac veins in about 1 – 3% of cases (8). Lesions of CS are fatal as these are very difficult to repair (9).

The coronary sinus is the main vein of heart which drains about 60% of venous blood from heart into the right atrium. The CSO is present in the right atrium between the opening of the inferior vena cava and the right atrioventricular aperture. The CSO is guarded by an endocardial fold known as Thebesian valve. The CS is considered as a continuation of GCV which is also the largest tributary of CS. Vieussens valve is an endocardial fold which is present at the termination of GCV or the commencement of CS. The GCV begins near the apex of heart in the anterior atrioventricular groove (10).

The present study aimed to report the incidence of different types of TV and their role in obstruction of CS cannulation. We also evaluated the Vieussens valve and great cardiac vein as impeding factors for CS cannulation. As the existing data on the TV morphology and factors impeding coronary sinus catheterization are limited, the data obtained in the present study would aid the vigilant approach for the invasive cardiological procedures

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Materials & Methods

In this cross-sectional observational study, we examined 110 formalin-fixed Indian cadaveric hearts of both sexes aged from 22–96 years. The study was conducted in the Department of Anatomy, Mahatma Gandhi Medical College, Jaipur. The approval of the Institutional Ethics Committee was obtained before the start of the study. The heart specimens were obtained from cadavers during routine dissection for undergraduate students. The intact heart specimens which were devoid of any decomposition and pathologies, were included in the study. The heart specimens with severe macroscopic pathologies or decomposition were excluded from the study. The wall of right atrium was incised along the sulcus terminalis and the specimen was thoroughly washed to remove any blood clots. The CS was opened longitudinally to observe the Vieussens valve.

The transverse and craniocaudal diameter of CSO and the height of TV were measured by using digital vernier callipers with an accuracy of 0.1mm. The height of TV was measured from its free margin to the attached margin as a single maximum measurement. The attachment site of TV at the margin of CSO was noted. The TV was observed for its morphological characteristics. The TV was classified as semilunar; projecting significantly into the lumen of CSO with a semilunar edge, remnant; small in size, fold; almost covering the complete CSO, cord; thick strand of endocardium and mesh; net-like (11). The height of TV and the percentage coverage of CSO were measured for remnant, semilunar, and fold type. On the basis of CSO coverage, TV was classified as covering less than 15% of CSO, from 15% to 75%, and more than 75% of the CSO. The TV covering >75% was considered as potentially complicating the CS catheterization (6). The length of GCV was measured with the help of a thread placed along the course of GCV from its origin to termination and it was straightened to measure the length. The diameter of GCV was measured at its termination into CS by using digital vernier callipers with 0.1mm precision. The angle of the bend of GCV was measured using a 360-degree goniometer. One prong of the goniometer was placed anteriorly along the course of the great cardiac vein in the anterior interventricular groove and the other prong was placed posteriorly along the course of the vein in the posterior atrioventricular groove. All the measurements were carried out by one investigator to avoid any observer bias.

The student t-test was used to evaluate the difference in the diameter of CSO with TV and without TV. A *P-value* of < 0.05 was considered statistically significant. Pearson's correlation coefficients were calculated to find the statistical dependence between the height of TV and the maximum diameter of coronary sinus ostium. The MS Excel and SPSS software were used for the tabulation and statistical analysis.

Results

The Thebesian valve was observed in 91 (82.7%) heart specimens with a variable morphology of remnant, semilunar, fold, cord, fenestrated type (Table 1, Figures 1 & 2), and also a double TV (Table 1, Figure 3). The semilunar shape (Figure 1B) was most commonly (52.7%) seen, and followed by fold (Figure 1C) (10%) type. One heart specimen was observed with the semilunar-shaped double Thebesian valve (Figure 3). Thebesian valve was absent in 19 (17.3%) heart specimens (Figure 4). The percentage coverage of the CSO by TV was calculated for type I – remnant, type II – semilunar, and type III – fold. The TV with a percentage coverage of more than 75% of CSO was observed in 16 (20.5%) hearts with one TV in this group covering more than 100% of CSO. The Vieussens valve (Figure 5) was present in 59 (53.63%) hearts.

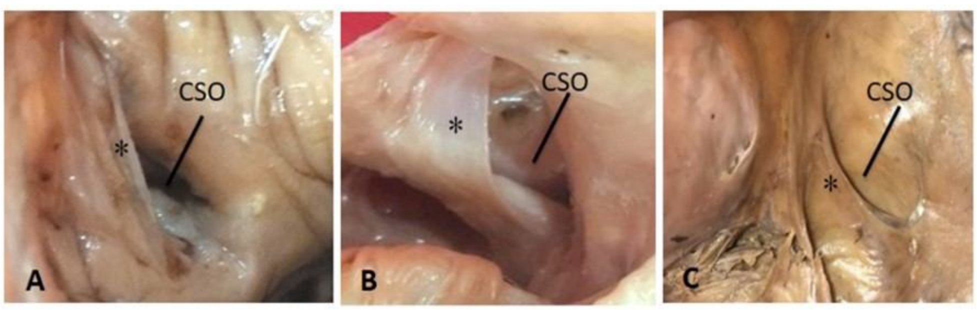

Fig. 1. Showing coronary sinus ostium (CSO) with types of Thebesian valve (*): A – Type I (remnant), B – Type II (semilunar), C – Type III (fold)

Fig. 2. Showing coronary sinus ostium (CSO) with types of Thebesian valve (*): D – Type IV (cord), E – Type V (fenestrated)

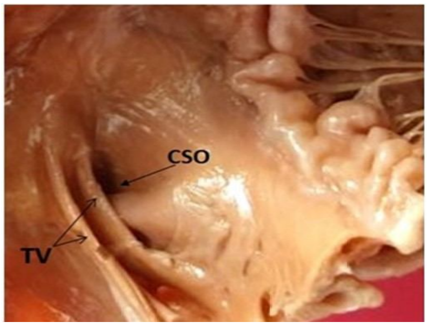

Fig. 3. Showing coronary sinus ostium (CSO) with double Thebesian valve (TV)

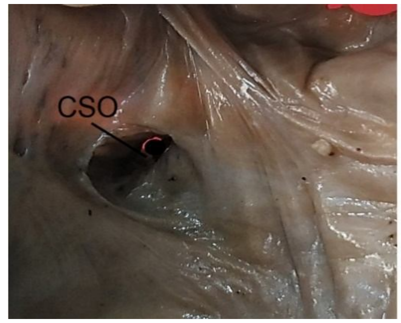

Fig. 4. Showing coronary sinus ostium (CSO) without Thebesian valve

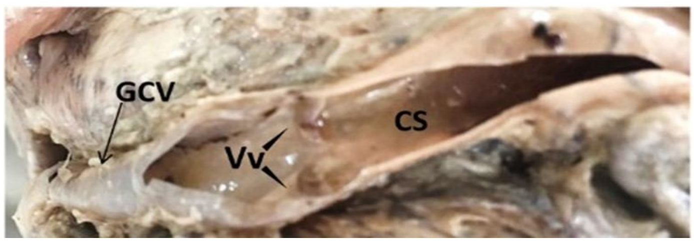

Fig. 5. Showing Vieussens valve (Vv) at the termination of great cardiac vein (GCV); coronary sinus (CS)

Table 1. Morphological features of Thebesian valve

Morphological feature		No. of specimens (n)	Percentage of specimens (%)
Valveless CSO		19	17.3%
Remnant		9	8.2%
Semilunar		58	52.7%
Fold		11	10%
Cord		4	3.6%
Mesh or fenestrated		9	8.2%
Double TV of semilunar type		1	0.9%
Percentage of the CSO coverage	< 15%	1	1.3%
	15 – 75%	61	78.2%
	> 75%	16	20.5%

CSO, coronary sinus ostium; TV, Thebesian valve

The Thebesian valve was attached to the right margin of CSO in the majority (89.09%) of cases, with some extension to the superior or inferior margins. No Thebesian valve was attached to the left margin of CSO. The TV was observed to be attached to the superior and inferior margin of CSO in 1 (0.9%) and 11 (10%) hearts respectively.

The mean height of TV was observed as 5.05 ± 2.36 mm with a range of 0.91 to 11.20 mm. The mean height was also calculated for TV types I, II, and III. The mean height was 4.9 ± 1.87 mm, 7.88 ± 2.37 mm, and 2.0 ± 0.72 mm for semilunar, fold, and remnant type of TV respectively. The average width of type IV – cord was measured as 0.75mm. There was a significant difference in the diameter of CSO with TV and CSO without TV. The transverse and craniocaudal diameters were significantly smaller in CSO with TV (7.95 ± 2.9 mm, 9.5 ± 3.9 mm, respectively) in comparison to the CSO without TV (9.85 ± 3.7 mm, 13.3 ± 4.4 mm, and p = 0.01, P < 0.001, respectively). The height of TV was inversely correlated with the maximum diameter of CSO (r = -0.25; P = 0.008). The student t-test and Pearson's correlation coefficients were used for the statistical analysis.

The great cardiac vein was present in all the specimens of heart. The mean length of GCV was measured as 135.1 ± 31.6 mm with a range of 71 to 209 mm. The mean diameter of GCV was measured at its termination in the coronary sinus, it was 4.31 ± 1.44 mm with a range of 2.1 to 9.1 mm. The angle of bend of GCV ranged from 83 to 126 degrees. The mean angle was calculated as 104.1 degrees.

Discussion

Coronary revascularization can relieve the symptoms of cardiovascular disease, but some patients suffering from multivessel disease have a variable anatomy of the coronary arterial system which is not acquiescent to revascularization (12). These patients can be treated by retrograde perfusion via CS. CS was used for the first time as a conduit to deliver arterial blood to ischemic myocardium by Pratt (13).

Most of the authors have concluded that 75% coverage of CSO by TV obstructs CS cannulation (6, 11, 14). In earlier studies, 2% to 24.7% of TV were reported as potentially complicating for catheterization (14-17). In the present study, such TV was observed in 16 (20.5%) heart specimens which were covering more than 75% of CSO. A previous study reported 16% of cases of large and obstructive valves covering ≥ 75% of CSO (18).

The present study reported TV in 91 (82.7%) hearts. Previous studies on TV reported 36-80% prevalence of TV (6, 11, 15, 17, 19). In another study by Anh DJ et al., TV was observed during the procedure of biventricular pacemaker implantation. The TV was present in 54% of patients. A TV covering >70% of CSO was seen in 6.8% of hearts. The lower prevalence of TV in the study by Anh DJ et al. could be caused due to the technological limitations to visualize TV with smaller dimensions (20).

There are different estimates to define an obstructive TV. Some authors believe that crescentic valve is optimal, semilunar valve is suboptimal, and band-shaped or fenestrated valve is worst for CS cannulation (14) whereas other authors stated that a non-fenestrated valve of a considerable size covering >75% of CSO may act as a potential obstruction (6). Another study also suggested that fenestrated TV may not hinder the passage of standard electrocardiologic catheters but can complicate the manipulations of catheters or act as an obstruction to a catheter with a larger diameter and additional equipment (11). The present study reported semilunar morphology as the most common (52.7%) type of TV which is comparable with a previous study (16). The incidence of cord type and fenestrated type were observed as 3.6% and 8.2% respectively which are close to the results of a cadaveric study of 52 hearts (14). In the present study, a semilunar-shaped double TV was observed in one heart specimen which is a very rare observation. The double TV was reported previously reported by Hellerstein et al. (17).

Vieussens valve is also reported as one of the obstacles to the passage of catheter. Vieussens valves were observed in 53.63% of cases which are closer to the incidence reported by Randhawa et al. (18). In an earlier study by Karaca et al. the Vieussens valve was found in 75% of hearts (14).

The diameter of CSO is also an important factor to be considered before the catheterization of CS. A study by Ghosh et al. (16) measured the diameter of CSO with and without TV. The average transverse and craniocaudal diameter of CSO with TV were 7.15 ± 1.5 mm and 9.4 ± 2.1 mm respectively. The average transverse and craniocaudal diameter of CSO without TV was observed as 9.6 ± 0.8 mm and 11.2 ± 1.4 mm, respectively. These findings are comparable to our study. The minimum dimensions of mean transverse and craniocaudal diameter were reported in a cadaveric study by Randhawa et al. who reported the average transverse and craniocaudal diameter of CSO with TV as 3.4 ± 1.1 mm and 5.7 ± 1.3 mm, respectively and in CSO without TV as 3.6 ± 0.8 mm and 5.9 ± 1.3 mm, respectively (18). In the present study, a strong correlation was observed between the diameter of CSO and the height of TV. Hearts without TV were observed to have a larger diameter of CSO in comparison to the hearts with TV. These observations are comparable with the results of the previous studies (11, 6). The average height of TV of the remnant, semilunar, and fold type was measured as 5.05 ± 2.36mm, and the mean width of the cord type was 0.75mm which resembles the study by Holda et al. (11). The correlation between the diameter of CSO and the height of TV can be explained by the effect of coronary blood flow on the valves of the venous system. An increased flow of blood in the CS leads to atrophy of all the venous valves with an increase in the diameter of CSO. The presence of persistent left superior vena cava also causes an increased flow of blood in the CS (21).

The study by Corcoran et al. (5) concluded that the acute bend in the GCV causes obstruction to the advancement of the catheter. They observed the acute bend in 56% of hearts in their study of 50 cadaveric hearts and also in 20% of cases of a study on 10 patients by the method of contrast venography. In the present study, only 3.6% of GCV were observed with acute bend. The difference in the results may be because of the different methods used in these two studies. The mean diameter of GCV in our study (4.31 ± 1.44 mm) was similar to that reported in another study (22).

Study Limitations and Future Perspectives

In the present study, we examined cadaveric hearts so all the measurements are regardless of the changes in dimension of TV and CSO in a cardiac cycle. The functional significance of different types of morphologies of TV can be variable in hearts in vivo. More statistically significant results may be obtained from a greater sample size. The anatomical study of the coronary venous system with the aid of multimodality imaging techniques can be more insightful.

Conclusion

In our study, we summarized the potential obstructions which can complicate the coronary sinus catheterization. Thebesian valve with greater percentage coverage, Vieussens valve, and the acute angle of the bend of the great cardiac vein may cause the failure of coronary sinus catheterization. The complications or failure of coronary sinus catheterization can be minimized with the knowledge of these impeding factors. Cognizance of the potential obstructions will help to select a suitable catheter and technique for invasive cardiological surgeries.

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Ethical statement

The ethical approval was obtained from the Institutional Ethics Committee with approval number MGMCH/IEC/JPR/2018/05. All the procedures in this study that involved cadavers followed the ethical standards of the Institutional Review Board and the Helsinki Declaration of 1975 and its later amendments or comparable ethical standards.

Data availability

None declared.

Conflict of interest

The authors declare that they have no conflict of interest.

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Author contributions

All authors reviewed the manuscript. Vandana Dave did protocol/project development and data acquisition. Vandana Dave, Manish Singh Ahuja, and Vandana Mehta did the data analysis. Vandana Dave and Samta Gaur designed and prepared the draft of the manuscript. Vandana Dave wrote and edited the manuscript. Vandana Dave, Vandana Mehta, Manish Singh Ahuja, and Samta Gaur did the critical revision of the manuscript. Vandana Dave, Samta Gaur, Manish Singh Ahuja, and Vandana Mehta approved the final version of the manuscript.

References

1. Gras D, Leclercq C, Tang AS, Bucknall C, Luttikhuis HO, Kirstein-Pedersen A. Cardiac resynchronization therapy in advanced heart failure the multicenter InSync clinical study. Eur J Heart Fail 2002;4(3):311-320. https://doi.org/10.1016/s1388-9842(02)00018-1
2. Molhoek SG, Bax JJ, Van Erven L, Bootsma M, Boersma E, Steendijk P, et al. Effectiveness of resynchronization therapy in patients with end-stage heart failure. Am J Cardiol 2002;90(4):379–383. https://doi.org/10.1016/s0002-9149(02)02493-1
3. Cazeau S, Leclercq C, Lavergne T, Walker S, Varma C, Linde C, et al. Effects of multisite biventricular pacing in patients with heart failure and intraventricular conduction delay. N Engl J Med 2001;344(12):873-880. https://doi.org/10.1056/NEJM200103223441202
4. Mlynarski R, Mlynarska A, Tendera M, Sosnowski M. Coronary sinus ostium: the key structure in the heart's anatomy from the electrophysiologist's point of view. Heart Vessels 2011;26(4):449–456. https://doi.org/10.1007/s00380-010-0075-3
5. Corcoran SJ, Lawrence C, McGuire MA. The valve of vieussens: an important cause of difficulty in advancing catheters into the cardiac veins. J Cardiovasc Electrophysiol 1999;10(6):804-808. https://doi.org/10.1111/j.1540-8167.1999.tb00260.x
6. Mak GS, Hill AJ, Moisiuc F, Krishnan SC. Variations in Thebesian valve anatomy and coronary sinus ostium: Implications for invasive electrophysiology procedures. Europace 2009;11(9):1188-1192. https://doi.org/10.1093/europace/eup179
7. Gras D, Mabo P, Tang T, Luttikuis O, Chatoor R, Pedersen AK, et al. Multisite pacing as a supplemental treatment of congestive heart failure: preliminary results of the Medtronic Inc. InSync Study. Pacing Clin Electrophysiol 1998;21(11 Pt 2):2249–55. https://doi.org/10.1111/j.1540-8159.1998.tb01162.x
8. Azizi M, Castel MA, Behrens S, Rödiger W, Nägele H. Experience with coronary sinus lead implantations for cardiac resynchronization therapy in 244 patients. Herzschrittmacherther Elektrophysiol 2006;17(1):13–18. https://doi.org/10.1007/s00399-006-0502-4
9. Noble S, Vilarino R, Muller H, Sunthorn H, Roffi M. Fatal coronary sinus and aortic erosions following percutaneous transvenous mitral annuloplasty device. EuroIntervention 2011;7(1):148–150. https://doi.org/10.4244/EIJV7I1A24
10. Standring S. Gray's Anatomy: The anatomical basis of clinical practice. 40th edn. Churchill Living Stone Elsevier, London 2008. P. 1797-1799.
11. Hołda MK, Klimek-Piotrowska W, Koziej M, Mazur M. Anatomical variations of the coronary sinus valve (Thebesian valve): implications for electrocardiological procedures. Europace 2015;17(6):921-927. https://doi.org/10.1093/europace/euu397
12. Williams B, Menon M, Satran D, Hayward D, Hodges JS, Burke MN, et al. Patients with coronary artery disease not amenable to traditional revascularization: prevalence and 3-year mortality. Catheter Cardiovasc Interv 2010;75(6):886–891. https://doi.org/10.1002/ccd.22431
13. Pratt FH. The nutrition of the heart through the vessels of Thebesius and the coronary veins. Am J Physiol 1898;1(1): 86-103. https://doi.org/10.1152/ajplegacy.1898.1.1.86
14. Karaca M, Bilge O, Dinckal MH, Ucerler H. The anatomic barriers in the coronary sinus: implications for clinical procedures. J Interv Card Electrophysiol 2005;14(2):89–94. https://doi.org/10.1007/s10840-005-4596-0
15. Christiaens L, Ardilouze P, Ragot S, Mergy J, Allal J. Prospective evaluation of the anatomy of the coronary

venous system using multidetector row computed tomography. Int J Cardiol 2008;126(2):204–208. https://doi.org/10.1016/j.ijcard.2007.03.128

16. Ghosh SK, Raheja S, Tuli A. Obstructive Thebesian valve: anatomical study and implications for invasive cardiologic procedures. Anat Sci Int 2013;89(2):85–94. https://doi.org/10.1007/s12565-013-0203-0
17. Hellerstein HK, Orbison JL. Anatomic variations of the orifice of the human coronary sinus. Circulation 1951;3(4):514–523. https://doi.org/10.1161/01.cir.3.4.514
18. Randhawa A, Saini A, Aggarwal A, Rohit MK, Sahni D. Variance in coronary venous anatomy: a critical determinant in optimal candidate selection for cardiac resynchronization therapy. Pacing Clin Electrophysiol 2013;36(1):94–102. https://doi.org/10.1111/pace.12026
19. Pejković B, Krajnc I, Anderhuber F, Kosutić D. Anatomical variations of the coronary sinus ostium area of the human heart. J Int Med Res 2008;36(2):314–321. https://doi.org/10.1177/147323000803600214
20. Anh DJ, Eversull CS, Chen HA, Mofrad P, Mourlas NJ, Mead RH, et al. Characterization of human coronary sinus valves by direct visualization during biventricular pacemaker implantation. Pacing Clin Electrophysiol 2008;31(1):78–82. https://doi.org/10.1111/j.1540-8159.2007.00928.x
21. Tyrak KW, Holda J, Holda MK, Koziej M, Piatek K, Klimek-Piotrowska W. Persistent left superior vana cava. Cardiovasc J. Afr 2017; 23;28(3):e1-e4. https://doi.org/10.5830/CVJA-2016-084
22. El-Maasarany S, Ferrett CG, Firth A, Sheppard M, Henein MY. The coronary sinus conduit function: anatomical study (relationship to adjacent structures). Europace 2005;7(5):475-481. https://doi.org/10.1016/j.eupc.2005.05.013