Visually Guided Sequential Pulmonary Vein Isolation: Insights into Techniques and Predictors of Acute Success

BORIS SCHMIDT, M.D., MELANIE GUNAWARDENE, M.D., VERENA URBAN, M.D., MEHMET KULIKOGLU, M.D., BRITTA SCHULTE-HAHN, M.D., BERND NOWAK, M.D., STEFANO BORDIGNON, M.D., and KR J. CHUN, M.D.

From the Cardioangiologisches Centrum Bethanien, Frankfurt, Germany

Sequential PVI with Laser Balloon. ***Introduction:*** **Pulmonary vein isolation (PVI) is a challenging procedure most often requiring sophisticated technical aids such as electroanatomical mapping, double transseptal access, and the use of a circular mapping catheter. We sought to develop a PVI strategy solely based on visual guidance with a single ablation device as well as a single transseptal puncture using the endoscopic ablation system (EAS).**

Methods and Results: **In 35 patients with drug-refractory atrial fibrillation (18 male, mean age: 62 ± 9 years) ablation was performed. PVI was achieved in 96 of 137 PVs (70%) purely by visually guided circular ablation. Predictors of acute isolation were the degree of PV occlusion by EAS as well as the number of catheter repositionings but not total ablation energy or the number of laser applications. Conduction gaps were detected at sites with suboptimal occlusion as well as esophageal temperature elevations. Further EAS ablation resulted in a 98% acute isolation rate. Mean procedure and fluoroscopy times were 154 ± 38 minutes and 16 ± 6 minutes, respectively. Between the first and last 12 cases, a reduction in procedure times (175 ± 48 minutes vs 138 ± 26 minutes; P = 0.05) was observed. One pericardial tamponade and 1 right-sided phrenic nerve palsy occurred. During a median follow-up of 266 days (q-q3: 218–389), 27 of 35 patients (77%) remained free of any tachyarrhythmia recurrence off antiarrhythmic drugs.**

Conclusions: **Sequential PVI based solely on endoscopic visual information with a single device and a single transseptal puncture is feasible. Optimal PV occlusion and few controlled repositionings facilitate PVI.** *(J Cardiovasc Electrophysiol, Vol. pp. 1-7)*

ablation, atrial fibrillation, laser balloon, pulmonary vein isolation

Introduction

Pulmonary vein isolation (PVI) is the critical endpoint of a successful atrial fibrillation (AF) ablation procedure.[1] Circumferential ablation using irrigated radiofrequency current catheters and a circular mapping catheter to confirm electrical PVI are most widely used.[2] Nonetheless, this is a challenging and complex procedure requiring an experienced operator with advanced navigation skills. Facilitated approaches to achieve PVI purely based on 3-dimensional (3D) electroanatomical information and without the use of a circular mapping catheter led to disappointing results.[3,4]

Alternatively, balloon-based catheters using cryothermal or laser energy aiming at simplified PVI have been introduced.[5–8] However, these approaches were still complicated by the use of either multiple ablation devices or a second transseptal access for PV recordings.

The aim of this study was to develop a PVI strategy using a single ablation device as well as a single transseptal puncture to achieve electrical PVI solely based on visual information using the endoscopic ablation system (EAS). We also sought to determine predictors of acute procedural success by analyzing intraprocedural parameters potentially affecting acute PVI.

Methods

The study was approved by the local ethical committee. All patients gave written informed consent before the procedure.

Inclusion and Exclusion Criteria

Patients with symptomatic drug-refractory paroxysmal AF (PAF) or short-lasting persistent AF (<2 months) aged 18–70 years without previous PVI attempt were enrolled. At least 1 AF episode had to be documented within the past 6 months. Left atrium (LA) size had to be less than 50 mm and the maximal allowed PV diameter was 32 mm. The presence of structural heart disease with reduced left ventricular function <30% or valvular dysfunction >II° was an exclusion criterion.

Preprocedural Imaging

All patients underwent transthoracic and transesophageal echocardiography to rule out LA thrombus the day before the procedure.

The study was supported by a research grant of CardioFocus, Marlborough, MA, USA.

Drs. Schmidt and Chun received speaker's bureau fees from CardioFocus. Other authors: No disclosures.

Address for correspondence: Boris Schmidt, M.D., Cardioangiologisches Centrum Bethanien, Wilhelm Epstein-Str. 4, 60431 Frankfurt/M. Germany. Fax: +49 69 945028119; E-mail: b.schmidt@ccb.de

Manuscript received 2 Septemper 2011; Revised manuscript received 13 October 2011; Accepted for publication 9 November 2011.

doi: 10.1111/j.1540-8167.2011.02247.x

In addition, LA magnetic resonance angiography was performed before and 3 months after the ablation to assess PV geometry and size and to screen for PV stenosis.

Electrophysiological Procedure

The ablation procedures were performed under sedation, using boluses of midazolam, and fentanyl as well as continuous infusion of propofol 1%. An esophageal temperature probe (SensiTherm™, St. Jude Medical, Minnetonka, MN, USA) was inserted. If esophageal temperature exceeded 38.5 °C energy delivery was terminated.

After placing 6F decapolar catheters into the coronary sinus and along the His bundle region, a single transseptal puncture was performed. An 8F sheath (SL1; St. Jude Medical) was introduced into the LA. Heparin was administered to maintain activated clotting time between 300 and 350 seconds. Selective PV angiography was performed to identify the PV ostia. A spiral mapping catheter (Biosense Webster Inc., Diamond Bar, CA, USA) was placed at the PV ostium to record PV potentials using a computerized EP-system (Lab system pro; C. R. Bard Inc., Lowell, MA, USA).

The transseptal sheath was then exchanged by a guidewire placed in the left superior PV (LSPV) for a 12F (15F outer diameter) steerable sheath. The second 8F sheath in the femoral vein was exchanged to the long 8F transseptal sheath and placed in the superior vena cava carrying a diagnostic catheter to perform phrenic nerve stimulation (20 mA, 2.9 milliseconds) during ablation of the right superior PV (RSPV). If loss or weakening of capture was observed, energy delivery was instantaneously terminated.

The EAS

The details of the EAS (CardioFocus, Marlborough, MA, USA) have been described in detail elsewhere.[7] In brief, it consists of a nonsteerable, compliant balloon catheter with a range of diameters from 9 to 35 mm. After introduction into the LA by a steerable 12F sheath it is filled and continuously flushed with deuterium (D_2O) for cooling purposes. The central catheter shaft houses a 2F fiber optic endoscope that enables direct visualization of the PV antrum once the balloon has been inflated. Laser energy can also be delivered by a second fiber from a 980 nm, laser diode source.

EAS Positioning and Ablation

The EAS was positioned at each individual PV ostium to perform ablation. Optimal PV occlusion with maximal exposure of LA tissue was attempted. The degree of PV occlusion/LA tissue exposure was categorized as follows: (1) 360°; (2) 270–359°; (3) 180–269°; and (4) <180°. Under visual guidance ablation lesions were deployed in a contiguous fashion by overlapping the individual lesions by 30–50%. Overlapping was facilitated using the LightTrack™ (CardioFocus) software enabling visualization of energy delivery location and review by fusion of screenshots of any individual ablation site. Energy was titrated from 5.5 to 12 W (20–30 seconds ablation time) according to the degree of tissue exposure. If laser applications behind the catheter shaft could not be avoided, the minimal energy (5.5 W) was chosen.

The number of applications and the total energy deployed was collected for each individual PV. For further analysis, PVs were divided into 4 quadrants (anterior superior [AS], posterior superior [PS], anterior inferior [AI], and posterior inferior [PI]). In all patients, PVs were treated in the following sequence: LSPV, left inferior PV (LIPV), RSPV, and right inferior PV (RIPV). If a left common PV (LCPV) was present, it was treated first.

Special ablation techniques were used in a standardized fashion.

Superior PVs and "Controlled Rotation"

At each superior PV catheter orientation was adjusted to obtain an initial shaft position at the carina separating the superior from the inferior PV ostium (Fig. 1A). The laser applications were deployed from 1 edge of the shaft to the other in a clockwise or counter clockwise fashion. Without deflating the balloon, the EAS was rotated 180° in a controlled fashion to expose the remaining segment of the PV, i.e., the carina, and circular ablation was completed under visual guidance (Fig. 1B).

Inferior PVs and "Flex-Down Technique"

The EAS was then positioned at the inferior PV ostium using a similar inflation pressure with the shaft rotated to the carina. Laser applications were deployed along the circumference of the inferior PVs from 1 edge of the shaft to the other. In case of suboptimal exposure of the inferior part of the PV ostial myocardium, the "flex-down" maneuver was applied using the deflectable sheath and pushing the inferior aspect of the EAS towards the myocardium (Fig. 2). Finally, a controlled rotation was performed to connect the ablation lines to the carina.

Reassessment of LA-PV Conduction

After completion of the initial circular ablations at all PVs, the deflated EAS was "parked" in the RIPV and the large transseptal sheath was withdrawn into the RA. The transseptal hole was cannulated using a steerable diagnostic catheter and a regular transseptal sheath was advanced over this catheter. Positioning the circular mapping catheter at the index site according to fluoroscopy, LA-PV conduction was reassessed.

If individual electrical PVI was not achieved after a single ablation circle, gap mapping was performed according to the circular mapping catheter activation sequence. The circular mapping catheter was placed distally to the inflated EAS. It was attempted to document electrical PVI real time by the circular mapping catheter during deployment of laser energy.

If the circular mapping catheter could not be placed distally to the EAS, PVI was reassessed after reablation in each quadrant. For analysis of conduction gaps, PVs that had to be reablated in all quadrants were excluded.

The endpoint for ablation was complete electrical isolation of all PVs assessed by a circular mapping catheter positioned at each PV ostium.

To further analyze the individual aspects of the procedure it was divided into 3 consecutive stages: (1) Preparation (prep stage): skin puncture to end of initial PV mapping; (2) Ablation (ablation stage): EAS insertion to last energy application of initial ablation; and (3) Gap mapping (gap stage): cannulation of transseptal hole to removal of EAS.

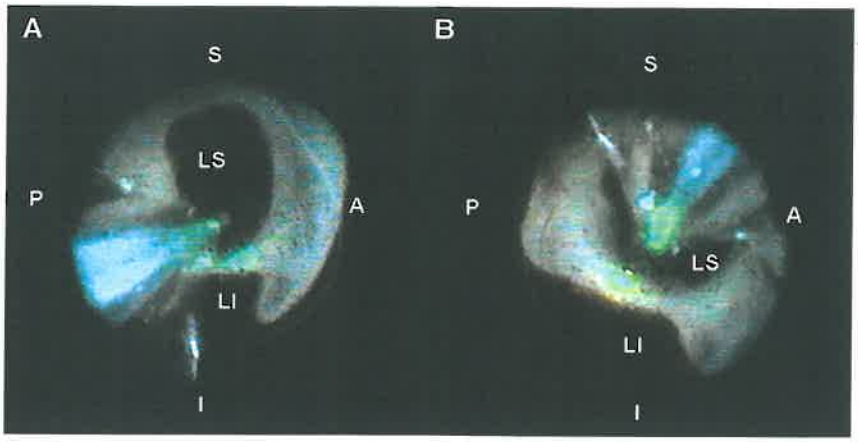

Figure 1. *Balloon maneuvers. (A) The EAS is situated at the LSPV ostium (LS) with optimal occlusion. However, the catheter shaft impedes the view to the posterior inferior quadrant and the carina. (B) After a "controlled rotation" of 180°, the carina is exposed and the circular ablation can be continued. LS = left superior PV; LI = left inferior PV; A = anterior; P = posterior; S = superior; I = inferior. The green dot is the aiming laser beam.*

Postprocedural Care

After echocardiographic exclusion of pericardial effusion, oral anticoagulation with phenprocoumon was resumed targeting an INR of 2–3 for at least 3 months. Low-molecular weight heparin was administered in a therapeutic dose until a therapeutic INR of 2–3 was reached. Antiarrhythmic drug therapy was continued for 30 days.

Study Endpoints

The primary efficacy endpoint of this study was acute PVI. The primary safety endpoint was periprocedural complications.

The secondary endpoint was freedom from AF lasting longer than 1 minute between 90 and 365 days postablation off antiarrhythmic drugs. The study protocol included a 3-month blanking period.

Follow-Up

At day 90, patients attended an outpatient visit including 24-hour Holter ECG and MRI to exclude PV stenosis. Patients were equipped with a transtelephonic ECG monitor to transmit weekly ECG or in case of symptoms suggestive of arrhythmia recurrence. At 3, 6, and 12 months, patients were scheduled for outpatient visits including a 24-hour Holter ECG.

Statistical Analysis

Data mean ± standard deviation were used to describe continuous variables with normal distribution; otherwise median and interquartile range were used. For diagnostic parameters, the absolute frequency and relative frequency were counted. For between group comparisons, parametric and nonparametric tests were used as appropriate (for details see Results). Multiple group comparisons were performed using 1-way ANOVA and Tukey's multiple comparison test.

Results

Thirty-five patients (18 male; mean age: 62 ± 9 years) were enrolled in the study. Patients had a median AF history of 4 years (q1–q3: 3–8 years) and had been treated with a mean of 2 ± 1 antiarrhythmic drugs (Table 1). Left ventricular function was normal in all patients (mean LV-EF 64 ± 7%) and mean LA size was 38 ± 5 mm. Arterial hypertension and stable coronary artery disease was present in 19 and 4 patients, respectively.

Pulmonary Vein Isolation

In 35 patients, a total of 137 PVs were treated with the EAS (4 patients with LCPVs, 2 right middle PVs [RMPVs], and 1 RCPV). In 3 PVs, acute isolation was not achieved because of phrenic nerve palsy (1 RSPV; patient #22) and because of the occurrence of pericardial tamponade after the initial ablation (1 RIPV and 1 LCPV; patient #21).

Visually Guided Circular Ablation

After an initial visually guided ablation (ablation stage) 96 of 137 PVs (70%) were isolated. Isolation rate was 1 of 4 for LCPV (25%), 23 of 31 (74%) for LSPV, 23 of 31 (74%) for LIPV, 1 of 1 (100%) for RCPV, 2 of 2 (100%) for RMPV, 24 of 34 (71%) for RSPV, and 22 of 34 (65%) for RIPV,

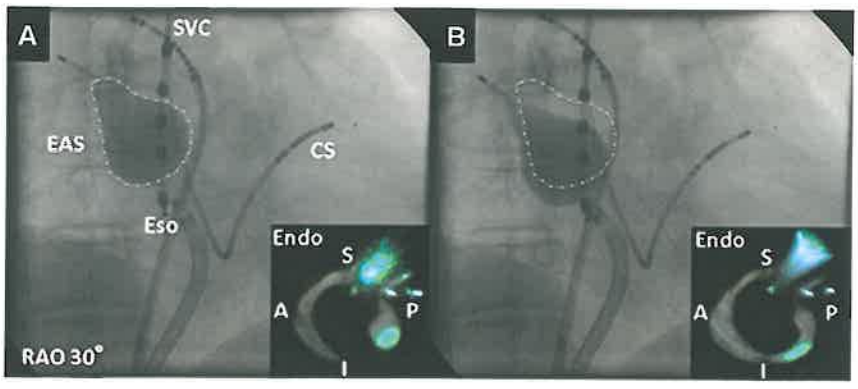

Figure 2. *Flex-down maneuver. The balloon catheter (EAS) is located at the right common PV (RCPV). As shown in the endoscopic view (Endo) the inferior aspect of the ostium is imperfectly sealed. After deflection and pull down of the sheath occlusion of the inferior ostium is achieved and circular ablation completed. The dotted line indicated the initial balloon position. CS = coronary sinus; Eso = temperature probe in the esophagus; SVC = pacing catheter in the superior vena cava. A = anterior; S = superior; P = posterior; I = inferior.*

TABLE 1
Patient Characteristics

Number of Patients	35
Gender	F: 17, M: 18
Age (years)	62 ± 9
Type of AF	PAF: 31, Pers: 4
Median duration of AF (q1:q3) (years)	4 (3–8)
Median # of failed AAD (q1;q3)	2 (1–2)
LV-EF (%)	64 ± 7
LA size (mm)	38 ± 5

AAD = antiarrhythmic drug; F = female; LA = left atrium; LV-EF = left-ventricular ejection fraction; M = male; PAF = paroxysmal atrial fibrillation; pers = persistent AF.

respectively (Fig. 3). The difference in acute isolation rate was not significantly different among PVs (1-way ANOVA with Dunn's multiple comparison test). In 13 of 35 (37%) patients, PVI was achieved in all PVs opposed to 3 of 30 patients (10%; patients # 2, #6, and #8) in whom no PV was isolated after the initial lesion set.

The mean number of laser applications during the initial ablation was 48 ± 17 at LCPV, 34 ± 6 at LSPV, 26 ± 5 at LIPV, 29 ± 7 at RSPV, and 27 ± 6 at RIPV, respectively.

Gap Mapping and Analysis of Conduction Gaps

For 41 PVs, touch-up ablation was required using the EAS. However, 3 PVs were not reablated after the initial ablation because of procedural complications. In addition, for 3 PVs an analysis was not feasible because of software failure (no images stored). For the remaining 35 PVs, gap localization was unambiguous in 24 (69%; Fig. 4).

At the LSPV, all 4 gaps were located anterior and 3 of 4 gaps were located in the AI quadrant at the myocardial ridge separating the PV from the LA appendage, despite the fact that the total ablation energy was significantly higher in AI as compared to all other quadrants (1,743 ± 422 Watt-seconds AI: vs 1,196 ± 324 AS: vs 1,190 ± 348 PS: vs 1,408 ± 552 PI; P < 0.05; 1-way ANOVA with Tukey's multiple comparison test). A significantly fewer number of applications were deployed in the AS quadrant compared to

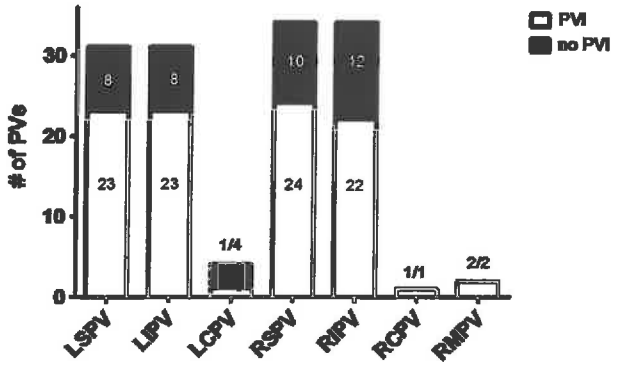

Figure 3. *Results of visually guided ablation. The acute isolation rate was not statistically significant different among PVs (1-way ANOVA, Kruskal Wallis).*

AI and PI (AS: 7 ± 2 vs AI: 10 ± 3 vs PI: 9 ± 3; P < 0.05; 1-way ANOVA with Tukey's multiple comparison test).

At the LIPV, 5 of 6 (83%) gaps were located at the posterior wall. Similarly, at the RIPV 5 of 6 (83%) conduction gaps were located at the posterior LA wall. At the RSPV, gaps were also located posterior in 6 of 7 (86%) patients. No statistical differences in application number and total ablation energy were found comparing the 4 quadrants for LIPV, RSPV, and RIPV.

Imperfect sealing (blood spilling; n = 7), an obstructed view (n = 3), or an esophageal heat rise (n = 4), were detected at the incompletely isolated PV quadrant during the initial visually guided ablation, respectively. The reason for the remaining 10 conduction gaps was undetermined.

Predictors of Successful PVI

The median degree of the initial occlusion was significantly better in PVs that were isolated (1; q1–q3: 1–2) after the initial visually guided ablation compared to PVs that were not isolated (2; 1–3; P = 0.04; Mann–Whitney test; Fig. 5). Similarly, the mean number of catheter repositionings during the initial circular ablation was significantly different (1.6 ± 1 vs 2.2 ± 1.2; P = 0.005; unpaired *t*-test).

In contrast, the mean number of laser applications per PV (29 ± 7 vs 29 ± 10; P = 0.97; unpaired *t*-test) and the total amount of energy deployed per PV (4,849 ± 1,372 Watt-seconds vs 4,610 ± 1,780 Watt-seconds; P = 0.41; unpaired *t*-test) did not significantly differ among isolated PVs and PVs with residual PV spikes.

Procedural Parameters

The mean total procedure time was 154 ± 38 minutes composed of 3 stages: (1) prep stage 34 ± 8 minutes, (2) ablation stage 89 ± 16, and (3) gap stage 31 ± 30 minutes. The mean fluoroscopy time was 16 ± 6 minutes: (1) 4 ± 2 minutes; (2) 6 ± 3 minutes; and (3) 4 ± 3 minutes. A clear learning curve was observed including a significant reduction in procedure time between the first 12 and the last 12 patients (175 ± 48 minutes vs 138 ± 26 minutes; P = 0.05; paired *t*-test).

The major determinant of procedure duration was gap mapping (Fig. 6). A statistically significant difference in total procedure time (235 ± 9 minutes vs 126 ± 17 minutes; P ≤ 0.001; 1-way ANOVA with Tukey's multiple comparison test) and gap stage duration (103 ± 33 minutes vs 9 ± 5 minutes; P = 0.001) between patients with 0 and 4 isolated PVs was observed whereas duration of prep stage (36 ± 15 minutes vs 31 ± 8 minutes; P = 0.43) and ablation stage (96 ± 21 minutes vs 86 ± 16 minutes; P = 0.44) was not statistically different.

Complications

In 2 patients periprocedural complications occurred. In patient #21, a right-sided phrenic nerve palsy occurred whereas lasing at the anterior superior quadrant of the RSPV. The ablation at the RSPV was, therefore, not completed. During a follow-up of 3 months nerve function has partially recovered.

In patient #22, pericardial tamponade occurred after completion of the ablation stage. It was managed by pericardiocentesis and did not require surgical intervention. Although, insertion of the steerable transseptal sheath into the LA was difficult because the guidewire dislodged out of the LSPV,

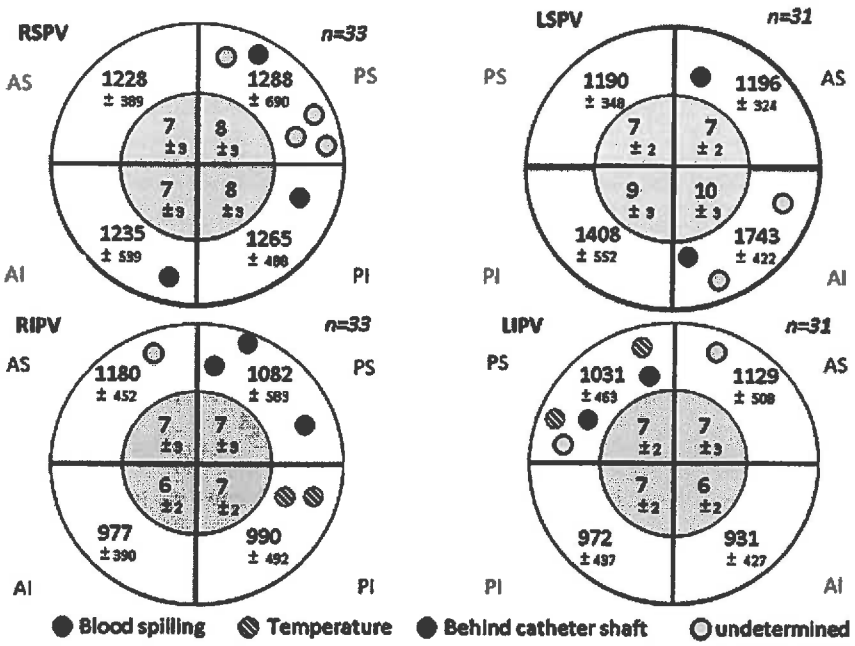

Figure 4. *Ablation results and gap locations. Each circle represents a PV divided in 4 quadrants. The numbers in the outer and inner circle give the total amount of ablation energy (Mean ± SD; [Ws]) and the mean number of applications for each quadrant after the initial visually guided ablation, respectively. The dots indicate the gap location and the particular event during the initial ablation.*

the exact reason for the mechanical complication remained unknown. The time interval from sheath insertion and hemodynamic compromise was >60 minutes.

Follow-Up

During a median follow-up of 266 days (q1–q3 218–389 days), 27 patients (77%) remained in stable sinus rhythm off antiarrhythmic drugs. No PV stenosis was detected by MRI 3 months postablation.

Discussion

Recently, the EAS has been described as a novel technology to perform PVI in patients with PAF.[6–8] The aim of this study was (1) to test the hypothesis that PVI can be achieved using a purely visually guided approach with a single ablation device and a single transseptal puncture, (2) to develop techniques to facilitate PVI, and (3) to analyze predictors of acute procedural success.

Purely Visually Guided PVI

With increasing popularity of catheter ablation as a treatment modality for PAF and its widespread use outside specialized ablation centers the desire for simple ablation technologies grows.

Attempts to dispense the circular mapping catheter with the standard PVI approach using a 3D mapping system led to disappointing results.[3] Only 42% of the LPVs were isolated after visually guided circumferential ablation using 3D mapping.[4] This might partly be explained by difficult catheter navigation for point-by-point ablation and insufficient catheter to tissue contact as shown by the results of the TOCCATA trial demonstrating that a substantial number of ablations were performed with a contact force of less than 5 g.[9]

The EAS may compensate for these disadvantages with easier navigation properties (single movements to the individual PV) and its compliant balloon, providing optimal catheter to tissue contact. In this study, 70% of all PVs were isolated by a purely visually guided ablation with a single transseptal puncture and a single ablation device. The ability to endoscopically visualize the periostial myocardium allows for precise deployment of ablation energy. Further analysis revealed that optimal contact and stable catheter positioning were important predictors of acute PV isolation rather than the total ablation energy. This calls into question the assumption that a lack of contact may be compensated by more laser ablation energy.

The carina seems to be of particular importance to achieve permanent PVI and to eliminate AF triggers.[10,11] However, navigating a tip catheter on the narrow myocardial ridge between the ipsilateral PVs is challenging.[12] Endoscopic visualization of the carina region allows for its precise ablation and may thus be of additional benefit.

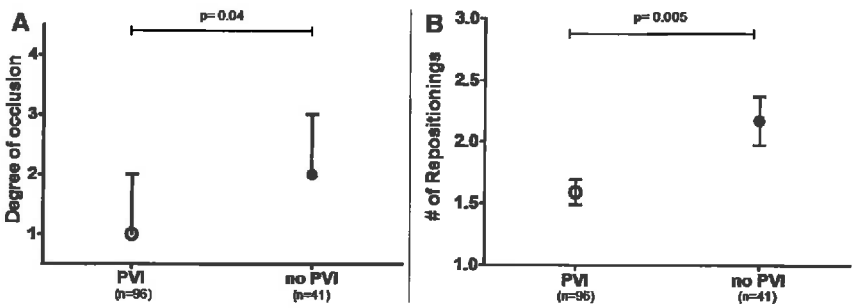

Figure 5. *Predictors of acute PVI. (A) The initial PV occlusion was significantly better in isolated PVs than in nonisolated PVs. (B) The number of repositionings was significantly lower in isolated PVs than in nonisolated PVs.*

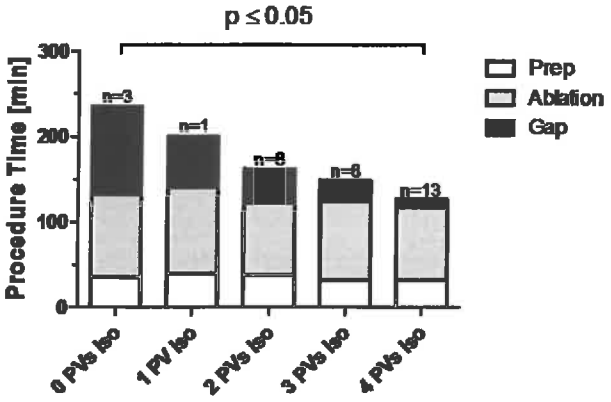

Figure 6. *Procedure time according to initial ablation success. The total procedure time was divided into 3 stages. Prep stage and ablation stage did not significantly differ among groups whereas gap stage was significantly longer if no PV was isolated after visual guided ablation compared to 3 or 4 isolated PVs (1-way ANOVA). Patient #21 and #22 were excluded from this analysis (see text for details).*

In contrast to other balloon technologies, a single device seemed to be sufficient to finally isolate 98% of all PVs including anatomical variants such as common PV ostia and supplemental PV variants such as RMPVs. In the largest trial using the cryoballoon, only 92.5% of PVs were isolated requiring 2 different balloon sizes or focal touch-up ablation in a substantial number of patients.[5]

Gap Mapping

All PVs were isolated with similar success rates demonstrating the amiable navigation properties and adaptive conformance to the individual anatomy. Unlike other balloon technologies that exhibit a characteristic conduction gap pattern at the inferior PVs, the distribution of initially nonisolated PVs seems more random.[13] However, in 14 of 23 cases the presence of gaps seemed to be associated with impeded energy transfer to the tissue caused by suboptimal occlusion, suboptimal visualization because of the catheter shaft or aborted applications because of esophageal temperature rise. Interestingly, despite a higher number of laser applications and more energy applied to the AI quadrant of the LSPV, this region was the dominant site of residual LA-PV conduction. This indicates the difficulty to achieve transmural ablation lesions because of the particular anatomic properties of this region.[14,15] Future studies using EAS need to determine the optimal ablation energy to achieve contiguous transmural lesions.

Techniques to Facilitate PVI

The use of balloon catheters for AF ablation requires special techniques to achieve complete electrical PVI. In this study, a systematic ablation approach was developed that facilitated to accomplish the procedural endpoint. Different approaches aiming at circumferential PVI encircling both ipsilateral PVs have been described but were associated with prolonged procedure times and the need for double transseptal puncture.[8] Future studies may provide further insights into the individual long-term success rates.

Procedural Parameters

The study revealed that the procedure duration is determined by the presence of nonisolated PVs after an initial visual guided ablation and the need for gap mapping. The inability to record local electrograms with the EAS and the lack of reliable 3D information on lesion location aggravate the gap mapping approach. This was partly compensated for by the insertion of a circular mapping catheter distally to the inflated EAS. However, at individual PVs a novel circular ablation rather than focal completion of an incomplete line were required to achieve PVI. Future developments may focus on lesion visualization or the ability to simultaneously record PV electrograms distal to the balloon by a circular mapping catheter advanced in a central lumen, as previously reported.[16]

It was clearly demonstrated that the operators progressed through a learning curve resulting in significantly reduced procedure times, which compare favorably to standard radiofrequency current (RFC)-based procedures.

Complications

Balloon-based AF ablations are associated with a substantial number of phrenic nerve injuries. In this patient, series 1 patient experienced phrenic nerve palsy that partially recovered after 3 months. This matches the relative risk of 3% recently described from a worldwide experience including the first 200 patients treated with EAS.[17] In the same series the risk of cardiac tamponade was 2% including the learning curve of 33 different operators.

Limitations

The aim of this study was to determine predictors of acute procedural success to develop a standardized approach for a novel technology. Given the study's short follow-up time, little information on chronic success rates is presently available. Recently, Metzner *et al.* published a 60% chronic success rate after circumferential PVI using EAS.[18] Future trials, in particular randomized trials comparing the EAS with other energy sources, are needed.

Conclusion

Sequential PVI based solely on endoscopic visual information with a single device and a single transseptal puncture is feasible using standardized ablation techniques. Optimal PV occlusion and few controlled repositionings facilitate reproducible electrical PVI. However, mapping residual conduction gaps after a single circular ablation significantly prolongs procedure times

Acknowledgments: We thank our study nurse Mrs. Ines Timmermanns for perfect data collection and completion of CRFs.

References

1. Calkins H, Brugada J, Packer DL, Cappato R, Chen SA, Crijns HJ, Damiano RJ Jr, Davies DW, Haines DE, Haissaguerre M, Iesaka Y, Jackman W, Jais P, Kottkamp H, Kuck KH, Lindsay BD, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Natale A, Pappone C, Prystowsky E, Raviele A, Ruskin JN, Shemin RJ: HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for personnel, policy, procedures and follow-up. A report of the Heart Rhythm Society (HRS)

Task Force on Catheter and Surgical Ablation of Atrial Fibrillation developed in partnership with the European Heart Rhythm Association (EHRA) and the European Cardiac Arrhythmia Society (ECAS); in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), and the Society of Thoracic Surgeons (STS). Endorsed and approved by the governing bodies of the American College of Cardiology, the American Heart Association, the European Cardiac Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, and the Heart Rhythm Society. Europace 2007;9:335-379.

2. Ouyang F, Bansch D, Ernst S, Schaumann A, Hachiya H, Chen M, Chun J, Falk P, Khanedani A, Antz M, Kuck KH: Complete isolation of left atrium surrounding the pulmonary veins: New insights from the double-Lasso technique in paroxysmal atrial fibrillation. Circulation 2004;110:2090-2096.
3. Hocini M, Sanders P, Jais P, Hsu LF, Weerasoriya R, Scavee C, Takahashi Y, Rotter M, Raybaud F, Macle L, Clementy J, Haissaguerre M: Prevalence of pulmonary vein disconnection after anatomical ablation for atrial fibrillation: Consequences of wide atrial encircling of the pulmonary veins. Eur Heart J 2005;26:696-704.
4. Furnkranz A, Julian JK, Schmidt B, Wohlmuth P, Tilz R, Kuck KH, Ouyang F: Ipsilateral pulmonary vein isolation performed by a single continuous circular lesion: Role of pulmonary vein mapping during ablation. Europace 2011;13:935-941.
5. Neumann T, Vogt J, Schumacher B, Dorszewski A, Kuniss M, Neuser H, Kurzidim K, Berkowitsch A, Koller M, Heintze J, Scholz U, Wetzel U, Schneider MA, Horstkotte D, Hamm CW, Pitschner HF: Circumferential pulmonary vein isolation with the cryoballoon technique results from a prospective 3-center study. J Am Coll Cardiol 2008;52:273-278.
6. Reddy VY, Neuzil P, Themistoclakis S, Danik SB, Bonso A, Rossillo A, Raviele A, Schweikert R, Ernst S, Kuck KH, Natale A: Visually-guided balloon catheter ablation of atrial fibrillation: Experimental feasibility and first-in-human multicenter clinical outcome. Circulation 2009;120:12-20.
7. Dukkipati SR, Neuzil P, Skoda J, Petru J, D'Avila A, Doshi SK, Reddy VY: Visual balloon-guided point-by-point ablation: Reliable, reproducible, and persistent pulmonary vein isolation. Circ Arrhythm Electrophysiol 2010;3:266-273.
8. Schmidt B, Metzner A, Chun KR, Leftheriotis D, Yoshiga Y, Fuernkranz A, Neven K, Tilz RR, Wissner E, Ouyang F, Kuck KH: Feasibility of circumferential pulmonary vein isolation using a novel endoscopic ablation system. Circ Arrhythm Electrophysiol 2010;3:481-488.
9. Schmidt B, Reddy VY, Natale A, Shah D, Soudi N, Herrera C, Hindricks G, Jais P, Yulzari A, Kuck KH, Lambert H: TOCCATA Multi-Centre Clinical Study: Irrigated RF ablation catheter with an integrated Contact Force Sensor–long-term results. Heart Rhythm 2010;7:1-5.
10. Valles E, Fan R, Roux JF, Liu CF, Harding JD, Dhruvakumar S, Hutchinson MD, Riley M, Bala R, Garcia FC, Lin D, Dixit S, Callans DJ, Gerstenfeld EP, Marchlinski FE: Localization of atrial fibrillation triggers in patients undergoing pulmonary vein isolation: Importance of the carina region. J Am Coll Cardiol 2008;52:1413-1420.
11. Udyavar AR, Chang SL, Tai CT, Lin YJ, Lo LW, Tuan TC, Tsao HM, Hsieh MH, Hu YF, Chiang SJ, Chen YJ, Wongcharoen W, Higa S, Ueng KC, Chen SA: The important role of pulmonary vein carina ablation as an adjunct to circumferential pulmonary vein isolation. J Cardiovasc Electrophysiol 2008;19:593-598.
12. Schmidt B, Ernst S, Ouyang F, Chun KR, Broemel T, Bansch D, Kuck KH, Antz M: External and endoluminal analysis of left atrial anatomy and the pulmonary veins in three-dimensional reconstructions of magnetic resonance angiography: The full insight from inside. J Cardiovasc Electrophysiol 2006;17:957-964.
13. Furnkranz A, Chun KR, Nuyens D, Metzner A, Koster I, Schmidt B, Ouyang F, Kuck KH: Characterization of conduction recovery after pulmonary vein isolation using the "single big cryoballoon" technique. Heart Rhythm 2010;7:184-190.
14. Wittkampf FH, van Oosterhout MF, Loh P, Derksen R, Vonken EJ, Slootweg PJ, Ho SY: Where to draw the mitral isthmus line in catheter ablation of atrial fibrillation: Histological analysis. Eur Heart J 2005;26:689-695.
15. Cabrera JA, Ho SY, Climent V, Sanchez-Quintana D: The architecture of the left lateral atrial wall: A particular anatomic region with implications for ablation of atrial fibrillation. Eur Heart J 2008;29:356-362.
16. Chun KR, Furnkranz A, Metzner A, Schmidt B, Tilz R, Zerm T, Koster I, Nuyens D, Wissner E, Ouyang F, Kuck KH: Cryoballoon pulmonary vein isolation with real-time recordings from the pulmonary veins. J Cardiovasc Electrophysiol 2009;20:1203-1210.
17. Reddy VY, Dukkipati SR, Neuzil P, Natale A, Schmidt B, Woollett I, McElderry HT, Kuck KH: Pulmonary vein isolation using the visually guided laser balloon: The first 200-patient multicenter clinical experience. Heart Rhythm 2011;8:S80.
18. Metzner A, Schmidt B, Fuernkranz A, Wissner E, Tilz RR, Chun KR, Neven K, Konstantinidou M, Rillig A, Yoshiga Y, Mathew S, Koester I, Ouyang F, Kuck KH: One-year clinical outcome after pulmonary vein isolation using the novel endoscopic ablation system in patients with paroxysmal atrial fibrillation. Heart Rhythm 2011;8:988-993.