

Presence of the Vieussens valve on cardiac computed tomography

Rafał Młynarski^{1,2}, Agnieszka Młynarska^{1,3}, Maciej Sosnowski^{4,5}

¹ Department of Electrophysiology, Upper Silesian Medical Centre, Katowice, Poland

² Department of Electrophysiology and Heart Failure, School of Health Sciences, Medical University of Silesia, Katowice, Poland

³ Department of Gerontology and Geriatric Nursing, School of Health Sciences, Medical University of Silesia, Katowice, Poland

⁴ Unit of Noninvasive Cardiovascular Diagnostics, Upper Silesian Medical Centre, Katowice, Poland

⁵ 3rd Division of Cardiology, Medical University of Silesia, Katowice, Poland

KEY WORDS

computed tomography, coronary veins, vein of Marshall, Vieussens valve

ABSTRACT

BACKGROUND The Vieussens valve is a venous valve often found between the coronary sinus ostium and the great cardiac vein.

AIMS This study aimed to analyze the Vieussens valve in vivo using cardiac computed tomography (CT).

METHODS A total of 325 patients (120 women; mean [SD] age, 58 [11] years) were included into the study. Retrospective scanning using 64 slices of 0.5 mm in thickness was performed and multiplanar reformatted reconstructions and 3-dimensional volume renderings were used. As the Vieussens valve is difficult to find in standard reconstructions owing to its very small thickness, we decided to prepare and use indirect analyses in order to determine the presence of the valve. The basis for the analysis was the fact that even a very thin valve is an obstacle to the flow of the contrast agent in the same way as the much larger valves are.

RESULTS The Vieussens valve was present on CT in 141 of the 325 study patients (43.38%). No sex differences were found ($P = 0.83$): the valve was present in 88 of 205 men (42.92%) and in 53 of 120 women (44.17%). The mean (SD) distance between the Vieussens valve and the coronary sinus ostium was 38.89 (7.47) mm. We determined 3 types of the Vieussens valve: varicose, diminutive, and Marshall vein type.

CONCLUSIONS It is possible to visualize the Vieussens valve on CT. Due to the usually small size of the valve, the best way to find it is to analyze the distribution (density) of a contrast agent in the coronary sinus. Differentiating the proposed valve types can facilitate further analysis.

INTRODUCTION The Vieussens valve is a venous valve often found between the coronary sinus ostium and the great cardiac vein. Some authors have claimed that the presence of this valve is a formal, virtual marker of the time when the great cardiac vein transforms into the coronary sinus.^{1,2} It is usually composed of 1 to 3 leaflets and found in 80% to 90% of the human population.¹ If it is larger, its presence can obstruct catheters or leads during, eg, cardiac resynchronization therapy (CRT) in about 20% of patients.³ Cardiac resynchronization therapy is a type of invasive treatment for patients with advanced heart failure, which obtained the highest level of recommendation from both the European and American cardiology societies.⁴⁻⁶ In this method,

an additional left ventricular lead is implanted into one of the target veins via the coronary sinus. Those veins are preferably located in the left ventricular area. If the Vieussens valve is present, some complications may occur during cannulation of the coronary sinus. An example of the Vieussens valve seen on intraoperative fluoroscopy is presented in [FIGURE 1](#). Most of the analyses of the Vieussens valve have been conducted as part of postmortem studies. However, new diagnostic, imaging-based methods can support such analysis. In our opinion, as research has shown the possibility of coronary venous system imaging using cardiac computed tomography (CT) and only a few studies have been focused on the Vieussens valve, further research in this field is needed.⁷⁻¹⁰

Correspondence to:
Rafał Młynarski, MD, PhD,
Department of Electrophysiology,
Upper Silesian Medical Centre,
ul. Ziołowa 45/47,
40-635 Katowice, Poland,
phone: +48 32 202 40 25,
email: joker@mp.pl

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WHAT'S NEW?

In this article, we present a new method of imaging of the Vieussens valve using computed tomography, which is based on the distribution of a contrast agent in the coronary sinus. In addition, we suggest dividing the Vieussens valve variants into 3 types.

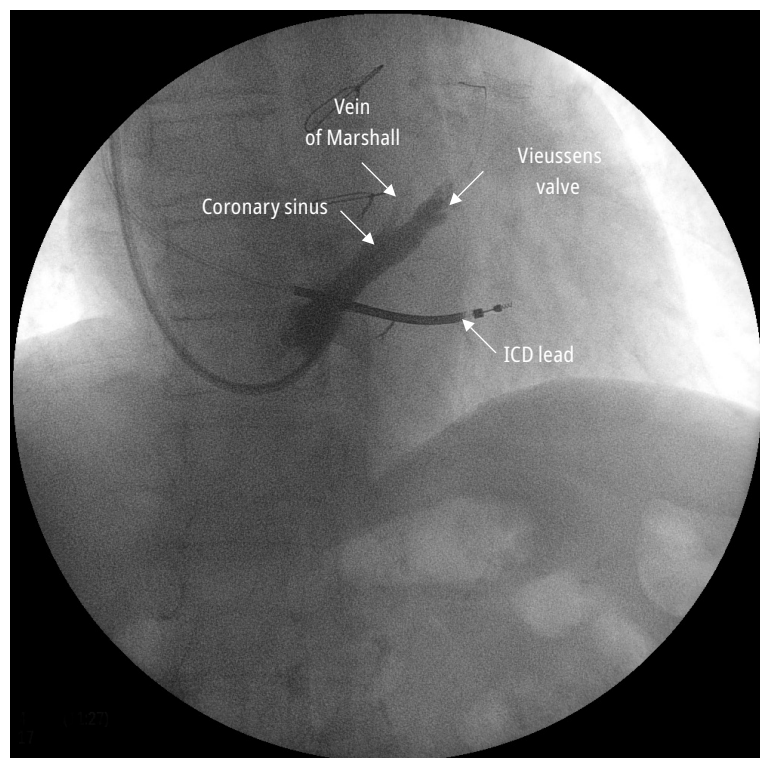


FIGURE 1 Intraoperative fluoroscopy during implantation of cardiac resynchronization therapy device in a patient with heart failure

Abbreviations: ICD, implantable cardioverter-defibrillator

METHODS A total of 332 consecutive patients who were eligible for cardiac CT were included into this retrospective study. In 7 patients, scans were excluded from the analysis because of poor quality, not acceptable for clinical evaluation. Finally, 325 patients (120 women; mean (SD) age, 58 [11] years) were included into this single-center study. Cardiac CT using the Aquilion 64 scanner (Toshiba, Hamamatsucho, Japan) was performed in all patients because of suspicion of coronary artery disease, which is a typical indication for cardiac CT.¹¹ The approval of the local bioethics committee was obtained. The study protocol conformed with the current Declaration of Helsinki. Patient consent was not required in this study.

Computed tomography protocol Scanning with retrospective electrocardiographic gating during a breath hold was performed using 64 slices of 0.5 mm in thickness. The standard protocol for imaging of the coronary arteries was applied. A retrospective analysis of the CT data in all phases of the cardiac cycle at a step of 10% was possible during postprocessing.

The optimal scanning parameters were always selected, the helical pitch was 12.8, and the rotation time was 0.4 s. Depending on the scanning range, the effective dose varied between 12 and 18 mSv. In each case, a nonionic contrast agent was administered. The required volume of the contrast medium was calculated for each individual, and the mean volume was around 80 to 100 ml. In patients in whom the heart rhythm was faster than 65 bpm, 5 to 10 mg of metoprolol succinate was administered intravenously unless contraindicated. When the expected heart rhythm was not achieved, the patient was excluded from the study. We evaluated the quality of imaging with a 5-point Likert scale: 5 points designated optimal image quality, 4 points—almost optimal quality, 3 points—average quality, 2 points—significant imaging difficulties, and 1 point—an image was unacceptable for clinical evaluation. Only scans that obtained a score of 5 to 3 points were accepted for further analysis.

Postprocessing of the imaging data The search for the Vieussens valve was performed using the Vitrea 2 workstations (Vital Images, Minnetonka, Minnesota, United States). Both multiplanar reformatted reconstructions and 3-dimensional volume renderings were used for analysis. As the Vieussens valve is very thin and it is difficult to visualize it on standard reconstructions, we decided to prepare and use indirect analyses to determine the presence of the valve. The indirect analysis was based on the fact that even a very thin valve obstructs the flow of a contrast agent in the same way as the much larger valves visible on CT do. Therefore, retention of a contrast agent in the theoretical site of the valve presence will prove its actual presence. We conducted an analysis of 2-dimensional multiplanar reformatted reconstructions and 3-dimensional volume rendered images to assess changes in contrast agent density in the coronary sinus, which enabled us to distinguish different types of the Vieussens valve. The analyses were performed independently by 2 experienced researchers. Differences in evaluation were resolved by consensus.

Statistical analysis The quantitative variables were analyzed by calculating mean (SD). The values of the quantitative variables in 2 study groups were compared using the *t* test (if the variable had normal distribution in these groups) or the Mann–Whitney test (otherwise). If more than 2 groups had been compared, the Kruskal–Wallis test was used. The reproducibility of the phase determination was evaluated using the Bland–Altman method and by calculating the interrater agreement κ coefficient. The normality of the variable distribution was determined using the Shapiro–Wilk test. A *P* value less than 0.05 was considered significant. The analyses were performed using the MedCalc (Ostend,

Belgium) and Statistica 13 (StatSoft, Tulsa, Oklahoma, United States) software.

RESULTS Basic hemodynamic characteristics of the study patients by the presence of the Vieussens valve are presented in **TABLE 1**. The Vieussens valve was found on CT in 141 of the 325 study patients (43.38%). In a sex-dependent analysis, we did not find any significant differences ($P = 0.83$) between sexes: the valve was present in 88 of 205 men (42.92%) and in 53 of 120 women (44.17%). The mean (SD) age of patients with the Vieussens valve

present was 57.5 (11.39) and was not lower than in the general population.

Most often, the valve was found during the systolic phases (R-R interval, 30%–40%)—it was optimally visualized in those phases in 39.41% of the study participants. The distribution of the optimal phases of Vieussens valve visualization is presented in **FIGURE 2**. The mean (SD) visualization quality based on the Likert scale was 3.76 (0.96), and, in most cases, the image was easy to analyze. The Vieussens valve was found at a mean (SD) distance of 39 (7) mm from the coronary sinus ostium.

We also performed inter- and intraobserver analyses. There was a very good agreement between the researchers in evaluating the presence of the Vieussens valve (95% CI, 0.9599–1; inter-rater agreement κ , 0.982). The results were similar in the repeated evaluation of the Vieussens valve by the same observer (95% CI, 0.9503–0.9993; κ , 0.975).

A precise analysis of the Vieussens valve on CT enabled us to determine 3 various types of the valve. Characteristics of the study patients by the Vieussens valve type are presented in **TABLE 2**.

The varicose type was defined as an abrupt widening of the coronary sinus, usually of less than 50%, at the site of the transition to the great cardiac vein on the lateral wall (**FIGURE 3**). This type was most often found in our study group, that is, in 76 patients (53.9%).

The diminutive type was regarded as a mild narrowing of the coronary sinus at the site of the transition to the great cardiac vein on the lateral wall, which was usually less than 20% of its diameter (**FIGURE 4**). This type was the second most common variant in our analysis, found in 53 patients (37.59%).

The Marshall vein type was the third form where the Vieussens valve was accompanied by the vein of Marshall. It was the most difficult type to identify, found in 12 of the study patients (8.51%) (**FIGURE 5**).

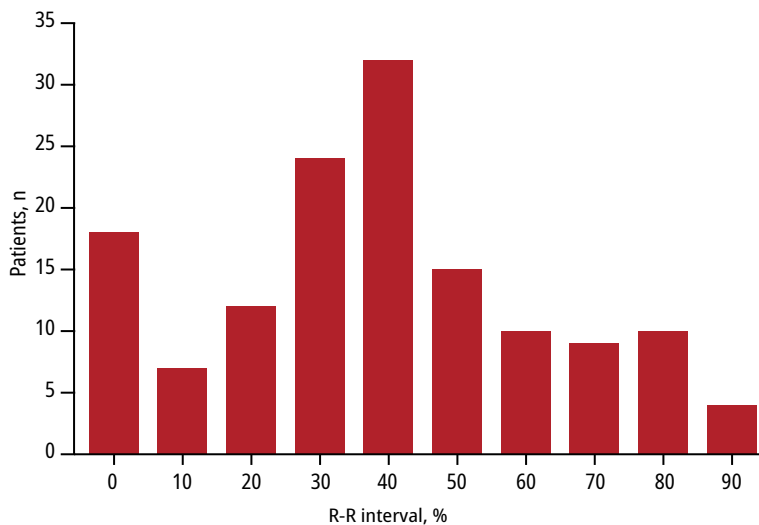


FIGURE 2 Distribution of the optimal phases of the R-R interval in the visualization of the Vieussens valve

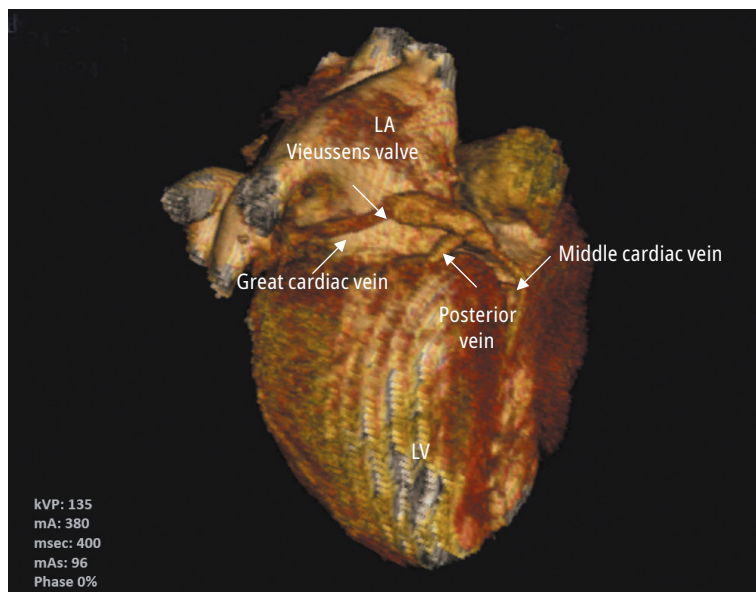


FIGURE 3 The varicose type of the Vieussens valve on cardiac computed tomography: an abrupt widening of the coronary sinus, usually less than 50% of the diameter, at the site of the transition to the great cardiac vein on the lateral wall
Abbreviations: LA, left atrium; LV, left ventricle

DISCUSSION For many years, cardiac CT has had its place in the analysis of the coronary venous system,¹² as it provides quite good image quality and is fully acceptable for clinical use.^{13,14} What is more, the most recent papers have documented the possibility of using 3-dimensional techniques to analyze the Thebesian valve in the ostium of the coronary sinus.^{15,16} However, there is lack of data on the possibility of visualizing the Vieussens valve using CT. Of note, the presence of the Vieussens valve may, in selected cases, cause problems with cannulation of the target cardiac veins during cardiac resynchronization.

The first question that should be answered is: how frequent is the occurrence of the Vieussens

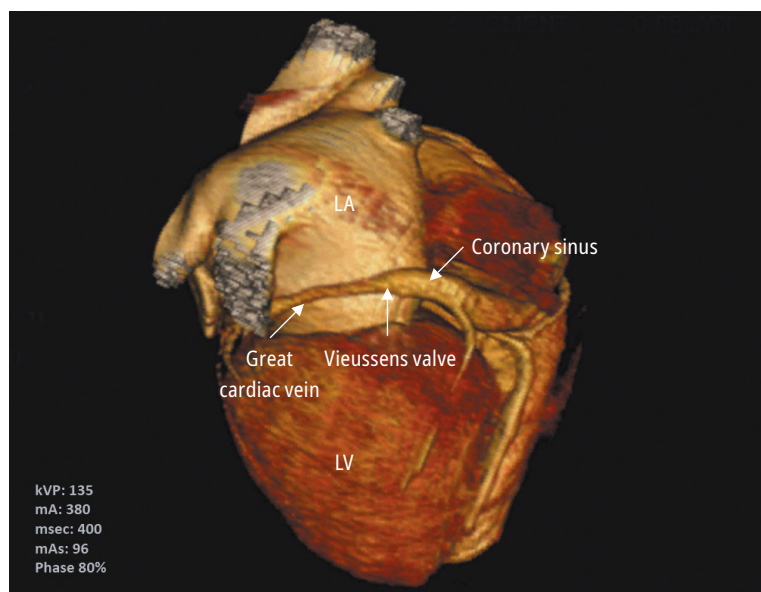


FIGURE 4 The diminutive type of the Vieussens valve on cardiac computed tomography: a slight narrowing of the coronary sinus, usually less than 20% of the diameter, at the site of the transition to the great cardiac vein on the lateral wall
Abbreviations: see **FIGURE 3**

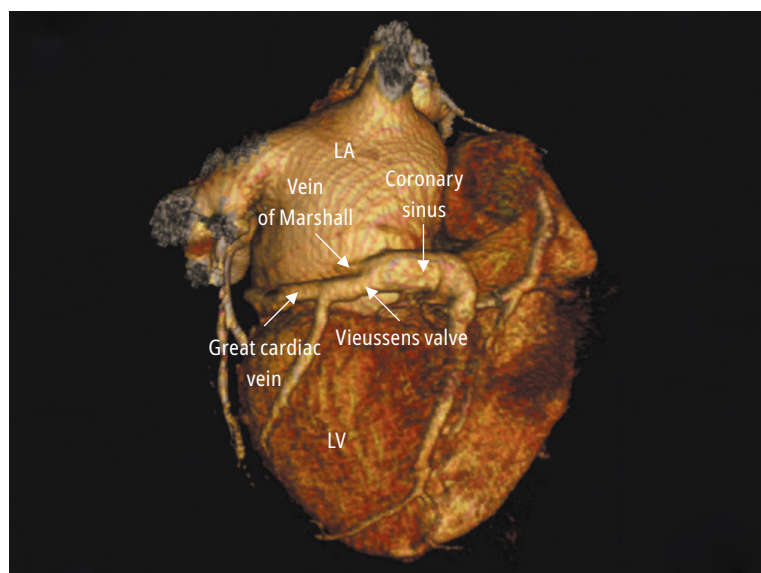


FIGURE 5 The Marshall vein type of the Vieussens valve, the most difficult one to recognize, where the valve is accompanied by the vein of Marshall
Abbreviations: see **FIGURE 3**

valve in the overall population? Looking at the available literature, the answer is equivocal. Most studies that attempted to find the answer were postmortem studies. Noheria et al¹⁷ examined 620 human hearts from consecutive autopsies: the Vieussens valve was found in 50 of 595 them (8%) and was classified as circumferential in 6 cases and as obstructive in a single case. A postmortem analysis by Randhawa et al¹⁸ was another interesting paper on the anatomy of the coronary sinus. The Vieussens valve was present in 60% of 50 typical, formalin-fixed, adult

cadaveric hearts. Similar results were obtained by Silver et al,¹⁹ who studied 50 human hearts in order to evaluate the functional anatomical features of the coronary sinus. The Vieussens valve was found in 59% of the hearts. Zawadzki et al¹ analyzed the morphology of the Vieussens valve, which was observed in 78% of the hearts. In that study, the types of the Vieussens valve were analyzed according to the number of leaflets: 36% of the valves had a single leaflet, 40% a double leaflet, and 2% a triple leaflet. The abovementioned postmortem studies have documented a similar range of presence of the Vieussens valve (8%–78%). The most interesting investigation concerning the Vieussens valve and invasive cardiology procedures was performed postmortem by Corcoran et al.² In 50 cadaveric hearts, a 7F catheter was introduced into the coronary sinus from the right atrium and, finally, into the great cardiac vein.² An obstruction of the catheter was caused by the Vieussens valve in 46% of the analyzed hearts. When the presence of the valve was confirmed, the obstruction was caused by an acute bend in the great cardiac vein area in 56% of the cases. The studies described above were based on postmortem analyses, and our study appears to be one of the first to analyze the Vieussens valve in vivo—we documented its presence in almost 44% of this relatively large study population of more than 300 patients. In this context, a study by Żabówka et al¹⁰ is of key importance. The authors performed a comparative analysis, in which they included 145 human autopsied hearts and 114 CT images. They found out that the valve identification rates were significantly lower when CT was used compared with postmortem tests (18.4% vs 62.1%). In our study, we found a more frequent occurrence of the Vieussens valve on CT than that determined by Żabówka et al.¹⁰ This could be explained by different analysis methods used in both studies, ie, direct and indirect methods. Although we did not look at the CT image of the valve itself, which sometimes is very small and below the resolution of modern CT scanners, we performed a contrast agent analysis in the targeted anatomical area. The Vieussens valve was also examined on cardiac CT by Saremi et al.²⁰ In that study, the valve was found in 51% of patients, at a distance of 30 mm from the coronary sinus ostium. In our study, the valve was found in almost 44% of cases and at a distance of 38.9 mm from the coronary sinus ostium. In our opinion, these results are similar and can confirm the value of cardiac CT in Vieussens valve visualization. The differences may result from the study group size (325 patients in our study versus 65 patients in the study by Saremi et al²⁰) and the methodology used. Those divergences do not affect the overall message of the studies.

The second question is: does the presence of the Vieussens valve have practical implications

TABLE 1 Basic hemodynamic characteristics of the study patients by the presence of the Vieussens valve

Parameter	Vieussens valve present	Vieussens valve absent	P value
Ejection fraction, %	61.78 (9.67)	59.68 (12.79)	0.11
End-diastolic volume, ml	146.81 (42.18)	148.76 (52.51)	0.73
End-systolic volume, ml	56.83 (29.31)	61.45 (43)	0.31
Stroke volume, ml	88.93 (19.81)	85.42 (20.43)	0.18
Cardiac output, l/min	5.36 (1.39)	5.23 (1.67)	0.48

Data are presented as mean (SD).

TABLE 2 Characteristics of the study patients by the Vieussens valve type

Characteristic	Marshall vein type	Varicose type	Diminutive type	P value
Age, y	61 (9)	57 (15)	58 (11)	0.43
Female sex, %	50	38.16	33.96	0.96
Distance from the coronary sinus, mm	39 (8)	40 (8)	38 (6)	0.27
Quality of visualization, points	4.17 (0.94)	3.93 (0.89)	3.41 (0.95)	0.003
Ejection fraction, %	62.17 (14.42)	62.16 (8.85)	61.16 (9.69)	0.69
End-diastolic volume, ml	143.91 (53.99)	114.91 (36.75)	150.44 (47.35)	0.69
End-systolic volume, ml	59.45 (47.59)	55.80 (26.56)	57.78 (28.2)	0.65
Stroke volume, ml	87.62 (19.89)	89.41 (19.07)	88.42 (21.52)	0.93
Cardiac output, l/min	5.77 (1.63)	5.35 (1.13)	5.29 (1.69)	0.63

Data are presented as mean (SD).

during implantation? The answer to this question was provided in a case report by Bernhard Strohmer,³ who documented the case of an 80-year-old patient who was considered for an upgrade from a DDDR system to CRT. The author observed that the contrast agent stopped in the proximal coronary sinus that drained into the large vein of Marshall. We also noted such an effect using standard fluoroscopy (FIGURE 1). An early analysis of fluoroscopy images by Strohmer et al³ showed an atypical coronary sinus course that was unfavorable for left ventricular lead placement. The Vieussens valve was identified and the placement of the lead into the great cardiac vein was achieved using a hydrophilic guidewire in order to avoid coronary sinus dissection. Finally, the coronary sinus was cannulated and the procedure was successful. This single report proves that the Vieussens valve can be an obstacle for left ventricular lead placement during CRT device implantation. Identifying this anatomical structure prior to a procedure can facilitate the intervention, as an operator will be better prepared for it.

However, performing CT just before CRT device implantation is not the target, as it causes patient exposure to a significant dose of radiation and an iodine-based contrast agent. It seems that re-analyzing previous raw digital imaging and communication in medicine data, if

available, to determine if the Vieussens valve is present, can be useful and relevant from the clinical point of view.

The key limitation of our study was the difficulty in differentiating the Vieussens valve from a variant of the great vein with the outgoing vein of Marshall. In our opinion, the identification of patients with a variant of the Marshall vein is crucial, because accidental implantation of a left ventricular electrode into the vein of Marshall can be dangerous for the patient. It is also very difficult to differentiate the Thebesian valve, often found in the coronary sinus ostium, from the Vieussens valve, which should be localized in the lateral wall. In our previous analyses, we have never observed a case in which both valves were visible together and, therefore, differentiation was based on the anatomical borders and the individual decision of the researcher; of note, these are no strict borders. Our study presented only a hypothesis, as there is no gold standard in the evaluation of the Vieussens valve. Results from our study are only an attempt to find the valve. It is not possible to fully confirm the hypothesis clinically. Those results were not compared with fluoroscopic images, so we only emphasize that 2 independent observers identified “some phenomenon,” which can be regarded as the Vieussens valve. Computed tomography remains

a diagnostic tool that, due to its excellent image parameters, seems to be the number one examination in imaging of the cardiac venous system. Of course, it should be noted that CT uses potentially harmful radiation and iodine-based contrast agents, which may cause specific adverse effects. Using different cardiac-cycle phases for evaluation of the Vieussens valve may be a source of variability. Due to its size, the Vieussens valve should be recorded and analyzed only by a very experienced team. What is more, retrospective scanning should be used, as it allows for the analysis of the heart in various functional phases.

Conclusions Our study showed that it is possible to visualize the Vieussens valve on cardiac CT. Due to the usually small size of the valve, the best way to find it is to analyze the distribution pattern of a contrast agent in the coronary sinus. Differentiating the valve type can further facilitate the analysis.

ARTICLE INFORMATION

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CONFLICT OF INTEREST None declared.

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