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ELECTROPHYSIOLOGY

Feasibility and safety of left atrial access for ablation of atrial fibrillation in patients with persistent left superior vena cava

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Abstract

Background: In patients with persistent left superior vena cava (PLSVC) ablation procedures can be challenging. We sought to determine the feasibility and safety of left atrial ablations in patients with PLSVC, especially when PLSVC is unknown prior to the ablation procedure.

Methods and results: In this retrospective analysis 15 adult patients (mean age 64.6 ± 14.5 years, 53.3% male) with PLSVC undergoing 27 ablation procedures for atrial fibrillation or left atrial flutter were included. In 5 (33.3%) patients PLSVC was only discovered during the procedure. Transseptal puncture (TSP) was declared "difficult" by the ablating physician in 13 of 27 (48.2%) procedures and was not successfully completed in the first attempt in two patients with known PLSVC. Once TSP was successfully completed, all relevant structures were reached both during mapping and ablation in all procedures independent of whether PLSVC was known prior to the procedure. One major complication (3.7%) occurred in 27 procedures in a patient with known PLSVC. In the patients with unknown PLSVC no complication occurred.

Conclusion: In experienced hands, left atrial access and ablation in patients with PLSVC is feasible and safe, particularly with regard to patients in whom the PLSVC is unknown prior to the ablation procedure.

KEYWORDS
ablation, feasibility, left atrium, persistent left superior vena cava, safety, transseptal puncture

1 | BACKGROUND

The ablation of left atrial arrhythmias, mostly atrial fibrillation and left atrial flutter, is recommended in symptomatic patients and the procedure is performed in increasing numbers and in many countries worldwide.[1,2] Commonly, isolation of the pulmonary veins is performed as a first step in patients with atrial fibrillation. In other rhythm entities like left atrial flutter, other additional appropriate ablation modalities (e.g., lines, localized ablation, etc.) may be performed.[1] In recent years, a persistent left superior vena cava (PLSVC) was described as a source of atrial fibrillation and hence gained importance as an ablation site.[3–5] The PLSVC is a rare anatomic entity which can cause trouble in ablation procedures due to deviating anatomical

Abbreviations: CFAE, complex fractionated atrial electrograms; CT, computertomography; CS, coronary sinus; ICE, intracardiac echography; LAA, left atrial appendage; LAO, left anterior oblique; PFO, persistent foramen ovale; PLSVC, persistent left superior vena cava; PVI, pulmonary vein isolation; TEE, transesophageal echocardiography; TSP, transseptal puncture conditions, especially if the specific anatomy is unknown prior to the ablation procedure. Often a PLSVC is associated with other congenital heart defects.[6] It occurs when the left common cardinal vein (vena cardinalis communis sinistra) does not obliterate during embryonic development. Usually, it drains via the coronary sinus, which then is commonly enlarged, into the right atrium. However, diverse anatomic variations occur.[7,8] In the rare case of coronary sinus atresia, the PLSVC drains retrogradely via innominate vein and superior right vena cava into the right atrium.[9]

1.1 | Aim of the study

This study sought to assess the feasibility and safety of left atrial ablations in patients with PLSVC, especially when the deviation from normal anatomy is unknown prior to the ablation procedure.

2 | METHODS

This monocentric retrospective analysis included patients with PLSVC who underwent a catheter ablation in the left atrium between January 2006 and December 2018 at our institution. Patients with complex congenital heart disease and patients undergoing other than left atrial ablations were excluded from the analysis. All performed ablation procedures in patients with PLSVC were included in the analysis. In the case of repetitive ablation procedures of left sided arrhythmias in the same patient within the study period, the first ablation procedure was defined as index procedure. Previous ablation procedures which were performed prior to the study period or at other institutions were defined as such and are incorporated in the baseline characteristics. The study protocol was approved by the ethics committee of the Technische Universität München, Munich, as the leading ethics committee for the German Heart Center Munich.

2.1 | Assessment prior to ablation

At our institution patients undergo transesophageal echocardiography (TEE) or a computertomography (CT) scan of the heart to exclude left atrial thrombi one day before the ablation procedure is scheduled. The equality of TEE and CT in the exclusion of left atrial thrombus was shown earlier by our study group.[10] Oral medication and especially oral anticoagulation are not interrupted prior to the ablation procedure.

2.2 | Ablation procedure

Ablation procedures in the left atrium are generally performed under conscious sedation and with support of a 3D-Mapping system at our institution. The manufacturer of the 3D-Mapping system is chosen by the ablating physician (NavX Ensite, Abbott Vascular; CARTO 3, Biosense Webster; Rhythmia, Boston Scientific). Intracardiac electrograms are recorded on the BARD recording system (Boston Scientific Corporation). In general, the workflow is the following: after placement of a decapolar coronary sinus catheter, fluoroscopy guided and pressure guided transseptal puncture (TSP) is performed using a steerable transseptal sheath (Agilis Abbott). Only one TSP is used to position the ablation catheter and the steerables heath, which is subsequently used to guide the mapping catheter, in the left atrium. After successful TSP, heparin is administered, targeting a value of 300s activated clotting time. Depending on the underlying arrhythmia, a voltage map and/or a map of complex fractionated atrial electrograms (CFAE) and/or an activation map of the left atrium and, if the ablation location, of the right atrium and coronary sinus is routinely performed at the beginning of every procedure using a multipolar catheter (Lasso Nav eco, Biosense Webster Inc.; Orbiter PV, Boston Scientific Corporation; Intellamap Orion, Boston Scientific Corporation; Advisor HD Grid, Abbott). Low voltage areas in the atria are defined as atrial signal amplitude below 0.1 mV and notated by the operating physician on the basis of the 3D voltage map. Cycle length is measured in the left atrial appendage prior to ablation. For radiofrequency ablation a 4 mm irrigated tip catheter is used. Energies between 25 and 40 Watts, depending on the anatomical site and the performing physician, are applied to the atrial myocardium. Depending on the atrial arrhythmia circumferential pulmonary vein isolation (PVI), the ablation of CFAE, the deployment of atrial lines or punctual ablation is performed to terminate the arrhythmia. If the arrhythmia cannot be terminated by ablation, an external cardioversion is performed. The quality of the ablation is proven at the end of the ablation procedure (i.e., thorough isolation of pulmonary veins in sinus rhythm and after adenosine administration, bidirectional blockage of lines etc.) and the procedure is terminated.

2.3 | Ablation in PLSVC and coronary sinus

The necessity of an ablation in the coronary sinus or in the PLSVC is defined by the ablating physician and depends on the underlying arrhythmia. Prior to the ablation, 3D maps displaying atrial electrograms and voltage parameters of these structures are regularly elaborated as mentioned above, using a multipolar catheter as far as possible. During radiofrequency ablation within the coronary sinus and PLSVC energies from 20 to 30 watts are usually administered at our institution.

2.4 | Supportive methods/assistive technology

In the case of difficulties in the placement of catheters or in the performance of TSP due to deviations from the normal anatomy, the following supportive methods are available at our institution: angiography of the relevant anatomical structures, intraprocedural transesophageal (TEE) or intracardiac echography (ICE) and overlay of CT-derived and segmented individual anatomy onto fluoroscopy as published earlier in detail.[11]

3 | STATISTICS

Data analysis was performed using the software package IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, NY, USA).

TABLE 1 Patient characteristics

Patientcharacteristics ($n = 15$ patients)	
Age [years], mean ± STD	64.6 ± 14.5
Male *n* (%)	8 (53.3)
BMI [kg/m^2], mean ± STD	25.9 ± 4.0
LV-EF [%], median (min – max)	59.0 (50–68)
Area of the left atrium [cm^2], mean ± STD	25.3 ± 6.1
Prior Ablation Procedures	
No Procedure *n* (%)	12 (80.0)
1 Procedure *n* (%)	0 (0.0)
2 Procedures *n* (%)	2 (13.3)
≥3 Procedures *n* (%)	1 (6.7)
Concomitant diseases	
Arterial hypertension *n* (%)	11 (73.3)
Diabetes mellitus *n* (%)	1 (6.7)
Hyperlipidemia *n* (%)	5 (33.3)
Renal insufficiency *n* (%)	1 (6.7)
Ischemic cardiomyopathy *n* (%)	1 (6.7)
Mitral valve insufficiency *n* (%)	7 (46.7)
Tricuspid valve insufficiency *n* (%)	2 (13.3)
Antiarrhythmic drugs class I *n* (%)	1 (6.7)
Antiarrhythmic drugs class II *n* (%)	14 (93.3)
Antiarrhythmic drugs class III *n* (%)	1 (6.7)
Antiarrhythmic drugs class IV *n* (%)	0 (0.0)
Glycosides *n* (%)	2 (13.3)

Means and standard deviations or medians and ranges (minimum to maximum) are shown for quantitative measures. Absolute and relative frequencies are displayed for categorical outcomes.

4 | RESULTS

Between January 2006 and December 2018 a total number of 31 adult patients with PLSVC were referred to our center for ablation. Patients with complex congenital heart disease and patients experiencing other than left atrial procedures were excluded from the study. The remaining 15 patients with PLSVC underwent in total 27 left atrial ablations (mean ± STD 1.8 ± 0.75 left atrial ablations) and were included in the study. The baseline patient characteristics are shown in Table 1.

4.1 | Anatomy

In 5 of 15 (33.3%) patients PLSVC was unknown prior to the index ablation procedure and was only discovered during the procedure. Three of the patients with primarily unknown PLSVC additionally featured a coronary sinus atresia (60% of patients with unknown PLSVC and 20% of the overall study population). In these three patients with ostium atresia, the inability to position the coronary sinus catheter at the beginning of the procedure lead to the suspicion and finally the diagnosis of PLSVC which was confirmed by angiography and 3D mapping. In the two other patients with primarily unknown PLSVC, the anatomic variation was suspected during ablation in the coronary sinus and diagnosed by angiography and 3D mapping. In two of 15 patients (13.3%) a persistent foramen ovale (PFO) was discovered during the procedure. In three other patients (20%) PLSVC came along with a lacking right superior vena cava. An overview of the anatomic and specific procedural data is shown in Table 2.

4.2 | Ablation procedure

In the index procedure, ablation was performed for persistent atrial fibrillation in nine patients (60%) and for paroxysmal atrial fibrillation in six patients (40%). Within this index procedure PVI was done in 14 patients (93.3%; PVI was done previously in another hospital in the remaining patient), the ablation of CFAE was performed in nine patients (100% of patients with persistent atrial fibrillation and 60% of the overall study population) and the application of lines was necessary in three patients (20%, $n = 2$ cavotricuspid isthmus lines, $n = 1$ anterior line and roof line in the left atrium). Ablation in the PLSVC was performed in six patients (40%, in four patients with persistent atrial fibrillation and two patients with paroxysmal atrial fibrillation) within the index procedure and in 13 of 27 (48.1%) left atrial ablation procedures in total. A second ablation procedure was necessary in nine patients (60%, five patients with persistent atrial fibrillation and four patients with paroxysmal atrial fibrillation) and a third procedure was necessary in three patients (20%, all patients with persistent atrial fibrillation). Within the second and third ablation procedure, the application of lines ($n = 3$ roof lines, $n = 2$ anterior lines, $n = 1$ mitral isthmus lines, $n = 2$ cavotricuspid isthmus lines) was performed in three patients due to macroreentrant atrial flutter. All 27 left atrial ablation procedures were supported by a 3D mapping system ($n = 17$ NAVX [Abbott], $n = 8$ CARTO [Biosense Webster], $n = 2$ Rhythmia [Boston Scientific]).

Once TSP was successfully completed, all relevant structures were reached both during mapping and during ablation in all patients and procedures, independent of whether PLSVC was known prior to the procedure. In one patient with known PLSVC and distinct venous kinking, the maneuverability of the catheters in the left atrium was described as “difficult”; nevertheless the intended isolation of the pulmonary veins was successfully completed. In one patient with unknown PLSVC and perimitral flutter, the conduction block of the mitral isthmus could only be reached in a unidirectional fashion after linear endo- and epicardial ablation including ablation inside the PLSVC. A bidirectional conduction block was finally achieved in a reablation procedure. In the three patients with coronary sinus atresia the mapping and ablation of the PLSVC and the coronary sinus was performed via a retrograde access (see Figure 1). In these patients, the multipolar coronary sinus catheter was used as mapping catheter. An overview of the procedural data of the index ablation procedure is demonstrated in Table 3.

TABLE 2 Overview of the anatomic and specific procedural data of the index procedure

PLSVC	Additional anatomical data	Arrhythmia	Number of procedures	TSP "difficult"	Complication	Supportive measures	
1	PLSVC (known)	PFO	Persistent AF	3	No	No	
2	PLSVC (known)		Paroxysmal AF	2	Yes (Giant CS Ostium)	No	W
3	PLSVC (known)		Persistent AF	2	Yes (Giant CS Ostium)	No	A
4	PLSVC (known)		Paroxysmal AF	2	Yes (Anatomy Deviation)	No	
5	PLSVC (known)		Paroxysmal AF	2	No	No	
6	PLSVC (known)		Paroxysmal AF	1	No	No	
7	PLSVC (known)		Persistent AF	1	Yes (Venous Kinking)	No	
8	PLSVC (known)	Lacking right SVC	Paroxysmal AF	1	Yes (Lacking right SVC)	No	A
9	PLSVC (known)	Lacking right SVC	Paroxysmal AF	2	Yes (Lacking right SVC)	Yes	A, M, O, W
10	PLSVC (known)	Lacking right SVC	Persistent AF	2	Yes (Lacking right SVC)	No	A
11	PLSVC (unknown)		Persistent AF	1	No	No	A, W
12	PLSVC (unknown)		Persistent AF	3	No	No	A
13	PLSVC (unknown)	CS ostium atresia	Persistent AF	1	No	No	A, M
14	PLSVC (unknown)	CS ostium atresia, PFO	Persistent AF	3	(No) Access via PFO	No	A
15	PLSVC (unknown)	CS ostium atresia	Persistent AF	1	Yes (Anatomy Deviation)	No	A, W

Abbreviations; A, angiography of relevant anatomic structures; M, 3D mapping of the right atrial anatomy prior to TSP; O,overlay of the individual CT derived anatomy onto fluoroscopy; W, guidewire to mark the aortic root.

4.3 | Feasibility of catheter placement and performance of transseptal puncture

All required mapping catheters as well as ablation catheters and the transseptal sheath were inserted from the right common femoral vein during all procedures and then positioned in the atria or coronary sinus according to their purpose. Coronary sinus was easily accessible for catheter placement in all procedures except for the three patients with coronary sinus atresia. In these patients, the coronary sinus catheter was placed retrogradely via right vena cava superior, innominate vein and PLSVC into the coronary sinus as described above (see Figure 2). TSP was classified as "difficult" by the ablating physician in 13 of 27 (48.2%) left atrial procedures. The reasons for difficult TSP were giant coronary sinus ostium ($n = 4$), lacking right vena cava superior ($n = 5$), general deviation from "normal" anatomy ($n = 3$), and kinking of the vena cava inferior disabling easy movement of the transseptal sheath ($n = 1$). In all patients who underwent one or more repeat procedures, the level of difficulty of the TSP was described by the ablating physicians as equal to that of the index procedure. In one patient transseptal access was reached via PFO during three procedures and left atrial access via PFO was described as "easy." To determine the correct position of the transseptal sheath at the favored septal location prior to TSP, an additional catheter or wire was placed in the aortic root in six of 27 procedures (22.2%) (see Figure 3). Angiography of relevant anatomical structures was performed before a 3D map was made in 12 of 27 procedures (44.4%) (see Figures 2, 4, and 5). A 3D map to guide the TSP was elaborated in four procedures in three patients (known PLSVC $n = 2$, unknown PLSVC $n = 1$), two of these presenting with a lacking right superior vena cava. In both of these patients with lacking right superior vena cava, TSP was not successful during the index procedure due to severe deviation from normal anatomy. In one of these patients a major complication occurred (for details please see chapter major complications). In both patients, the index procedures were stopped and the TSP was successfully completed in a second attempt some days later with support of a wire marking the aortic root, angiography of relevant structures, a 3D mapping of the right atrial anatomy and overlay of prior segmented anatomy from a CT scan with the actual fluoroscopy.

In the five patients with prior unknown PLSVC (number of procedures = 9), one TSP during the index procedure was classified as "difficult" due to deviation from "normal" anatomy (11.1%). Additional catheters or wires to mark the aortic root prior to TSP were placed in two of nine procedures (22.2%). An angiography of the anatomy was performed in all patients with unknown PLSVC during the index procedure. A 3D map of the right atrial anatomy prior to TSP was elaborated in one patient with unknown PLSVC and coronary sinus atresia. The support of an overlay of the individual CT derived anatomy onto fluoroscopy was not utilized in any patient with unknown PLSVC.

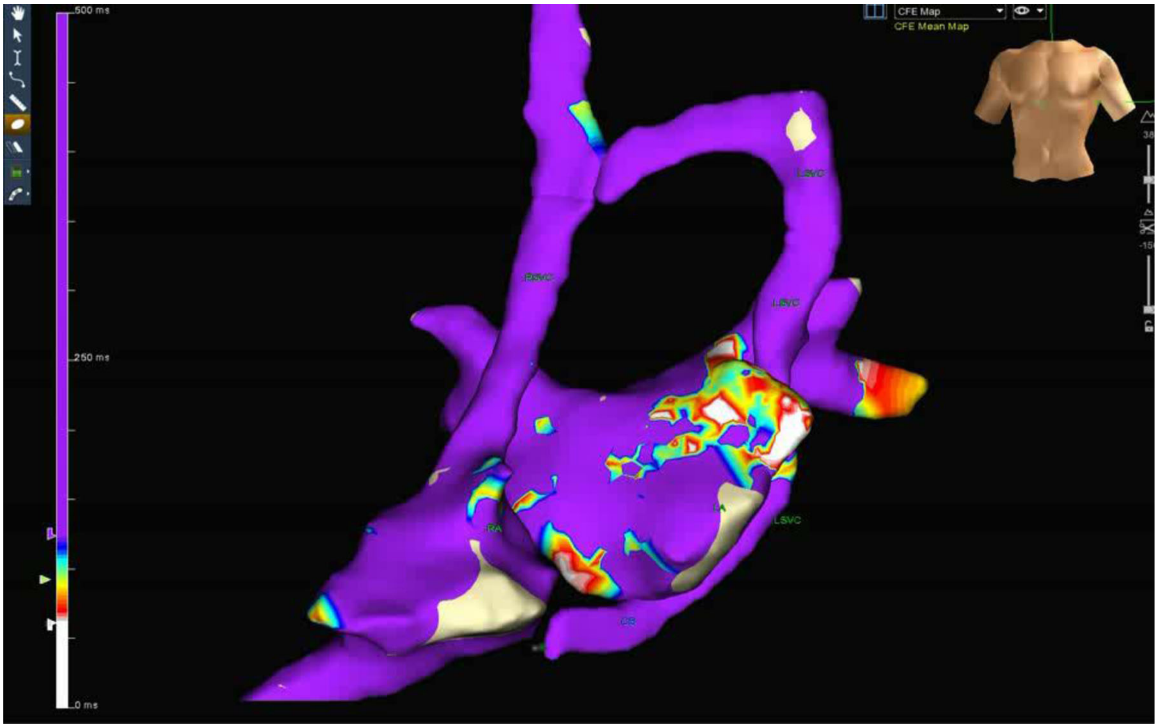

FIGURE 1 3D-Map and map of complex fractionated electrograms (NAVX Ensite, Abbott) in a patient with PLSVC and CS ostium atresia before ablation of persistent atrial fibrillation. The map shows the right superior vena cava, the PLSVC, the CS with CS ostium atresia and both atria. Access to the CS was performed retrogradely via right vena cava superior, innominate vein and PLSVC. LSVC, left superior vena cava; RSVC, right superior vena cava; CS, coronary sinus; LA, left atrium; RA, right atrium [Color figure can be viewed at wileyonlinelibrary.com]

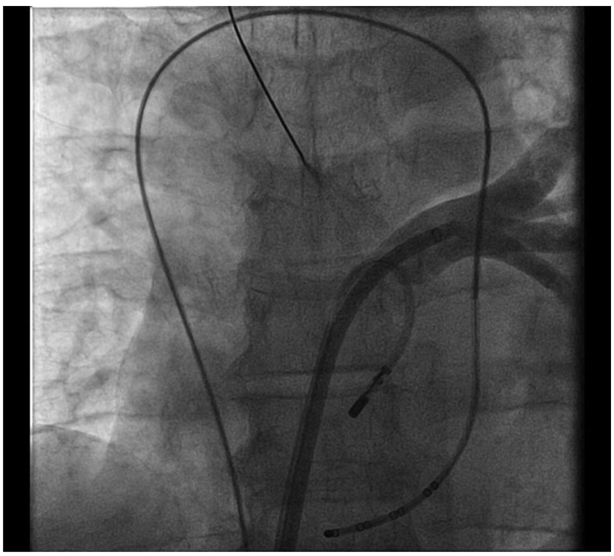

FIGURE 2 Retrogradely placed coronary sinus catheter in a patient with PLSVC and coronary sinus atresia. Angiography of the left superior pulmonary vein after transseptal puncture (fluoroscopy in anterior-posterior projection)

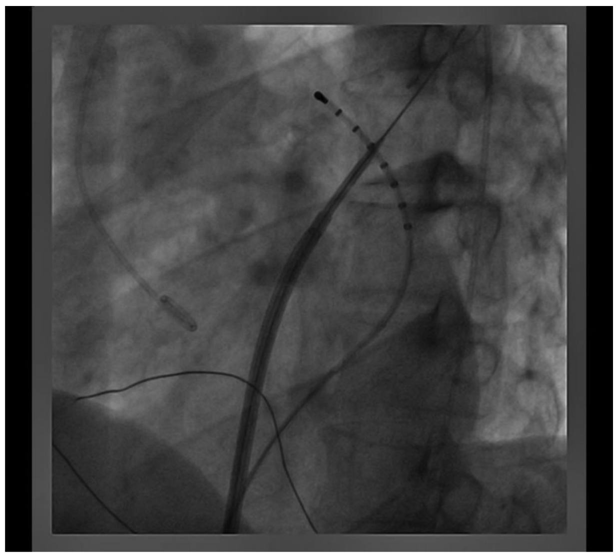

FIGURE 3 A pigtail catheter was placed to mark the aortic root during transseptal puncture in a patient with PLSVC (fluoroscopy in left anterior oblique [LAO] projection)

4.4 | Major complications

One major complication occurred in 27 procedures (3.7%). Within the index procedure in one of the patients with known PLSVC and lacking right superior vena cava, difficulties occurred with positioning of the transseptal sheath at the right atrial septum and resulted in a dissection of the atrial septum during the attempt of TSP. A guidewire marking the aortic root, angiography of relevant structures, a 3D map of the right atrium and the coronary sinus, as well as overlay of prior seg-

TABLE 3 Procedural data of the index ablation procedure

Procedural data of the index procedure (*n* = 15 patients)	
Pulmonary vein isolation *n* (%)	14 (93.3)
Ablation of CFAE[a] *n* (%)	9 (60.0)
Ablation of CFAE in the left atrium *n* (%)	8 (53.3)
Ablation of CFAE in the right atrium *n* (%)	5 (33.3)
Ablation of CFAE in the coronary sinus *n* (%)	4 (26.7)
Ablation of lines (left atrial and right atrial) *n* (%)	3 (20.0)
Ablation in PLSVC *n* (%)	6 (40.0)
Atria with low voltage/scar *n* (%)	5 (33.3)
Cycle length[b] (LAA$^+$) prior to ablation [ms], mean ± STD	170.8 ± 26.0
Duration of the procedure [min], median (min – max)	177.5 (87.0–255.0)
Duration until TSP is completed [min], median (min-max)	40.0 (12–74)
RF ablation time [min], median (min – max)	51.5 (15.7–72)
RF energy dose [W], mean ± STD	30.8 ± 0.8
Fluoroscopy dose [cGycm^2], median (min – max)	839.8 (176.7–4780.0)
Fluoroscopy time [min], median (min – max)	10.0 (4.0–52.0)

[a]CFAE; complex fractionated atrial electrograms.
[b]Cycle length measured in the $^+$left atrial appendage in patients with persistent atrial fibrillation prior to the ablation process.

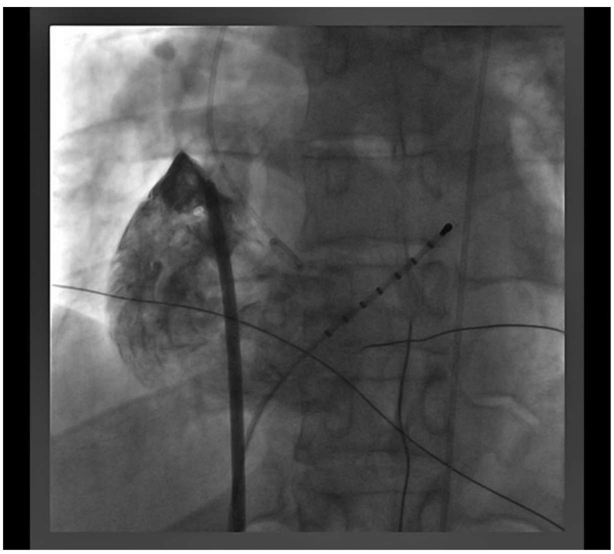

FIGURE 4 Angiography of the right atrium before transseptal puncture in a patient with PLSVC (fluoroscopy in anterior-posterior projection). A pigtail catheter marks the aortic root

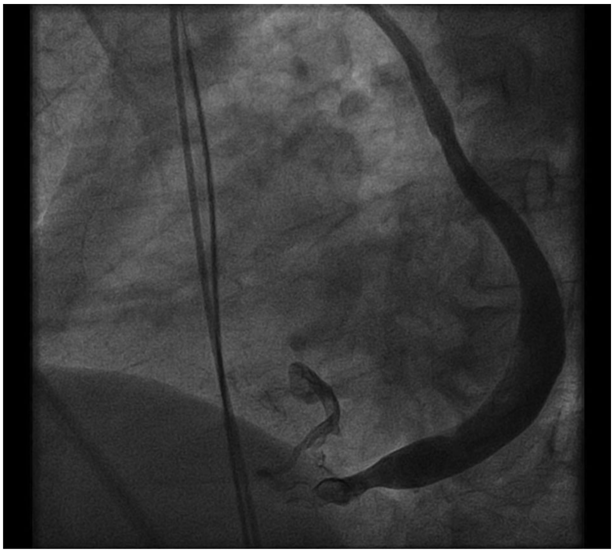

FIGURE 5 Angiography of the PLSVC in a patient with coronary sinus atresia before positioning of the coronary sinus catheter and transseptal puncture (fluoroscopy in anterior-posterior projection)

mented CT, derived anatomy onto the actual fluoroscopy were used in this attempt to support the finally unsuccessful TSP. The procedure was therefore terminated and the patient was continuously monitored on the intensive care unit without further incidents. In a second attempt, three days later, TSP was successfully achieved, again supported by the same methods.

In the group of five patients with prior unknown PLSVC no complication occurred during nine procedures.

5 | DISCUSSION

The aim of our study was to assess the feasibility and safety of left-sided atrial ablations in patients with PLSVC, especially when PLSVC is unknown prior to the ablation procedure. Our data shows that ablation in the left atrium is feasible and the complication rate is low, independently of whether the deviation from normal anatomy is known prior to the ablation procedure. The use of supportive measures like angiography, marking wires or overlay of CT-derived anatomy onto fluoroscopy to define the individual anatomy is an important consideration for the safe and successful performance of left atrial ablation procedures in patients with PLSVC.

5.1 | Feasibility

In all patients with PLSVC the coronary sinus catheter could successfully be placed in position. Due to mostly enlarged coronary sinus, this was described as "easy" except for the three patients with coronary sinus atresia, in whom the catheter was finally advanced retrogradely via the right superior vena cava and the innominate vein into the PLSVC and coronary sinus as published earlier in detail by our study group and others.[12,13] However, TSP was described as "difficult" in almost half of the procedures. TSP was not successful in the first attempt in two patients with PLSVC and additional absent right superior vena cava, going along with a case report describing this issue earlier.[14] However, in all patients with unknown PLSVC, the TSP and the ablation procedure were successfully completed in the first attempt. Within the fluoroscopic guidance for the placement of catheters and performance of the TSP, angiographic imaging of atrial and venous anatomy is able to give an orientation of anatomic landmarks, especially in patients with deviating or unknown anatomy. Additional catheters or wires placed at critical anatomical structures, like the aortic root, can help to position the needle and the transseptal sheath correctly.[15] Diverse methods other than the commonly used fluoroscopic guidance are able to support the TSP in difficult anatomies alternatively. TSP guided by alternative imaging like ICE or TEE is well established and is known for its advantages due to detailed views of the atrial anatomy.[15–19] This is especially interesting for procedures in patients with deviations from normal anatomy and in these, it is also potentially able to prevent complications.[14,17,20] In experienced hands, ICE provides accurate images of the anatomy of the heart and its adjacent vessels and therefore can play a substantial role for the left atrial access and the left atrial ablation procedure in patients with PLSVC.[5,18] Disadvantages of these methods are the need for a specialized examiner, an additional venous puncture and additional costs concerning ICE, a specialized examiner and a deep sedation concerning TEE and potentially longer preparation and procedure times concerning both methods.[16,19] Another method to support TSP in deviating or unknown anatomies is the combination of intraprocedural imaging with a 3D map, generated prior to the TSP, if a mapping system is used for the ablation procedure anyway. In our study population, a 3D map of the right atrial and venous anatomy in combination with fluoroscopy was used to guide the TSP successfully in four procedures. If a CT scan or MRI scan of the cardiac anatomy is available, the segmented 3D anatomy can be overlaid onto the actual fluoroscopy to support TSP in complex anatomies.[11] This method was published earlier by our study group and it was applied in both patients with PLSVC and lacking right superior vena cava to successfully guide the TSP and the following mapping procedure. Once left atrial access was completed successfully, atrial mapping and ablation in both atria and the PLSVC was feasible without greater difficulty to reach targeted structures and without complications in our patient population. This observation goes along with other publications describing sufficient ablation success of relevant structures in patients with isolated PLSVC.[5,21] Complete isolation of PLSVC currently seems to achieve the highest ablation success considering the special electrophysiological properties of PLSVC, ranging from multiple foci to fractionated electrograms to multiple intravenous electrical muscle connections which usually lead to high recurrence rates.[4,5,22] However, ablation on anatomical structures adjacent to the PLSVC may also be challenging. In particular, the achievement of conduction block of a mitral isthmus line by endocardial and epicardial ablation may seem easy due to possibly good maneuverability in the CS and the LPSVC. But finally this can be difficult due to multiple electrical connections between LPSVC and LA.[23] This might also have been the reason in one patient of our population, in whom the conduction block of the mitral isthmus line could only be achieved in a second procedure.

5.2 | Complications

In our population with 27 ablations in 15 patients one major complication occurred in a patient with PLSVC and lacking right superior vena cava, when the deviation from normal anatomy led to atrial septal dissection during the attempt of TSP. After thorough preparation and with diverse supportive measures this was performed successfully in a second procedure as described above. No complications occurred in the patients with prior unknown PLSVC. There were also no complications during mapping and ablation in both atria, the coronary sinus and the PLSVC in all our patients. A generally low complication rate of ablation procedures in patients with PLSVC was also described in other recent publications.[5,21] Nevertheless, there is a report of major intraprocedural complications in patients with PLSVC and ablation of atrial fibrillation, especially when the PLSVC is targeted as the ablation location. Namely cardiac tamponade due to perforation of the PLSVC or coronary sinus during ablation with radiofrequency energy and left phrenic nerve palsy during ablation with cryothermal energy in the PLSVC was observed.[24] Moreover, when ablating in the PLSVC and coronary sinus, other adjacent structures like coronary arteries and the conduction system should be kept in mind. In the case of associated coronary sinus atresia a stenosis of the PLSVC due to intraluminal ablation should be avoided as this may result in severe consequences like coronary venous congestion leading to myocardial ischemia and necrosis.[9] In our patient population, radiofrequency ablation in the PLSVC was performed in half of the procedures, all without complications. Finally, in complex anatomies and difficult procedures, the consultation and the support of an experienced examiner is advisable as this may lead to a successful procedure and may avoid complications.[25,26]

6 | LIMITATION

This study is a monocentric retrospective analysis including patients with PLSVC, who underwent left atrial ablations. No statement can be made about feasibility and safety of ablations on other ablation sites. Because the number of patients with PLSVC is generally very small, the results of this study may be subject to chance. As patients with complex congenital heart disease were excluded from the study, no conclusion can be made in this regard. In all procedures radiofrequency was used for ablation. No statement can be made about alternative energy sources. The degree of difficulty of the TSP was only evaluated by the ablating physician and hence is a subjective parameter. All ablating physicians in this study were experienced electrophysiologists (> 300 ablations per year). No statement can be made about feasibility and complication rates of ablations in patients with PLSVC in less experienced centers.

7 | CONCLUSION

In experienced hands and with the use of various supportive measures, the left atrial access and the left atrial ablation in patients with PLSVC is feasible and safe. No evidence was found to suggest that patients in whom the PLSVC was unknown prior to the ablation procedure were subject to elevated risks.

CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest concerning this study.

FINANCIAL SUPPORT

No financial support of the study.

AUTHOR CONTRIBUTION

VK: conception and design, analysis and interpretation of data, drafting the manuscript, final approval of the manuscript; MT&ER&MP&SL: conception and design, revision of the manuscript, final approval of the manuscript; MK&AB&CK&ID&GH: interpretation of data, revision of the manuscript, final approval of the manuscript; FB&TR: conception and design, interpretation of data, revision of the manuscript, final approval of the manuscript.

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