Laser balloon ablation in patients with a left common pulmonary vein.

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October 31, 2021

Abstract

Background: Pulmonary vein isolation (PVI) with a balloon-based visually guided laser ablation (VGLA) is regarded as a useful therapeutic tool for treating atrial fibrillation (AF). The clinical efficacy of a VGLA has never been fully investigated in patients with a left common pulmonary vein (LCPV). Objective: We investigated the procedural safety as well as clinical usefulness of VGLA in patients with an LCPV. Methods: This study consisted of 130 consecutive patients who underwent VGLA of de novo non-valvular paroxysmal AF. Results: Eleven patients (8.5%) had an LCPV (ostium maximal average diameter: 27.5 ± 4.9 mm, ostium minimal average diameter: 17.7 ± 3.5 mm). Nine out of 11 (81.8%) LCPVs were successfully occluded and isolated at the ostium with a VGLA guided PVI. The ablation procedure time was significantly shorter in the patients with than without an LCPV (61.5 ± 15.4 vs. 86.9 ± 32.9 min, p = 0.01). There was no difference regarding the atrial tachyarrhythmia recurrence between those with and without an LCPV (p = 0.18). A total of fifteen patients underwent a redo procedure, but reconnections were not observed in any of the LCPV patients. Conclusion: The VGLA guided PVI was a useful therapeutic tool even in patients with an LCPV. The presence of an LCPV was not associated with any atrial tachyarrhythmia recurrence.

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Conflict of interest statement

The authors declare no conflict of interest for this article.

Data Availability

Deidentified participant data will not be shared.

Funding Sources

The authors declare no conflict of interest for this article.

Word count

4973 words

Abstract

Background:

Pulmonary vein isolation (PVI) with a balloon-based visually guided laser ablation (VGLA) is regarded as a useful therapeutic tool for treating atrial fibrillation (AF). The clinical efficacy of a VGLA has never been fully investigated in patients with a left common pulmonary vein (LCPV).

Objective:

We investigated the procedural safety as well as clinical usefulness of VGLA in patients with an LCPV.

Methods:

This study consisted of 130 consecutive patients who underwent VGLA of de novo non-valvular paroxysmal AF.

Results:

Eleven patients (8.5%) had an LCPV (ostium maximal average diameter: 27.5 ± 4.9 mm, ostium minimal average diameter: 17.7 ± 3.5 mm). Nine out of 11 (81.8%) LCPVs were successfully occluded and isolated at the ostium with a VGLA guided PVI. The ablation procedure time was significantly shorter in the patients with than without an LCPV (61.5 ± 15.4 vs. 86.9 ± 32.9 min, $p = 0.01$). There was no difference regarding the atrial tachyarrhythmia recurrence between those with and without an LCPV ($p = 0.18$). A total of fifteen patients underwent a redo procedure, but reconnections were not observed in any of the LCPV patients.

Conclusion:

The VGLA guided PVI was a useful therapeutic tool even in patients with an LCPV. The presence of an LCPV was not associated with any atrial tachyarrhythmia recurrence.

Keywords

Left common pulmonary vein, catheter ablation, pulmonary vein isolation, laser balloon, atrial fibrillation

Introduction

Pulmonary vein isolation (PVI) is an effective treatment of atrial fibrillation (AF). A balloon-based visually guided laser ablation (VGLA) is considered to be a useful therapeutic tool for achieving a $PVI_{1)}$. A prior multicenter study revealed that VGLA was non-inferior to radiofrequency ablation in terms of the efficacy and safety in curing paroxysmal and persistent $AF_{2,3)}$. Moreover, a recent prospective randomized study showed that VGLA was as effective and safe as a cryoballoon (CB) guided $PVI_{4)}$.

The shape of the pulmonary veins (PVs) and left atrium varies among the candidates for AF ablation, and a left common pulmonary vein (LCPV) is the most frequently observed anatomical abnormality that operators encounter in performing PVI. Although radiofrequency energy (RF) ablation can be applied in a point-by-point fashion at the LCPV ostium without any difficulty, the balloon may not be able to occlude the PVs, which is mandatory for a successful PVI. The results of a balloon-based PVI may not be satisfactory especially in patients with a relatively large LCPV, and we previously reported that a CB guided PVI was unsuccessful in 15% of patients with an LCPV[5]. However, the clinical safety and efficacy of a VGLA has never been fully investigated in patients with an LCPV. We investigated the procedural safety and efficacy of VGLA in the patients with an LCPV.

Methods

Study population

Consecutive patients who underwent a PVI with VGLA as the first procedure for paroxysmal AF from July 2018 to January 2020 were eligible for this study. The subjects were patients who underwent catheter ablation of AF for standard clinical indications[1]. Written informed consent for the ablation procedures was obtained from all patients. The definition of paroxysmal AF was according to the American Heart Association/American College of Cardiology/European Society of Cardiology guidelines, which is as follows: paroxysmal AF was defined as AF that self-terminated within 7 days[1]. The study protocol was approved by the hospital's institutional human ethics committee. The study complied with the Declaration of Helsinki.

Management before the catheter ablation

A 12-lead electrocardiogram (ECG), chest X-ray, and echocardiogram were examined within 3 months before the catheter ablation. A transthoracic echocardiogram was performed to evaluate the left atrial diameter and left ventricular ejection fraction (LVEF). All patients underwent a 64-slice multi-detector row computed tomography (MDCT) within 1 week before the catheter ablation to obtain the configuration of the left atrial cavity and rule out any thrombi in the left atrium (LA) and left atrial appendage. A 60-100 ml bolus of iodinated intravenous contrast was administered at a rate of 2.5-5 ml/s, followed by a saline flush of 20-30 ml. The slice data of the MDCT image was reconstructed into a 3-dimensional volume rendering using computer software (ZAIO station2, ZAIOSOFT, Tokyo, Japan). The 3-dimensional image clarified the anatomy of the LA and PVs: left superior pulmonary vein (LSPV), left inferior pulmonary vein (LIPV), right inferior pulmonary vein (RSPV) and right inferior pulmonary vein (RIPV). An LCPV is generally defined as a common trunk length of 5 mm or more, short common trunk length of 5-15mm, and long common trunk length of more than 15mm[6,7]. In this study, an LCPV was defined as a PV with an entire length between the PV ostium and PV bifurcation of longer than 15mm based on the MDCT image. All patients received anticoagulation therapy for at least 3 weeks before the ablation procedure. All antiarrhythmic drugs were discontinued for more than 5 half-lives before the ablation procedure, and amiodarone was not administered in any of the study patients.

Catheter ablation procedure

Catheter ablation was performed under general anesthesia using an intravenous administration of propofol and dexmedetomidine. A single-use supraglottic airway device (i-gel, NIHON KOHDEN, Tokyo, Japan) was inserted in all eligible patients, and an esophageal temperature thermocouple catheter (Esophaster, Japan Lifeline, Tokyo, Japan) was inserted through this airway device into the esophagus for continuous monitoring of the luminal esophageal temperature. Vascular access was acquired through the right internal jugular and femoral veins. A 20-pole catheter (BeeAT, Japan Lifeline, Tokyo, Japan) was inserted into the coronary sinus for electrogram recording, atrial pacing, and defibrillation. Two transseptal punctures were performed; one for a 12-Fr inner-diameter deflectable sheath (CardioFocus, MA, USA) and VGLA catheter and the other for a circular mapping catheter. Heparin was given as intravenous boluses followed by a constant infusion to maintain an activated clotting time of >300 seconds during the ablation procedure.

An EnSite NavX navigation system (St. Jude Medical, St. Paul, MN, USA) was used for 3-dimensional

mapping. A mapping catheter (EPstar libero, Japan Lifeline, Tokyo, Japan) was used to construct the geometry of the LA and each PV. The bipolar electrogram filters were set between 30 and 500 Hz.

The first generation VGLA catheter (HeartLight, CardioFocus, MA, USA) was inserted into the LA, and expanded trying to occlude each PVs. The laser balloon (LB) was inflated in a slow fashion to maximize the contact between the LB and cardiac tissue according to the size and shape of the target PV orifice. An LCPV isolation was performed with a maximal dilated LB (balloon size 9). If the LCPV could not be completely occluded with the maximal size of the LB, the LB was further inserted into the distal superior and inferior branches of the LCPV for the sake of isolating the distal branches the LCPV individually. The laser console uses aluminum gallium arsenide as a semiconductor laser element and emits a therapeutic laser with a wavelength of 980 nm. The laser energy level was titrated according to the degree of tissue exposure between 5.5 and 12 W using the LightTrackTM software (CardioFocus, MA, USA). Every energy application was applied for 20 to 30 seconds depending on the applied laser energy. The area adjacent to the blood was applied with 5.5 W for 30 seconds in order to avoid an LB rupture. The laser energy was applied continuously overlapping each lesion by 50% around each PV ostium. The VGLA was prematurely terminated when the luminal esophageal temperature reached 39. The VGLA was performed in a sequence of the LSPV (or LCPV), LIPV, RSPV, and RIPV.

A 10-pole catheter was placed in the right subclavian vein or superior vena cava to pace the right phrenic nerve. The compound motor action potentials (CMAPs) were continuously measured, and the operators confirmed the tactile feedback of the diaphragmatic contractions during the VGLA of the RSPV or RIPV. The threshold for capturing the right-sided diaphragm was recorded, and phrenic nerve pacing was performed at a rate of 40 pulses per minute at an output exceeding the pacing threshold by 10%$_{8)}$. The VGLA was prematurely discontinued when the operator felt a reduction in the diaphragmatic contractions or the CMAP amplitude decreased by more than 30%$_{9)}$.

After the initial encirclement by the LB, the electrical isolation status of each PV was assessed. If all PVs were electrically isolated, dormant conduction was evaluated by an administration of adenosine triphosphate (ATP). The VGLA was subsequently applied at the electrical gap sites for touch-up ablation when the PVI was unsuccessful despite the initial encircling by the LB. When a PVI could not be successfully accomplished with only the VGLA, an irrigated RF catheter (TactiCath, Abbott, Illinois, USA) was used for touch-up ablation to eliminate all gap conduction sites. A successful PVI was defined as entrance and exit conduction block between the LA and PVs. After a successful initial PVI, it was reassessed 15 minutes after the last application. A voltage map of the PVs and LA was acquired before and after the PVI using a CARTO 3D mapping system (**Figure 1**).

A cavotricuspid isthmus ablation was also performed when atrial flutter was observed during the catheter ablation procedure or according to the discretion of the operator. No eligible patients underwent catheter ablation of non-PV foci. The RF energy was delivered with a maximum power of 35 W, and the catheter tip temperature was limited to 42 degC. The ovality index was calculated according to the method of a previous report based on the CT image: 2 * (maximal diameter - minimal diameter) / (maximal diameter + minimal diameter)$_{10)}$.

Follow-up

All patients were followed-up in the outpatient clinic at 1, 3, 6, 9, and 12 months after discharge. When the patients visited the outpatient clinic, a physical examination, 12-lead ECG, and review of the patients' symptoms were performed. All patients were encouraged to inform their physician of their physical status and whether they had any symptoms that were suggestive of an atrial tachyarrhythmia recurrence. If any atrial tachyarrhythmia recurrences were suspected, the cardiac rhythm was assessed using a 12-lead ECG. A Holter ECG examination was performed at 3 and 12 months after the VGLA procedure. Atrial tachyarrhythmia recurrence was defined as any sustained AF or atrial tachycardia (AT) lasting for ¿ 30 seconds, which appeared after the blanking period (¿ 90 days after the catheter ablation).

Statistical analysis

Continuous variables are expressed as the mean ± SD, and the significant differences were analyzed with a Student's t test. Categorical data are expressed as the number and percentages, and were compared using an χ^2 test or Fisher's exact test. Univariate and multivariate Cox proportional hazards regression analyses were performed on candidate variables to predict the dichotomous outcome. The variables with a $P < 0.1$ in the univariate analysis were input into the multivariate analysis. Survival curves were calculated using the Kaplan–Meier method and compared with the Log Rank test. A probability value of < 0.05 was deemed significant. Statistical analyses were conducted using the EZR software (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics

Table 1 shows the baseline clinical characteristics of the present study patients. In this study, 130 patients (67% male, age 66 ± 12 years) who underwent an initial PVI with VGLA were analyzed. The mean CHA2DS2-VASc score was 2.0 ± 1.5 and mean LA diameter 38.4 ± 6.1 mm.

The RIPV could not be electrically isolated in 4 patients, because of prematurely terminating the VGLA due to the sudden failure of right phrenic nerve capture, which persisted until the end of the procedure. In all but those 4 patients, all PVs were successfully isolated. The LB ruptured in 3 patients during the procedure, and 26 patients underwent additional touch up RF ablation to achieve the PVI.

There were no significant differences in the age, gender, body mass index (BMI), or comorbidities such as hypertension, diabetes, and a history of congestive heart failure or a stroke between those with and without LCPV. The LA diameter and LVEF were also comparable. Moreover,**Table 2** shows the procedural characteristics of the present study patients. The total procedure time and LB dwelling time in the LA were significantly shorter in the patients with an LCPV. There was no significant difference in the fluoroscopy time, number of ATP dormant conduction sites, and adjunctive RF touch-up ablation between the two groups. ATP dormant conduction was observed in 8 patients in the LSPV, 2 in the LIPV, 5 in the RSPV, 5 in the RIPV and none in the LCPV, respectively.

In the present study, 11 patients (8.5%) had an LCPV (LCPV ostium maximal diameter: 27.5 ± 4.9 mm, LCPV ostium minimal diameter: 17.7 ± 3.5 mm, and LCPV ovality index: 0.44 ± 0.15). The mean length between the LCPV ostium and bifurcation point of the superior and inferior PVs was 19.5 ± 3.4 mm. We could electrically isolate the LCPVs at the ostium with the VGLA in 9 patients, whereas the superior and inferior branches of the LCPV were isolated individually due to a large LCPV diameter in 2 patients. Those 2 patients had a significantly larger LCPV maximal ostium diameter than the remaining 9 patients (34.8 ± 1.1 mm vs. 25.9 ± 3.8 mm, $P = 0.01$).

Follow up

There were no significant differences in the atrial tachyarrhythmia recurrence and rate of the administration of antiarrhythmic drugs during the blanking period of 90 days after the ablation procedure (**Table 1**). The mean follow-up period was 337 ± 122 (ranging from 90 to 580) days. After the blanking period of the catheter ablation, atrial tachyarrhythmias recurred in 20 patients (15.4 %, AF recurrence in 19 patients including 3 with an LCPV, AT recurrence in 1 without an LCPV). A log-rank analysis demonstrated that there was no significant difference with regard to atrial tachyarrhythmia recurrence in the patients with and without an LCPV (**Figure 2**). In the univariate and multivariate analyses, recurrence during the blanking period after the PVI was an independent risk factor for an atrial tachyarrhythmia recurrence (**Table 3**).

Fifteen patients (11.5 %) underwent a second catheter ablation procedure including 3 (2.3 %) with an LCPV. Perimitral atrial flutter was observed in 1 patient without an LCPV. Reconnections of the RSPV, RIPV, LSPV, and LIPV were 8 out of 15 (53.3%), 8 out of 15 (53.3%), 4 out of 12 (33.3%), and 4 out of 12 (33.3%), respectively. The ATP dormant conduction sites were identical to the reconnected sites during the second

ablation session in 2 patients. Of note, no reconnections were observed in any of the LCPV patients, and the LCPV ovality index was not associated with atrial tachyarrhythmia recurrence (P = 0.63).

Discussion

One hundred and thirty patients who underwent VGLA using the first generation LB were analyzed in the present retrospective single center study. The main findings of our study were as follows: (1) we could successfully isolate the LCPVs at the ostium with only the VGLA in 9/11 patients (81.8%), (2) the total procedure time was significantly shorter in the patients with an LCPV than in those without (174.9 ± 31.6 min vs. 148.2 ± 19.9 min, P < 0.01), and (3) the presence and configuration of the LCPV was not a significant predictor of any atrial tachyarrhythmia recurrence after the ablation procedure.

Impact of an LCPV in balloon based PVI procedures

There have been several prior reports on a CB guided PVI in patients of an LCPV. In the past, CB was considered technically challenging to achieve a PVI in patients with an LCPV, because the balloon size and lack of an appropriate balloon compliance made the complete occlusion of the PVs difficult. A previous study showed that atrial tachyarrhythmias were apt to recur after the ablation procedure using the first and second generation CBs[5,11,12]. A point by point RF energy application may be suitable for the isolation of an LCPV, because it can isolate the PV at the LCPV ostium regardless of the size, length, or configuration of the LCPV. However, prior studies comparing the 2nd generation CB and RF in patients with an LCPV reported no significant difference in the atrial tachyarrhythmia recurrence[13,14]. Moreover, a recent randomized clinical trial (CIRCA-DOSE study) revealed the presence of an LCPV was associated with a trend towards higher rates of atrial tachyarrhythmia recurrence following the PVI[15]. In this study, no significant difference in the atrial tachyarrhythmia recurrence was observed in the patients with an LCPV randomized to those undergoing a CB ablation and those undergoing an RF ablation[15].

On the other hand, Nakamura et al. investigated the efficacy and long-term outcome of a Hot-balloon guided PVI[16]. Of the patients in this study with an LCPV diameter of < 34 mm, 75% of the LCPVs were isolated at the ostium and 25% needed an individual isolation of the superior and inferior branches[16]. Nakamura et al. revealed that the presence of an LCPV was not associated with recurrent AF, and significantly fewer Hot-balloon applications were sufficient for accomplishing the PVI[16].

An LCPV is generally defined as having a length of 5 mm or more from the PV ostium to the bifurcation point (a short common trunk is 5-15mm and a long common trunk more than 15mm[6,7]), but we defined the LCPV length between the PV ostium and bifurcation point as longer than 15mm on the MDCT findings. In the present study, a short LCPV was found in 21 patients. Since each short LCPV could not be isolated at the ostium, the superior and inferior branches of the LCPV had to be isolated individually. Therefore, those short LCPV cases were excluded from the present study analysis. There was no difference with regard to the total procedure time, ablation time for accomplishing the PVI, and atrial tachyarrhythmia recurrence between the patients with a short LCPV and those without an LCPV.

To the best of our knowledge, the present study was the first report to evaluate the efficacy of a VGLA guided PVI for an LCPV. The LB is so compliant that it can be inflated to any pressure and size change, which enables a maximum balloon/tissue contact regardless of the size or shape of each PV ostium. In the present study, we achieved a successful electrical isolation at the LCPV ostium in the majority of the patients with an LCPV. In addition, a comparable clinical result of atrial tachyarrhythmia recurrence could be observed in our study between the patients with and without an LCPV. Moreover, the ablation procedure time was shorter in the patients with an LCPV because the superior and inferior branches were isolated simultaneously with the VGLA as a result, which presumably attributed to a shorter catheter manipulation time. Although an electrical isolation at the LCPV ostium is difficult in cases with a large LCPV, VGLA could be selected as the first-line therapy in terms of the acute success and long-term clinical outcome.

Long-term outcome and PVI durability

The present study demonstrated that the predictors of any atrial tachyarrhythmia recurrence were not

associated with the presence of an LCPV, but were related to the recurrence during the blanking period. In general, recurrence within 90 days of the blanking period is a major risk factor for any atrial tachyarrhythmia recurrence after the blanking period[17-19], which was similar to the results of the VGLA in the present study.

VGLA enabled maintaining a high durable PVI. Nagase et al. and Okishige et al. demonstrated that the lesion depth, lesion volume, and maximum lesion diameter were associated with the laser output energy and total laser energy delivered in an in vitro model[20,21]. A prior multicenter study revealed that 86% of the PVs remained isolated, and 62% of the patients had all their PVs remaining isolated after the VGLA guided PVI[22]. In the present study, PV reconnections were found in 24 out of 57 (42.1%) PVs among the patients who had recurrent atrial tachyarrhythmias and underwent a redo procedure. However, no electrical reconnections were found in any of the LCPV cases. The VGLA might create a highly durable lesion for LCPVs as derived from the present study results.

Study limitations

Our study had several limitations. First, this study was a single-center, retrospective analysis, and the study sample size was relatively small. A larger volume study might be needed to verify the present results. Second, the first generation VGLA (HeartLight, CardioFocus, MA, USA) was used in present study. The third generation VGLA (HeartLight X3, CardioFocus, MA, USA), which enables a single-sweep PVI with very short procedure times[23], might be more effective for the LCPV isolation.

Conclusion

The clinical safety and long-term clinical efficacy of VGLA of paroxysmal AF was comparable between the patients between with and without an LCPV. A VGLA guided PVI could be regarded as a useful therapeutic tool even in patients with an LCPV.

Acknowledgements

There was no financial support associated with this study.

Disclosures

None.

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Table 1 . Patient characteristics

Variable	Overall (n=130)	LCPV - (n=119)	LCPV + (n=11)
Age, years	66.0 ± 11.8	65.7 ± 11.8	69.0±12.1
Female, n	43 (33.1%)	39 (32.8%)	4 (36.3%)
BMI, kg/m^2	23.8 ± 3.7	23.8 ± 3.8	24.6 ± 3.0
Hypertension, n	54 (41.5%)	48 (40.3%)	6 (54.5%)
Diabetes, n	10 (7.7%)	8 (6.7%)	2 (18.2%)

Variable	Overall (n=130)	LCPV - (n=119)	LCPV + (n=11)
Heart failure, n	8 (6.2%)	8 (6.7%)	0 (0%)
Stroke or TIA, n	11 (8.5%)	10 (8.4%)	1 (9.0%)
CHA_2DS_2 VASc score	2.0 ± 1.5	2.0 ± 1.4	2.3 ± 1.9
LA diameter, mm	38.4 ± 6.1	38.4 ± 6.1	38.2 ± 5.5
LVEF, %	65.9 ± 9.0	65.8 ± 9.1	66.1 ± 8.1
Atrial tachyarrhythmia recurrence during the blanking period, n	22 (16.9%)	20 (16.8%)	2 (18.2%)
AAD the blanking period, n	8 (6.2%)	8 (6.7%)	0 (0%)

LCPV = left common pulmonary vein; BMI = body mass index; TIA = transient ischemic attack; LA = left atrium; LVEF = left ventricular ejection fraction; AAD = antiarrhythmic drug.

Values are expressed as the mean ± SD or as n (%). *P value is compared between the LCPV - and LCPV + groups, respectively.

Table 2 . Procedural characteristics of the patients with and without an LCPV

Procedural valuables	Overall (n=130)	LCPV - (n=119)	LCPV + (n=11)	*P value
Total procedure time, min	172.7 ± 31.7	174.9 ± 31.6	148.2 ± 19.9	<0.01
LB dwelling time in LA, min	84.8 ± 32.5	86.9 ± 32.9	61.5 ± 15.4	0.01
Fluoroscopy time, min	55.5 ± 15.3	55.8 ± 15.3	51.9 ± 15.7	0.44
Laser mean output, W				
RSPV	8.7 ± 1.4	8.7 ± 1.5	9.3 ± 1.2	0.18
RIPV	7.9 ± 1.4	7.9 ± 1.4	8.0 ± 1.5	0.82
LSPV	8.6 ± 1.5	8.6 ± 1.5		
LIPV	7.7 ± 1.6	7.7 ± 1.6		
LCPV	8.5 ± 1.3		8.5 ± 1.3	
Total energy, J				
RSPV	6014.9 ± 2667.3	6037.1 ± 2741.3	5774.6 ± 1742.0	0.76
RIPV	4489.5 ± 1506.7	4507.1 ± 1522.3	4290.9 ± 1374.6	0.67
LSPV	6745.3 ± 3070.0	6745.3 ± 3070.0		
LIPV	4647.9 ± 2374.6	4647.9 ± 2374.6		
LCPV	7610.8 ± 4681.5		7610.8 ± 4681.5	
ATP dormant conduction, n	19 (14.6%)	18 (15.1%)	1 (9.0%)	1.0
Radiofrequency touch up, n	26 (20.0%)	23 (19.3%)	3 (27.2%)	0.46
CTI ablation, n	119 (91.5%)	109 (91.6%)	10 (90.9%)	1.0

LCPV = left common pulmonary vein; LB = laser balloon; LA = left atrium; RSPV = right superior pulmonary vein; RIPV = right inferior pulmonary vein; LSPV = left superior pulmonary vein; LIPV = left inferior pulmonary vein; ATP = adenosine triphosphate; CTI = cavotricuspid isthmus.

Values are expressed as the mean ± SD or as n (%). *P value is compared between the LCPV - and LCPV + groups, respectively.

Table 3. Univariate and multivariable analysis for the prediction of an atrial tachyarrhythmia recurrence

	Univariate analysis	Univariate analysis	Multivariate analysis	Multivariate an
	HR (95% CI)	P value	HR (95% CI)	P value
Age	1.03 (0.98-1.08)	0.20		
Female	1.16 (0.46-2.96)	0.75		

	Univariate analysis	Univariate analysis	Multivariate analysis	Multivariate an
BMI	1.0 (0.89-1.12)	0.96		
CHA_2DS_2 VASc score	1.28 (0.95-1.72)	0.10	1.28 (0.95-1.73)	0.11
LA diameter	1.05 (0.98-1.13)	0.18		
LCPV	2.42 (0.70-8.40)	0.16		
Recurrence during the blanking period	3.06 (1.21-7.78)	0.02	3.04 (1.19-7.73)	0.02

BMI = body mass index; LA = left atrium; LCPV = left common pulmonary vein; HR = hazard ratio; CI = confidence interval.

Figure Legends

Figure 1. An example of a voltage map of the left atrium and pulmonary veins before and after the PVI (purple area; a voltage of more than 0.5 mV, gray area; a voltage of less than 0.1 mV). The distance between the LCPV ostium and bifurcation was 18mm. The LCPV was successfully isolated with an LB inserted into the LCPV superior branch.

PVI = pulmonary vein isolation; LCPV = left common pulmonary vein; LB = laser balloon.

Figure 2. Long-term freedom from atrial tachyarrhythmia recurrence after an initial VGLA guided PVI.

VGLA = visually guided laser ablation; PVI = pulmonary vein isolation.

Figures

Figure 1.

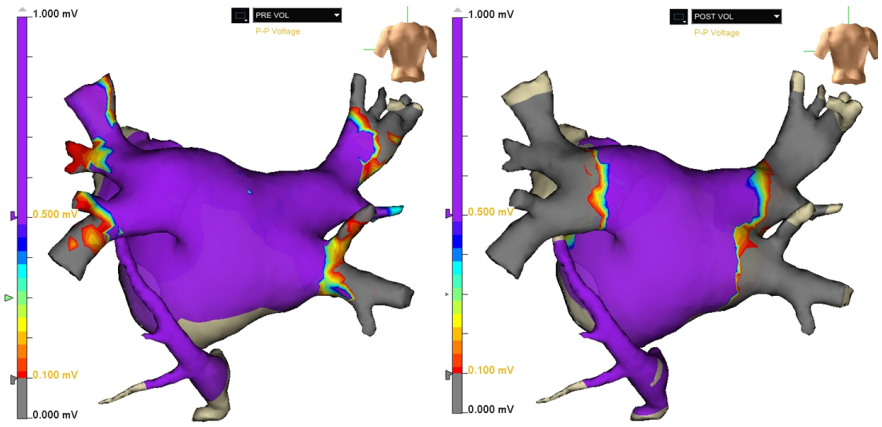

Figure 2.