Incidence of ablation-induced esophageal injury associated with high-power short duration temperature-controlled pulmonary vein isolation using a specialized open-irrigated ablation catheter: A retrospective single-center study

Robert Piringer¹ | Thomas Deneke MD, FHR² | Borek Foldyna MD³,⁴ | Kai Sonne MD² | Karin Nentwich MD² | Elena Ene MD² | Sebastian Barth MD² | Ulrich Lüsebrink MD⁵ | Artur Berkovitz MD² | Philipp Halbfass MD²,⁵

¹Philipps-University Marburg, Marburg, Germany
²Clinic for Invasive Electrophysiology, Heart Center Bad Neustadt, Bad Neustadt a.d. Saale, Germany
³Clinic for Diagnostic and Interventional Radiology, Heart Center Bad Neustadt a.d. Saale, Bad Neustadt a.d. Saale, Germany
⁴Cardiovascular Imaging Research Center, Massachusetts General Hospital - Harvard Medical School, Boston, Massachusetts, USA
⁵Department of Cardiology and Angiology, Philipps-University Marburg, Marburg, Germany

Correspondence
Philipp Halbfass, Clinic for Invasive Electrophysiology, Heart Center Bad Neustadt, Von-Guttenberg-Strasse 11, 97616 Bad Neustadt a.d. Saale, Germany. Email: philipp.halbfass@campus-nes.de

Disclosures: None.

Abstract

Introduction: To evaluate short-term efficacy and incidence of ablation-induced endoscopically detected esophageal injury in patients undergoing high-power, short-duration (HPSD) pulmonary vein isolation using a novel irrigated radiofrequency ablation catheter and ablation generator setup.

Methods and Results: Atrial fibrillation (AF) patients, who underwent AF ablation using an irrigated radiofrequency ablation catheter specifically designed for a HPSD ablation approach (50 W, with a target Ablation Index of 350 at posterior wall), received postablation esophageal endoscopy after ablation. In total 45 consecutive patients (67 ± 10 years; 58% male; 42% paroxysmal AF) undergoing AF ablation using a specialized ablation catheter (QDOT) were included in the study. Thirty-one of 45 patients (69%) underwent a first-time pulmonary vein isolation (Group 1, 67 ± 11 years; 55% male; 48% paroxysmal AF). Fourteen patients (31%) underwent a redo AF procedure (Group 2, 66 ± 8 years; 64% male; 29% paroxysmal AF). Patients undergoing first-time pulmonary vein isolation were included in the final analysis. In these patients an endoscopically detected esophageal lesion (EDEL) was detected in 5 of 31 (16%) patients (erosion n = 2, ulcer n = 3). Mean contact force at posterior wall ablation sites was significantly lower in patients with postprocedural EDEL compared with patients without EDEL (11.9 ± 0.8 g vs. 15.6 ± 4.7 g).

Conclusion: PVI using a specialized high-power ablation catheter in conjunction with a HPSD ablation approach results in a 16% incidence of EDEL in first AF ablation candidates. Future studies evaluating high-power short duration ablation strategies should include esophageal endoscopy to estimate the risk of clinically relevant esophageal complications.

Keywords
atrial fibrillation, endoscopically detected esophageal lesion, high-power short duration ablation, pulmonary vein isolation, QDOT ablation catheter

[Correction added on 13 March 2021, after first online publication: Projekt Deal funding statement has been added.]
1 | INTRODUCTION

Efficacy and safety of catheter ablation in patients with paroxysmal and persistent atrial fibrillation have increased substantially over the last two decades. However, pulmonary vein reconnection limiting long-term success on the one hand and relevant peri-procedural complications like cardioembolic events and ablation-induced esophageal injury on the other hand are clinically relevant procedure-related problems.

Recent efforts have focused on modifying ablation energy, ablation time, and combinations of different ablation parameters to increase acute and long-term success and limit the incidence of esophageal lesions. Endoscopy is feasible to detect ablation induced esophageal lesions. Endoscopically detected esophageal lesions (EDEL) are considered a surrogate parameter for the risk of clinically relevant esophageal complications like perforation and fistula. According to pre-existing literature the incidence of atrio-esophageal fistula after atrial fibrillation (AF) ablation was below 0.2%, whereas another study found an incidence of atrio-esophageal fistula and esophageal perforation of up to 0.6% in patients undergoing post-ablation esophageal endoscopy. A novel approach aims to overcome these limitations by using high-power and short duration (HPSD) radio-frequency ablation. The QDOT Fast Trial, using an ablation setup of 90 W and 4 s per lesion, one endoscopically detected injury—that is, an esophageal ulcer—occurred, resulting in a relatively low rate of esophageal lesions of only 2%. To the best of our knowledge no studies evaluating the incidence of EDEL when using the QDOT Micro ablation catheter in conjunction with different energy and ablation time settings have been published so far. A unique characteristic of the QDOT ablation catheter is, that thermocouples are placed directly at the catheter tip and tissue interface. This enables acquisition of tissue temperature directly beneath the catheter tip. In a temperature controlled ablation mode the risk of tissue-overheating or steam-pops could possibly be reduced compared with the use of conventional ablation catheters.

Aim of the current study was to characterize the safety profile of a HPSD strategy using the same ablation catheter but lower energy settings compared with the QDOT Fast Trial.

2 | METHODS

Consecutive patients undergoing an AF ablation procedure using a novel ablation catheter (QDOT Micro; Biosense Webster) from November 2019 to February 2020 at our institution were included. The study was approved by the local institutional review board. All patients gave informed consent to the ablation procedure and postablation diagnostics. According to our standard approach all patients underwent postablation endoscopy on the day after ablation to identify thermal esophageal injury related to AF ablation.

2.1 | Atrial fibrillation ablation procedure

All procedures were performed using a three-dimensional electro-anatomic mapping system (CARTO 3, BiosenseWebster) under analgo-sedation using continuous propofol infusion in conjunction with morphine derivatives. In Group 1 patients (de-novo AF ablation) all patients were treated with complete wide antral pulmonary vein isolation (PVI). Isolation of the ipsilateral PVs was performed with point-by-point lesions. Group 2 patients (redo AF ablation) underwent re-isolation of PVs by ablating all identified gaps within the previous antral ablation lines to re-isolate all reconnected PVs. Following our standard approach the superior caval vein was isolated additionally in this group. In both groups ablations were done using a specialized single-electrode RF ablation catheter type with open catheter-tip irrigation (QDOT Micro; Biosense Webster; Figure 1). Following a modified ablation protocol including a generator set up with 50 W without power limitation at posterior wall and target contact force was between 10 and 20 g. Of note, we used a target ablation index of 350 at posterior wall sites and 450 at all other ablation sites (Figure 2). At posterior wall as well as at nonposterior wall sites ablation lesions were placed next to each other to form a line of contiguous lesions. Ablation procedures were performed by experienced operators each having performed more than 1000 AF ablation procedures. No esophageal temperature monitoring or mechanical esophageal deviation devices were used.

2.2 | Postablation esophageal endoscopy

Esophageal endoscopy (EE) was performed by experienced operators (having performed >3000 post-AF-ablation endoscopies) on the next day after ablation to assess for the presence and extent of EDEL. EDEL were categorized into mild (Category 1 lesion: erythema/erosion or ulcers ≤ 5 mm diameter) or severe (Category 2 lesion: ulcer > 5 mm diameter) based on our prior clinical experience.

2.3 | Postprocedural treatment

All patients received proton pump inhibitors in double standard dose for 6 weeks postprocedurally. In case of EDEL, control endoscopy was performed within 7 days. Patients with Category 2 lesions received a liquid diet until regression of EDEL was confirmed in a repeat endoscopy during the initial hospital stay.

2.4 | Statistical analysis

The data are expressed as mean ± SD for continuous variables or as frequencies and percentages for categorical variables. To compare continuous and categorical variables between those with and without EDEL, we used t-test or Fisher’s exact test as appropriate. Two-sided
p-values of less than .05 were considered statistically significant. All statistical analyses were performed using GraphPad Prism 8 (GraphPad Software).

3 | RESULTS

A total of 45 patients (67 ± 10 years; 58% male; 42% paroxysmal AF) were included in the study. In total 14/45 (31%) patients underwent a redo AF ablation procedure due to AF recurrence. In 9/14 (64%) patients additional left and right atrial RF ablation was performed. In eight patients isolation of the superior caval vein was done additionally to re-isolation of PVs. In two patients a box lesion at posterior left atrial (LA) wall and in six patients additional lines not at posterior wall sites were applied due to occurrence of a LA macro reentrant tachycardia. Of note, 31/45 (69%) patients receiving a first AF ablation procedure were included in the final analysis (67 ± 11 years; 55% male; 48% paroxysmal AF). Patient characteristics of the complete study cohort are shown in Table 1 and the group of patients undergoing first-time AF ablation are shown in Table 2. In all 31 patients effective pulmonary vein isolation with bidirectional block was achieved at the end of the procedure.

3.1 | Incidence of EDEL

In Group 1 patients endoscopy was done on the day after the procedure in all 31 patients. In 5/31 (16%) patients EDEL was detected on postablation endoscopy (Category 1: erosion \( n = 2 \), Category 2: ulcer \( n = 3 \); Figure 3). The 3/14 (21%) Group 2 patients did not undergo postprocedural endoscopy due to a lack of ablation at posterior wall. None of 11 patients with postprocedural endoscopy showed a thermal lesion. The group of patients undergoing first-time PVI and the group undergoing a redo ablation procedure did not differ significantly regarding procedural parameters (Table 3).

Patient characteristics in the group of patients with postprocedural EDEL and in the group of patients without EDEL did not differ significantly regarding patient characteristics (Table 2). Of
note, all patients demonstrating EDEL were clinically completely asymptomatic.

### 3.2 Comparison of procedural parameters in EDEL positive and EDEL negative patients

Regarding patient characteristics including comorbidities like coronary artery disease, diabetes mellitus and arterial hypertension, no statistically significant differences were found between patients with and without EDEL (Table 2). When comparing procedural parameters, that is, procedure time, total ablation time and ablation time at posterior wall, mean ablation index (AI) per lesion, mean ablation temperature, and mean contact force at posterior wall in patients with and without EDEL only the variable mean contact force at posterior wall showed a significant difference. Interestingly, mean contact force at posterior wall was significantly higher in patients without esophageal lesions in postprocedural esophageal endoscopy compared with patients with EDEL (15.6 ± 4.7 g vs. 11.9 ± 0.8 g; p = .001).

### Table 1 Patient characteristics of patients undergoing a first-time and a redo AF ablation procedure

|                      | Patient group first-time ablation n = 31 (69%) | Patient group redo ablation n = 14 (31%) | All patients n = 45 | p value |
|----------------------|-----------------------------------------------|------------------------------------------|---------------------|---------|
| Age in years         | 66.9 ± 10.7                                   | 66.4 ± 8.5                               | 66.8 ± 10.0         | .85     |
| Sex: male n (%)      | 17 (55)                                       | 9 (64)                                   | 26 (58)             | .75     |
| BMI                  | 28.8 ± 5.0                                    | 26.4 ± 2.0                               | 28.1 ± 4.4          | .03     |
| Paroxysmal AF, n (%) | 15 (48)                                       | 4 (29)                                   | 19 (42)             | .33     |
| LA (cm²)             | 25.8 ± 5.1                                    | 25.6 ± 3.9                               | 25.7 ± 4.7          | .92     |
| LVEF (%)             | 53.5 ± 14.3                                   | 53.9 ± 15.0                              | 53.7 ± 14.4         | .94     |
| CHA²DS²-Vasc Score   | 2.7 ± 1.5                                     | 2.4 ± 1.7                                | 2.6 ± 1.6           | .56     |
| Hypertension, n (%)  | 28 (86%)                                      | 12 (86%)                                 | 40 (89%)            | .64     |
| CAD, n (%)           | 12 (39%)                                      | 5 (36%)                                  | 17 (38%)            | 1.0     |
| Diabetes, n (%)      | 4 (13%)                                       | 1 (7%)                                   | 5 (11%)             | 1.0     |
| Prior stroke/TIA, n (%) | 4 (13%)                                 | 2 (14%)                                  | 6 (13%)             | 1.0     |

**Abbreviations:** AF, atrial fibrillation; BMI, body mass index; CAD, coronary artery disease; LA, left atrial; LVEF, left ventricular ejection fraction; TIA, transient ischemic attack.

### Table 2 Patient characteristics of patients undergoing a first-time AF ablation procedure

|                      | Patients with EDEL n = 5 (16%) | Patients without EDEL n = 26 (84%) | All patients n = 31 | p value |
|----------------------|-------------------------------|-------------------------------------|---------------------|---------|
| Age in years         | 63.0 ± 18.6                   | 67.7 ± 8.8                          | 66.9 ± 10.7         | .61     |
| Sex: male n (%)      | 2 (40)                        | 15 (58)                             | 17 (55)             | .64     |
| BMI                  | 29.7 ± 7.9                    | 28.6 ± 4.4                          | 28.8 ± 5.0          | .77     |
| Paroxysmal AF, n (%) | 4 (80%)                       | 11 (42%)                            | 15 (48%)            | .17     |
| LA (cm²)             | 27.0 ± 3.2                    | 25.6 ± 5.4                          | 25.8 ± 5.1          | .49     |
| LVEF (%)             | 62.0 ± 4.5                    | 51.9 ± 15.0                         | 53.5 ± 14.3         | <.01    |
| CHA²DS²-Vasc Score   | 2.4 ± 2.3                     | 3.3 ± 1.6                           | 3.1 ± 1.7           | .45     |
| Hypertension, n (%)  | 3 (60%)                       | 24 (92%)                            | 27 (87%)            | .11     |
| CAD, n (%)           | 0                             | 12 (46%)                            | 12 (39%)            | .13     |
| Diabetes, n (%)      | 1 (20%)                       | 3 (12%)                             | 4 (13%)             | .53     |
| Prior stroke/TIA, n (%) | 1 (20%)                     | 1 (4%)                              | 2 (7%)              | .30     |

**Abbreviations:** AF, atrial fibrillation; BMI, body mass index; CAD, coronary artery disease; EDEL, endoscopically detected esophageal lesions; LA, left atrial; LVEF, left ventricular ejection fraction; TIA, transient ischemic attack.
3.3 | Adverse events and follow-up

No clinically relevant intra-procedural adverse events were reported. Mean follow-up was 106 ± 29 days. During follow-up two adverse events—one fatal adverse event—were reported in patients after a first-time AF ablation (2/31, 6%). A female patient (75 years, ischemic cardiomyopathy, EF 20% at the time of procedure) experienced a progression of pre-existing congestive heart failure and died after implantation of a left ventricular assist device 53 days after AF ablation procedure. Of note, the patient was in AF at the time of re-hospitalization. This adverse event was not assumed to be related to the ablation procedure. Another patient (male, 71 years) experienced a subdural hematoma after recurrent orthostatic syncope 102 days after AF ablation, which was also not related to the ablation procedure. This patient was treated conservatively and recovery without clinical relevant sequelae was reported. None of these two patients showed EDEL in postablation endoscopy. None of the patients demonstrating EDEL in postablation endoscopy were symptomatic during follow-up. None of the patients included in the study experienced a severe esophageal complication like atrio-esophageal fistula or esophageal perforation.

At the time of FU 24/31 (77%) patients off antiarrhythmic drugs were in sinus rhythm in Group 1, whereas 8 of 14 Group 2 patients were in sinus rhythm during follow-up.

4 | DISCUSSION

Major findings of this retrospective single-center study are as follows: first, the use of a novel radio-frequency ablation catheter optimized for high-power short duration ablation in conjunction with a high-power short duration ablation approach using 50 W resulted in a relevant number of EDEL of 16% despite using a clearly defined target ablation index value at posterior LA wall. Of note, all patients experiencing EDEL (including Category 2 lesions) were completely asymptomatic. Second, none of the Group 2 patients undergoing a redo AF ablation procedure experienced EDEL in postprocedural endoscopy. And third, the average contact force at posterior wall was significantly lower in patients with compared with patients without EDEL.

Over the past decade modifications of catheter ablation strategies aimed at improving safety and efficacy of AF catheter ablation. Introduction of contact force measurement was one of the milestones relevantly influencing safety and efficacy. An optimized catheter cooling technique further improved ablation success. However, despite these achievements the problem of AF recurrence mostly driven by PV reconnection and the risk of serious adverse events still remain relevant issues of catheter ablation in patients with AF.

Due to the risk of potentially fatal esophageal injury ablation energy at posterior LA wall needs careful titration. The optimal ablation power and ablation time at posterior LA wall to safely avoid collateral esophageal damage on the one hand and to achieve durable contiguous ablation lesions on the other hand are still unknown. Using radiofrequency catheter ablation with moderate ablation power and longer ablation times results in a relevant number of EDEL. Very high-power short duration ablation seemed not to be associated with EDEL according to a small prospective study. However, whether this holds true for a larger number of patients treated in a real-world setting still has to be proven in larger studies and registries.
The approach of our study was to reduce the target ablation power at the cost of an increase in ablation time compared with very high-power short duration ablation strategies. A target ablation index of 350 at posterior wall ablation sites in conjunction with a target ablation power of 50 W was used. An ablation power of 50 W was higher compared with standard ablation protocols using between 20 and 35 W at posterior wall but relevantly lower compared with 70–90 W used in very high-power short duration ablation studies.\(^5\)\(^7\)

Of note, the incidence of EDEL resulting from an ablation approach using one set of ablation parameters and one ablation catheter type is not transferrable to other approaches using different sets of parameters and ablation catheters.\(^5\)\(^7\)\(^9\) Furthermore, ablation index was not evaluated in the setting of a high-power short-duration ablation strategy so far. Therefore, the relatively high incidence of EDEL might also be a result of a longer ablation duration per lesion compared with other high-power short-duration ablation trials. However, the rational of using a target ablation index value for posterior wall ablation was to objectify the amount of RF energy applied to each posterior wall ablation site. Kottmaier et al.\(^7\) chose a very-high-power short-duration ablation strategy (70 W) and a strict time limit of 5 s resulting in a reasonable 1-year success rate of 83%. Of note, in contrast to our trial this study did not include a rigorous endoscopic follow-up.\(^7\) Therefore, the incidence of EDEL associated with a high-power short-duration ablation protocol using fixed ablation time limits per lesion is unknown. It is clear that AI is not a safety but rather an efficacy tool and we evaluated the usefulness of AI in the regard of safety issues. Any cut-off value (if duration or AI) is arbitrarily selected and as long as no automatic stop at the cut-off is implemented into the generator software these limits can only be taken as gross markers.

And furthermore, creating contiguous lines at posterior LA wall using high-power 50 W ablations might have resulted in an additive temperature increase within adjacent esophageal tissue (heat stacking).\(^10\) An alternative ablation approach avoiding close spatial and temporal proximity of ablation lesions at posterior wall might have resulted in a different incidence of EDEL.

### 4.1 Rationale of a high-power short duration ablation strategy to reduce the incidence of EDEL without limiting ablation success

Increasing ablation power while reducing ablation time results in a shift from conductive to resistive tissue heating. This strategy of more shallow but superficially wider lesions theoretically leads to a faster, more direct and better predictable ablation result. If tissue ablation effect becomes better predictable, esophageal injury might be prevented without limiting ablation success due to PV reconnection caused by insufficient ablation lesions at posterior wall. Significantly reducing ablation time per ablation lesion possibly mitigates the effects of varying catheter stability and contact force at one ablation site resulting in more homogeneous, transmural and predictable ablation lesions. Ablation lines consisting of transmural

| Procedure parameters of patients with and without EDEL (first-time and redo ablation cohort) | p-value (EDEL + vs. EDEL -) | p-value (first-time abl. vs. redo-abl.) |
|-----------------------------------------------|-----------------------------|--------------------------------------|
| All patients (redo procedure) n = 14 | 100.8 ± 4.13 | .56 |
| All patients (first-time abl. n = 31) | 97 ± 3.8 | .78 |
| Patients with EDEL (first-time abl. n = 5 (16%)) | 9.6 ± 36.1 | .95 |
| Patients without EDEL (first-time abl. n = 26 (84%)) | 24.1 ± 11.2 | .01 |
| Procedure time (min) | 97.0 ± 37.7 | .78 |
| Ablation time total (min) | 92.9 ± 4.4 | .87 |
| Ablation time posterior wall (s) | 293 ± 116 | .62 |
| Ablation time per lesion posterior wall (s) | 9.3 ± 14 | .79 |
| Mean ablation index per lesion posterior wall | 368 ± 33 | .61 |
| Mean contact force at posterior wall (g) | 15.6 ± 4.7 | .001 |
| Mean ablation temperature (°C) | 35.6 ± 1.3 | .71 |
| Abbreviation: EDEL, endoscopically detected esophageal lesion. |
ablation lesions result in a lower rate of acute PV reconduction and necessity of repeat ablation at the same ablation sites. Therefore, high-power short duration ablation could potentially result in a lower risk of esophageal injury while maintaining a comparable or even higher clinical success rate. Reddy et al.\textsuperscript{5} reported a short-term success rate of 94% at 3 months FU.

4.2 | Pre-existing data supporting the use of a short-duration high-power ablation approach

A couple of retrospective clinical trials have already evaluated a strategy of increased ablation power of 50 W and higher in conjunction with standard ablation catheters resulting in a favorable safety and efficacy profile.\textsuperscript{7–9} Of note, according to published data of our own group the incidence of EDEL in a subgroup of 25 patients undergoing high-power short duration ablation using 50 W and an AI of 350 at posterior wall in conjunction with standard irrigated contact-force ablation catheter was 12%.\textsuperscript{11} Patients in this trial were ablated according to the same ablation protocol using the same ablation parameters as in the cohort of 25 patients mentioned above. The only differences was the use of a specialized ablation catheter designed for a "very high-power short-duration" ablation approach. Chelu et al.\textsuperscript{12} reported a rate of mild or moderate esophageal wall late enhancement in patients undergoing postablation LGE-MRI acutely after AF ablation using a 50 W high-power short duration ablation approach. Only one of the patients demonstrating esophageal late enhancement also underwent postablation endoscopy. None of these patients experienced any clinical signs of relevant esophageal injury. Another study of the same research group including a total of 687 patients undergoing first-time AF ablation using a 50 W 5 s high-power short duration ablation approach in 574 patients revealed a high rate of esophageal thermal injury pattern in LGE-MRI (21% mild, 12% moderate, and 3% severe esophageal late Gadolinium enhancement in MRI).\textsuperscript{13} However, it is not clear how ablation-induced esophageal late-enhancement in LGE-MRI translates into endoscopy detected esophageal lesions.

4.3 | Rational of using an optimized RF ablation catheter for high-power short duration ablation

Unique properties of the QDOT ablation catheters are thermocouples placed directly at the catheter tip and tissue interface. This enables a direct reaction of ablation power and irrigation-flow steering to tissue temperature changes. In combination with a novel automated power and irrigation steering algorithm ablation power can be kept near to or at the target power level during the whole ablation time without risking tissue-overheating or steam-pops.

Nonetheless, in this study using an optimized RF ablation catheter in conjunction with a specialized RF generator a relevant number of patients demonstrated ablation-induced EDEL. Safety data regarding esophageal injury are not transferable between different catheter or ablation generator types even when using the same set of high-power short duration ablation parameters.

4.4 | Rational for omission of luminal esophageal temperature monitoring

Temperature probes measuring intraluminal esophageal temperature were not used in this study. The value of intraluminal esophageal temperature measurement using conventional thermocouples is highly questionable as a measurable intraluminal temperature increase might be significantly too late to prevent esophageal injury, especially in the setting of a "high-power short-duration" strategy. Many studies including a recent meta-analysis have questioned the usefulness of standard temperature probes for preventing esophageal injury.\textsuperscript{14} The benefit of using esophageal temperature probes with discrete thermistor technology is limited by both low spatial resolution (maximum of 12 temperature measurement locations) and latency of the temperature sensing technology resulting in delayed and prolonged temperature increases for up to minutes after terminating endocardial ablation. So far, trials evaluating discrete temperature monitoring systems with specific cut-off values have not convincingly demonstrated a consistent prevention of ablation-induced esophageal injury. Even a recently published prospective randomized trial could not demonstrate an advantage of a strategy using esophageal temperature monitoring versus an empiric ablation strategy without esophageal temperature monitoring.\textsuperscript{15} Admittedly, in the study of Schoene et al.\textsuperscript{15} maximum ablation power was 25 W in the group undergoing ablation without and 30 W in the group with intraprocedural esophageal temperature measurement. In a recent study evaluating a novel infrared sensor esophageal temperature probe we could demonstrate a temperature rise of esophageal tissue that was much faster and much higher than temperature rises measured by conventional temperature probes.\textsuperscript{16} Nonetheless, if the use of standard temperature probes with thermocouples could have reduced the incidence of EDEL in this specific setting using 50 W ablation power and a relatively short ablation time in conjunction with a specialized ablation catheter, remains unanswered. Recently, Chen et al.\textsuperscript{17} published results of a prospective non-randomized study comparing 60 patients undergoing 50 W high-power short duration ablation with (cutoff luminal temperature > 39°C) and 60 patients without intraluminal esophageal temperature measurement resulting in a comparably low incidence of EDEL. Interestingly, in this study a target AI value of 400 at the posterior wall was chosen compared with a target AI of 350 in our study. Mean ablation time per lesion at posterior wall was not reported for this study. However, the authors reported a mean radiofrequency duration per ablation site of 8.8 s using 50 W and an average contact force of 22 g in a previous pilot study.\textsuperscript{18} Mean ablation time per lesion in our study was only slightly longer (9.3 s) with a lower mean contact force of 15 g. The use of intraluminal esophageal temperature measurement especially in the context of high-power short duration ablation strategies seems to be limited by an insufficient spatial resolution missing distant temperature rises and a relevant time delay between esophageal tissue heating and detection by the temperature probe.
LIMITATIONS

A major limitation of this study is the limited patient number. Despite the low sample size, it's strength is the timely and consistent manner of postprocedural endoscopy in all patients included in the study and the uniform ablation protocol.

The follow-up period for recording esophageal complications was limited to three months after ablation. However, perforating esophageal complications usually become clinically evident within 2–4 weeks, but potentially might evolve later during follow-up.

We used AI values to quantify and limit the amount of ablation at posterior wall. Of note, AI has neither been explicitly validated for ablation with high-power short duration ablation strategies nor validated for ablation in conjunction with the QDOT Micro ablation catheter.

And finally, this trial focused on the analysis of first-time AF ablation patients as this cohort received a comparable and relevant amount of RF-ablation at LA posterior wall. However, as we have also treated redo-patients using this ablation strategy in conjunction with the QDOT ablation catheter we did not want to withhold the results of this cohort.

CONCLUSION

PVI using a specialized high-power ablation catheter in conjunction with a moderate high-power short duration ablation approach results in a relevant number of post-procedural EDEL despite using prespecified AI target values at posterior and nonposterior LA wall ablation sites. Future studies evaluating high-power short duration ablation strategies should include postprocedural esophageal endoscopy to estimate the risk of clinically relevant esophageal complications.

ACKNOWLEDGMENT

Open access funding enabled and organized by Projekt DEAL.

CONFLICT OF INTERESTS

P.H. and T.D. have received lecture fees from Boston Scientific.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Thomas Deneke https://orcid.org/0000-0003-1379-1684
Borek Foldyna https://orcid.org/0000-0002-2466-4827
Kai Sonne https://orcid.org/0000-0002-9577-154X
Karin Nentwich https://orcid.org/0000-0002-3590-5980
Elena Ene https://orcid.org/0000-0003-4276-5944
Artur Berkovitz https://orcid.org/0000-0002-6744-9668
Philipp Halbfass https://orcid.org/0000-0002-4291-2417

REFERENCES

1. Cappato R, Calkins H, Chen SA, et al. Updated worldwide survey on the methods, efficacy, and safety of catheter ablation for human atrial fibrillation. Circ Arrhythm Electrophysiol. 2010;3:32-38.

2. Yarlagadda B, Deneke T, Turagam M, et al. Temporal relationships between esophageal injury type and progression in patients undergoing atrial fibrillation catheter ablation. Heart Rhythm. 2019;16:204-212.

3. Dagens N, Hindricks G, Kottkamp H, et al. Complications of atrial fibrillation ablation in a high-volume center in 1,000 procedures: still cause for concern? J Cardiovasc Electrophysiol. 2009;20:1014-1019.

4. Halbfass P, Pavlov B, Müller P, et al. Progression from esophageal thermal asymptomatic lesion to perforation complicating atrial fibrillation ablation: a single-center registry. Circ Arrhythm Electrophysiol. 2017;10. https://doi.org/10.1161/CIRCEP.117.005233

5. Reddy VY, Grimaldi M, De Potter T, et al. Pulmonary vein isolation with very high power, short duration, temperature-controlled lesions: the QDOT-FAST Trial. JACC Clin Electrophysiol. 2019;5:778-786. https://doi.org/10.1016/j.jacep.2019.04.009

6. Chinitz LA, Melby DP, Marchlinski FE, et al. Safety and efficiency of porous-tip contact-force catheter for drug-refractory symptomatic paroxysmal atrial fibrillation ablation: results from the SMART SF trial. Europace. 2018;20:392-400.

7. Kottmaier M, Popa M, Bourier F, et al. Safety and outcome of very high-power short-duration ablation using 70 W for pulmonary vein isolation in patients with paroxysmal atrial fibrillation. Europace. 2020;22:388-393. https://doi.org/10.1093/europace/euz342

8. Winkle RA, Moskovitz R, Hardwic Mead R, et al. Atrial fibrillation ablation using very short duration 50 W ablations and contact force sensing catheters. J Interv Card Electrophysiol. 2018;52:1-8.

9. Nilsson B, Chen X, Pehrson S, Svendsen JH. The effectiveness of a high output/short duration radiofrequency current application technique in segmental pulmonary vein isolation for atrial fibrillation. Europace. 2006;8:962-965.

10. Barbhaiya CR, Kogan EV, Jankelson L, et al. Esophageal temperature dynamics during high-power short-duration posterior wall ablation. Heart Rhythm. 2020;17:721-727. https://doi.org/10.1016/j.hrthm.2020.01.014

11. Halbfass P, Lehmkuhl L, Foldyna B, et al. Correlation of magnetic resonance imaging and post-ablation endoscopy to detect oesophageal thermal injury in patients after atrial fibrillation ablation: MRI-EDEL-study. Europace. 2020;22:1009-1016. https://doi.org/10.1093/europace/euaa081

12. Chelu MG, Morris AK, Kholmovski EG, et al. Durable lesion formation while avoiding esophageal injury during atrial fibrillation ablation: lessons learned from late gadolinium MR imaging. J Cardiovasc Electrophysiol. 2018;29:385-392. https://doi.org/10.1111/jce.13426

13. Baher A, Kheirkhahan M, Rechenmacher SJ, et al. High-power radiofrequency catheter ablation of atrial fibrillation: using late gadolinium enhancement magnetic resonance imaging as a novel index of esophageal injury. JACC Clin Electrophysiol. 2018;4:1583-1594. https://doi.org/10.1016/j.jaecp.2018.07.017

14. Ha JF, Han HC, Sanders P, et al. Prevalence and prevention of oesophageal injury during atrial fibrillation ablation: a systematic review and meta-analysis. Europace. 2019;21:80-90. https://doi.org/10.1093/europace/euy121

15. Schoene K, Arya A, Grashoff F, et al. Oesophageal probe evaluation in radiofrequency ablation of atrial fibrillation (OPERA): results from a prospective randomized trial. Europace. 2020;22:1487-1494. https://doi.org/10.1093/europace/euaa209

16. Deneke T, Nentwich K, Berkovitz A, et al. High-resolution infrared thermal imaging of the esophagus during atrial fibrillation ablation as a predictor of endoscopically detected thermal lesions. Circ Arrhythm Electrophysiol. 2018;11. https://doi.org/10.1161/CIRCEP.118.006681
17. Chen S, Schmidt B, Seeger A, et al. Catheter ablation of atrial fibrillation using ablation index-guided highpower (50 W) for pulmonary vein isolation with or without esophageal temperature probe (the AI-HP ESO II). *Heart Rhythm*. 2020;17:1833-1840. https://doi.org/10.1016/j.hrthm.2020.05.029

18. Chen S, Schmidt B, Bordignon S, et al. Ablation index-guided 50 W ablation for pulmonary vein isolation in patients with atrial fibrillation: procedural data, lesion analysis, and initial results from the FAFA AI high power study. *J Cardiovasc Electrophysiol*. 2019;30:2724-2731.

**How to cite this article:** Piringer R, Deneke T, Foldyna B, et al. Incidence of ablation-induced esophageal injury associated with high-power short duration temperature-controlled pulmonary vein isolation using a specialized open-irrigated ablation catheter: A retrospective single-center study. *J Cardiovasc Electrophysiol*. 2021;32:695-703. https://doi.org/10.1111/jce.14883