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Oesophageal temperature monitoring and incidence of oesophageal lesions after pulmonary vein isolation using a remote robotic navigation system

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Aims Oesophageal lesions (EL), a potential complication after pulmonary vein isolation (PVI), have been described recently. A new remote robotic navigation system (RNS; Hansen Medical) provides enhanced catheter stability along with more effective lesion placement. The aim of this prospective study was to evaluate temperature monitoring and incidence of EL when using RNS with an irrigated tip radiofrequency catheter for PVI.

Methods and results Circumferential PVI using RNS was performed in 73 patients (pts) with paroxysmal ($n = 46$, 63%) and persistent atrial fibrillation. An oesophageal temperature probe was placed in 58 (79.5%) pts and was integrated in the 3D-map (NavX). Power was limited to 25 W at the posterior wall, and in the case of an increase in temperature power was limited to 20 W. Endoscopy was performed in 42 pts within 24 h after PVI. In 44 of 58 (75.9%) pts, a significant rise in temperature ($>39^{\circ}C$) was observed. In 6 of 42 (14.3%) pts, an EL was found during endoscopy. In patients with EL, the body mass index (BMI) was significantly lower than in pts without EL (24.1 ± 2.0 vs. 29.0 ± 5.8, $P = 0.047$). The BMI of all patients with EL was <26, whereas all patients without EL had a BMI above 26. The EL showed brisk healing after re-endoscopy within 2 weeks in all pts.

Conclusion In patients undergoing PVI using the RNS, the incidence of EL is 14.3% when using power settings comparable to settings used in manual ablation. Patients with lower BMI (<26) are at higher risk for EL.

Keywords Atrial fibrillation • Catheter ablation • Robotic navigation • Oesophageal lesion • Temperature monitoring • Pulmonary vein isolation • Complication

Introduction

Catheter ablation has become a well-established therapy for the treatment of symptomatic drug-refractory atrial fibrillation. The most commonly used ablation strategy is pulmonary vein isolation (PVI), with the placement of circumferential lesions around the pulmonary veins[1]. Collateral damage to adjacent structures resulting in complications such as phrenic nerve injury, oesophageal lesions (EL) or even oesophageal fistula have been described. Atrio-oesophageal fistula is an extremely rare but potentially devastating complication of PVI.[2] Thermal injury of the oesophageal wall has been described when using conventional radiofrequency (RF) application,[3] irrigated tip RF ablation,[4,5] and cryoablation;[6] and although to date clear evidence is lacking, it seems that thermal injury of the oesophageal wall might trigger the development of an atrio-oesophageal fistula. New ablation tools such as the NIOBE™ (Stereotaxis) or the SENSEI™ (Hansen Medical) navigation systems have been introduced to facilitate catheter ablation of atrial fibrillation

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by enhanced catheter stability and improved navigation capability. As described recently, when using the remote robotic navigation system (RNS) the contact force at the posterior wall can be high[7] and the risk of oesophageal injury might be increased. Although one EL was described previously when using the RNS,[7] to the best of our knowledge to date no data exist regarding the potential for temperature rise and occurrence of EL when using the RNS in catheter ablation for atrial fibrillation. The aim of this prospective study was to determine the incidence of increases in oesophageal temperature as well as the incidence of EL as assessed by endoscopy after PVI with an RNS.

Methods

From December 2008 to July 2009, 73 consecutive patients with symptomatic paroxysmal ($n = 46/73$; 63%) and persistent drug-refractory atrial fibrillation were included in this prospective study and treated with circular PVI using an RNS; in 58 of 73 (79.5%) patients with paroxysmal ($n = 38/58$; 65.5%) and persistent ($n = 20/58$; 34.5%) atrial fibrillation [mean age 58.6 $\pm$ 10.1 years, $n = 28$ (48.3%) female], the placement of an oesophageal temperature probe was possible (see below for details) and oesophageal luminal temperature monitoring was performed. Forty-two patients (72.4%, $n = 42/58$) gave written informed consent for an endoscopy after ablation; endoscopy was performed within 24 h after the ablation procedure.

Patients with known oesophageal disease or with symptoms of reflux or any other gastric complaints within 4 weeks prior to ablation were excluded from this study.

Anticoagulation with warfarin was discontinued at least 5 days before ablation until an INR < 2 was reached and low-molecular heparin was administered as a bridging therapy. All patients were treated with at least one anti-arrhythmic drug before the ablation procedure.

Pulmonary vein isolation

Transoesophageal echocardiography was performed the day before ablation to rule out intracardiac thrombus or pulmonary vein stenosis. After having signed an informed consent, patients underwent the ablation procedure in the post-absorptive state and under conscious sedation with midazolam and fentanyl. After placing a coronary sinus catheter via the left subclavian vein, access for both the transseptal sheath and the artisan sheath (AS) was performed at the right femoral vein. A single transseptal puncture was performed with introduction of a transseptal sheath into the left atrium. The AS with a 3.5 mm cool-tip ablation catheter (Thermocool Navistar 3.5 mm, irrigated tip, Biosense Webster, Diamond Bar, CA, USA) was manually introduced into the left atrium across the same puncture site. Subsequently, the pulmonary veins were visualized by selective angiography in three projections (posterior–anterior, left anterior oblique 30°, right anterior oblique 30°) to rule out pulmonary vein stenosis prior to ablation and to define the pulmonary vein ostia.

A three-dimensional map of the left atrium was created using the NavX system and integrated into the Hansen workstation by the Cohesion software (*Figure 1A*).

In all patients with paroxysmal and persistent atrial fibrillation, circumferential PVI was performed. In each patient, all four pulmonary veins were isolated. In patients with persistent atrial fibrillation and ongoing atrial fibrillation at the time of ablation procedure, in addition to PVI, a stepwise approach was performed, comprising the ablation of a roof-line or a mitral isthmus line. Conduction block of the roof-line and the mitral isthmus line was confirmed during sinus rhythm using pacing manoeuvres as previously described. Complete isolation of the pulmonary veins was assessed by a decapolar Lasso catheter (Lasso, Biosense Webster) placed in each pulmonary vein as well as by exit block testing. Radiofrequency was delivered at each point with a maximum duration of 30 s depending on abolition of local electrograms or disappearance of local PV potentials during RF application. Power was limited to 25 W at the posterior wall and 30 W at the anterior wall of the LA using irrigation rates of 20 mL/min and a temperature limit of 43°C. With the aid of Intellisense™ software, the distal pressure levels were measured and a maximum pressure of 30 g was accepted.

Activated clotting time (ACT) levels were measured every 30 min with a target ACT > 300 s.

Oesophageal temperature monitoring and visualization of the oesophagus during the ablation procedure

An oesophageal temperature probe (SJM, Sensitherm, five poles, St Jude Medical, CA, USA; with a temperature measurement rapidity of the thermocouples of 0.5 s and a distance between the thermocouple sensors of 5 mm) was inserted nasally and advanced to the level of the left atrium under fluoroscopic guidance before ablation was started (*Figure 1B*). A baseline oesophageal temperature was recorded and the luminal oesophageal temperature was measured continuously throughout the procedure (FIAB, esotest 7717, FIAB, Florence, Italy); the position of the temperature probe was regularly checked by fluoroscopy and if necessary adjusted to the catheter tip within the left atrium. In addition, the temperature probe was integrated in the 3D map and the course of the oesophageal temperature probe therefore was visualized both by fluoroscopy and 3D imaging (*Figure 1A*). A significant rise in oesophageal luminal temperature was defined as a temperature rise >39°C.

RF-application was discontinued immediately whenever the luminal oesophageal temperature rose above 39°C and was reinitiated when the temperature returned to baseline. When encircling the ipsilateral pulmonary veins, at all locations where a significant temperature rise occurred ablation was continued at a reduced power setting with a maximum of 20 W and a maximum ablation time of 20 s. In these cases, the maximum tip force was limited to 20 g (controlled by the Intellisense™ software). All locations showing a temperature rise were marked in the 3D map. After encircling the pulmonary veins, mapping with the lasso catheter was performed and when necessary a remaining 'gap' was closed by additional RF applications. If an ablation site where a temperature rise occurred was suggested to be responsible for remaining pulmonary vein conduction, RF application was performed at this site despite the temperature rise. In each patient all four PVs were isolated. During each RF application, oesophageal temperature, the anatomical location of the RF lesion, and RF application duration (in seconds) were documented.

Endoscopy after pulmonary vein isolation

After written informed consent was obtained endoscopy was performed within 24 h after the ablation procedure. In all patients, careful assessment of oesophageal damage was performed; oesophageal mucosal changes were defined as either an oesophagitis or EL. Oesophageal mucosal damage was attributed to RF application during PVI, if it was located in the mid-oesophagus adjacent to the pulsating heart. In patients with documented EL, a repeat endoscopy was performed within 2 weeks to assess the course of the oesophageal damage. All patients were treated with proton-pump inhibitor and magaldrat for at least 4 weeks after ablation. In case of verified EL patients received a liquid diet for at least 3 days.

Statistical analysis

Statistics were calculated using the Statistical Package for the Social Sciences (SPSS software-version 11.0, Chicago, IL, USA). All values are expressed as mean ± standard deviation or median (range). Continuous data were compared using Student *t*-test and categorical variables using χ^2 analysis or Fisher exact test when appropriate. Pearson's correlation coefficient was calculated and multivariate analysis was used to evaluate the presence of associated variables in the relationship between various parameters. A $P < 0.05$ was considered statistically significant.

Results

Patient characteristics

In a total of 58 patients, an oesophageal temperature probe was successfully placed and temperature monitoring was performed during circumferential PVI using the RNS; in the remainder of the patients placement of the ratherly stiff probe was not possible due to different reasons (in three pts nasal insertion was not possible, pharyngeal revertion occurred in five pts, tracheal placement occurred in three, and four pts were not able to tolerate the temperature probe due to discomfort despite correct placement). Forty-two patients who consented to endoscopy underwent post-procedural endoscopy within 24 h after the ablation procedure. Patient characteristics with regard to age, body mass index (BMI) incidence of hypertension, hyperlipidaemia, diabetes mellitus, left atrial size, left ventricular function or incidence of paroxysmal or persistent atrial fibrillation are displayed in *Table 1*.

Oesophageal temperature monitoring

A temperature probe was placed successfully in 58 of 73 (79.5%) patients.

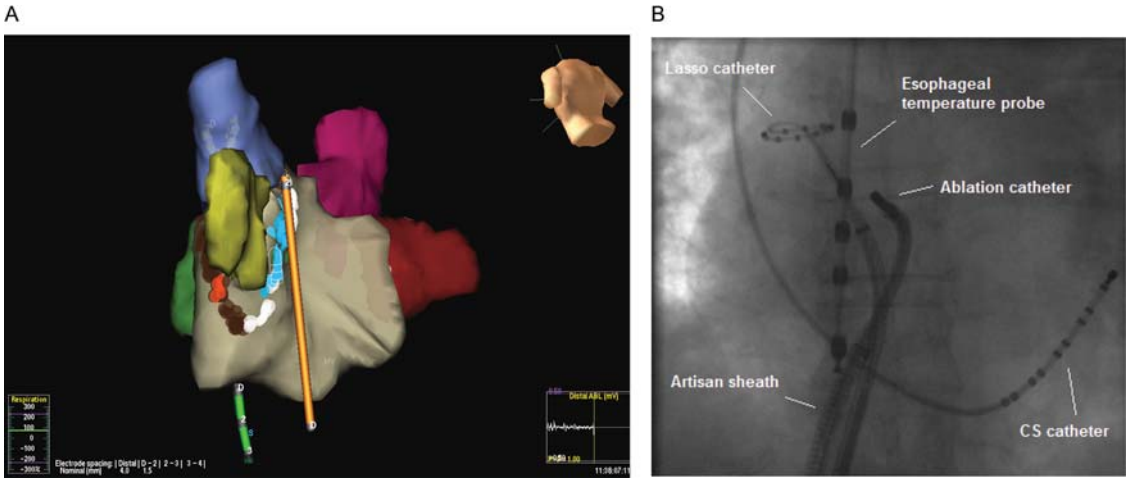

Figure 1 (*A*) 3D map of the left atrium (NavX) with location of the oesophagus via an oesophageal temperature probe (orange, see text for details). View from left lateral and slightly posterior. The left pulmonary veins are successfully encircled. The brown dots indicate lesions with 30 W (anterior wall), the white dots with 25 W (posterior wall), and the blue dots with 20 W (in case of temperature rise during ablation). (*B*) Fluoroscopic view of the ablation catheter in adjustment to the oesophageal temperature probe; CS catheter, coronary sinus catheter.

Table 1 Baseline characteristics of patients with and without temperature monitoring

	Patients with temperature monitoring ($n = 58$)	Patients without temperature monitoring ($n = 15$)	*P*-value
Age (years)	58.6 ± 10.1	61.4 ± 8.0	0.34
Female (*n*, %)	28 (48.3)	7 (46.6)	0.73
Body mass index (kg/m^2)	28.6 ± 5.0	27.3 ± 6.0	0.39
Hypertension (*n*, %)	28 (48.3)	9 (60)	0.42
Coronary heart disease (*n*, %)	3 (5.2)	2 (13.3)	0.22
Diabetes mellitus (*n*, %)	5 (8.6)	3 (20)	0.16
Hyperlipidaemia (*n*, %)	11 (19)	3 (20)	0.28
Left atrial diameter (mm)	45 ± 0.7	48 ± 1.0	0.29
Left ventricular ejection fraction (%)	61.5 ± 8.9	55.2 ± 17.5	0.09
Paroxysmal atrial fibrillation (*n*, %)	38 (65.5)	8 (53.3)	0.38
Persistent atrial fibrillation (*n*, %)	20 (34.5)	7 (46.6)	0.38

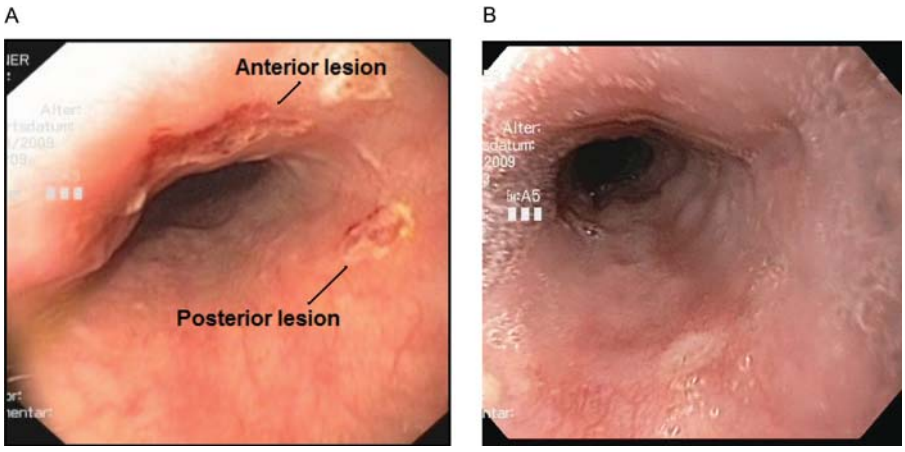

Figure 2 (*A*) Oesophageal lesion in one patient the day after ablation. (*B*) Brisk healing of the oesophageal lesion 2 weeks after the ablation procedure in the same patient.

A significant rise in temperature at the posterior wall (>39°C) was seen in 44 of 58 (75.9%) patients. Mean baseline temperature was 36.9 ± 0.4°C and mean maximal temperature 40.3 ± 1.1°C. Patient characteristics of those with a significant temperature rise and those without a temperature rise are shown in *Table 2*. Incidence of an oesophageal temperature rise was significantly higher in female patients (40.9 vs. 28.6%, $P = 0.047$). The incidence of a significant oesophageal temperature rise after energy reduction to 20 W in patients with and without EL is displayed in *Table 3*.

Results of endoscopy

Overall, EL located at the anterior oesophageal wall were found in 6 of 42 (14.3%) patients (*Figure 2A*). Of these six patients, two patients (33.3%) showed a lesion both at the anterior and posterior oesophageal wall (*Figure 2A*). Repeat endoscopy was performed in all patients within 2 weeks. Brisk healing of the lesions was documented in all patients under medication with proton pump inhibitors and magaldrat, and all patients recovered without sequelae (*Figure 2B*).

When comparing patients with or without EL, a significantly lower BMI was found in patients with EL (24.1 ± 2.0 vs. 29.0 ± 5.8, $P = 0.047$). The general characteristics of patients with oesophageal mucosal changes are displayed in *Table 4*, and the specific ablation data are displayed in *Table 3*.

Importantly, when comparing patients with a BMI < 26 to patients with a BMI > 26, all patients with EL were in the group with a BMI < 26 (6 of 20 pts with BMI < 26 vs. 0 of 22 pts with BMI > 26, $P = 0.006$).

In 35 of 42 patients with endoscopy, temperature monitoring was performed throughout the procedure. One of the patients without temperature monitoring developed an oesophageal ulcer as revealed by endoscopy the day after the procedure (*Figure 2A*), although power at the posterior wall was reduced to 20 W (see Methods section).

In the six patients with EL, a significantly lower BMI was found compared with patients with no EL. No differences were seen with regard to temperature rise, temperature rise after energy reduction, maximum temperature, left atrial diameter, overall energy delivered at the posterior wall, overall RF application time at the posterior wall or ablation of additional lines such as roof-line or mitral isthmus line (*Tables 3* and *4*).

Oesophageal course and movement during the ablation procedure

During ablation, the anatomical course of the oesophagus was visualized using flouroscopy, and by the 3D mapping system (NavX). At the beginning of the procedure, the oesophagus was located at the left posterior wall in 27 of 58 (46.6%) patients, at the right posterior wall in 14 of 58 (24.1%) patients, at the mid-posterior wall in 8 of 58 (13.8%), and mid-to-left posterior wall in 8 of 58 (13.8%). In one patient (1.7%), the oesophageal course was nearly horizontal. A shift of the oesophageal course from the left posterior wall to the right posterior wall during the ablation procedure occurred in 6 of 58 (10.4%) patients with a left posterior course at the beginning of the procedure. No shift from right to left was observed in the patients with a right posterior course of the oesophagus.

Importantly, although not statistically significant, in patients with an oesophageal course at the mid-posterior wall or mid-to-left posterior wall, no EL occurred.

Correlation analysis

A significant temperature rise (>39°C) was correlated with the occurrence of oesophageal ulcers ($r = 0.788$, $P = 0.046$). No correlation of a significant temperature rise was seen to age, atrial fibrillation type, coronary heart disease, hypertension, hyperlipidaemia, diabetes mellitus, mean catheter tip temperature at the posterior wall and overall energy delivered at the posterior wall. There was no significant correlation of EL with age, atrial fibrillation type, coronary heart disease, hypertension, hyperlipidaemia, diabetes mellitus, mean catheter tip temperature at the posterior wall, overall RF application time at the posterior wall, and overall energy delivered at the posterior wall.

Table 2 Characteristics of patients with and without a significant rise in temperature (>39°C)

	Patients with temperature rise >39°C (n = 44)	Patients without temperature rise >39°C (n = 14)	P-value
Age (years)	58.9 ± 9.6	57.9 ± 11.8	0.77
Female (n, %)	18 (40.9)	4 (28.6)	0.047
Body mass index (kg/m^2)	28.6 ± 5.3	28.8 ± 4.5	0.89
Hypertension (n, %)	21 (47.7)	7 (50)	0.88
Coronary heart disease (n,%)	3 (6.8)	0 (0)	0.43
Diabetes (n, %)	4 (9.1)	1 (7.1)	0.41
Hyperlipidaemia (n, %)	8 (18.2)	3 (6.8)	0.28
Left atrial diameter (mm)	44.3 ± 0.7	46.3 ± 0.6	0.48
Left ventricular ejection fraction (%)	61.1 ± 9.5	63 ± 6.3	0.55
Paroxysmal atrial fibrillation (n, %)	28 (63.6)	10 (71.4)	0.59
Persistent atrial fibrillation	16 (36.4)	4 (28.6)	0.23
Overall energy delivered at posterior wall	32 249 ± 21 049	22 753 ± 19 559	0.16
Mean temperature at distal catheter tip (posterior wall, °C)	35.5 ± 1.5	35.3 ± 1.7	0.66

Regression analysis

There was no association of age, BMI, overall energy delivered at the posterior wall, overall RF application time at the posterior wall or mean catheter tip temperature at the posterior wall to EL or significant temperature rise.

Discussion

To the best of our knowledge, this is the first study describing the incidence of temperature rise and EL in PVI when using a remote RNS and a power limit of 25 W at the posterior wall.

The main findings of this study are: (i) the incidence of EL was 14.3% when using RNS with power settings comparable to settings used in manual ablation, (ii) in patients with EL, BMI was significantly lower, (iii) in all patients with EL, brisk healing was confirmed by repeat endoscopy within 2 weeks and no atrio-oesophageal fistula occurred in any of the patients.

Energy settings and incidence of oesophageal lesions

Oesophageal lesions after RF ablation for the treatment of atrial fibrillation assessed by endoscopy[3,4] have been reported recently. The incidence of EL widely differs between several investigators, ranging from 2.9[4] to 18%[3,6,8] depending mainly on the energy source and the sedation state. In EL reported for open irrigated tip RF ablation the incidence varies between 2.9[4] and 9%[5] when using a power limit of 25 W at the posterior wall. In this investigation, open irrigated tip RF ablation with a power limit of 25 W at the posterior wall (with a reduction to 20 W whenever a rise in temperature >39°C occurred) using the RNS resulted in 14.3% EL. Despite the mode of energy delivery (irrigated tip RF or conventional RF application), the main parameters influencing an effective lesion depth/size are RF application time, overall energy and contact force at the catheter tip.[9] Owing to the increased catheter stability, energy delivery using RNS is more efficient,[9] resulting in deeper lesions and thus bearing the potential of increased oesophageal damage at ablation sites close to the oesophagus. In this study, the catheter contact force at the posterior wall during PVI was accurately controlled throughout the procedure by the Intellisense™ software and thus remained in a predefined range (see Methods section). It has already been shown in previous animal studies that contact pressure between 10 and 20 g might be sufficient to create a transmural lesion,[9] but pressure levels between 20 and 30 g and a power setting of 40 W appears to achieve transmurality by increasing safety.[10] Usually, a power setting of 40 W is judged to be too high at the posterior wall of the LA particularly when RNS is used.[7] Therefore, a power limit of 25 W (or 20 W in case of a rise in temperature >39°C) was chosen for this ablation setting. Although it has been shown that with a power setting of <30 W using the same pressure levels transmurality of lesions might be lost, the phenomenon of 'relative endocardial sparing' has been described[10] where the endocardial surface of lesions appear healthy despite clear evidence of lesion formation on the epicardium. This phenomenon might explain why, despite optimal pressure levels (20–30 g) and low power settings (25 W or less) at the posterior wall, EL occurred with a relatively high incidence in this study. Due to the character of the lesion created by the irrigated tip of the ablation catheters, epicardial and concomitant oesophageal damage might not be prevented even when lower power settings are used. Lower pressure levels (i.e.10 g) might decrease the incidence of EL, but might also prevent transmurality of the lesions and therefore increase the risk for AF recurrence.[10] A further aspect might be the pressure measurement of the RNS itself. The pressure sensors of the RNS are incorporated in the proximal part of the AS and therefore the catheter forces are not directly measured at the catheter tip; this might affect the accuracy of pressure measurement particularly when the catheter tip is not perpendicular to the LA wall. Thus transient pressure levels of >30 g at the posterior wall due to a non-perpendicular catheter

Table 3 Ablation data of patients with temperature monitoring, with and without oesophageal lesions after ablation with the robotic navigation system

	Patients with oesophageal lesions ($n = 5$)	Patients without oesophageal lesions ($n = 30$)	*P*-value
Baseline temperature (°C)	36.7 ± 0.3	36.9 ± 0.3	0.32
Temperature rise >39°C[a]	4 (80)	24 (80)	1.0
Temperature rise >39°C after energy reduction[b]	3 (60)	19 (63.3)	0.59
Mean maximal oesophageal luminal temperature (°C)	41.5 ± 1.7	40.2 ± 1.1	0.06

[a]At least one temperature rise >39°C.
[b]Maximum of 20 W and a maximum ablation time of 20 s.

Table 4 Characteristics of patients with and without oesophageal wall changes after ablation with or without temperature monitoring

	Patients with oesophageal lesions ($n = 6$)	Patients without oesophageal lesions ($n = 36$)	*P*-value
Age (years)	58 ± 6.8	59.8 ± 10.3	0.69
Female (*n*, %)	4 (66.6)	18 (50)	0.13
Body mass index (kg/m^2)	24.1 ± 2.0	29.0 ± 5.8	0.047
Hypertension (*n*, %)	2 (33.4)	21 (58.3)	0.19
Coronary heart disease (*n*, %)	0 (0)	3 (8.3)	0.62
Diabetes (*n*, %)	0 (0)	4 (11.1)	0.53
Hyperlipidaemia (*n*, %)	0 (0)	12 (33.3)	0.11
Left atrial diameter (mm)	46 ± 0.8	44 ± 0.8	0.74
Left ventricular ejection fraction (%)	60.4 ± 8.7	63.4 ± 5.0	0.29
Paroxysmal atrial fibrillation	4 (66.6)	24 (66.6)	0.36
Persistent atrial fibrillation	2 (33.4)	12 (33.4)	0.36
Roof-line	1 (16.6)	4 (11.1)	0.56
Mitral isthmus line	1 (16.6)	1 (2.7)	0.10
Overall energy delivered at posterior wall (W)	16 697 ± 11 655	23 874 ± 17 660	0.39
Overall RF application time at posterior wall (s)	995.2 ± 428.1	1172.6 ± 639.9	0.56
Mean temperature at distal catheter tip (posterior wall, °C)	34.8 ± 2.1	35.7 ± 1.4	0.29

tip position, possibly leading to a less accurate pressure measurement, cannot be ruled out. As the incidence of EL might be higher with RNS at a power setting comparable to the one usually used with manual ablation, we conclude that energy settings must be further modified at the posterior wall to reduce the incidence of EL when using RNS.

Body mass index and incidence of oesophageal lesions

In this study, patients with verified EL after PVI showed a significantly lower BMI than patients without oesophageal wall damage (*Table 4*). In previous studies, adjusting for BMI did not result in additional protection from oesophageal ulceration.[5] But usually a layer of adipose tissue insulates the anterior oesophageal wall from the posterior left atrium, showing a high-interindividual variety with a smaller or even discontinuous fat pad in some patients;[11] the size of adipose tissue tends to be larger in patients with higher BMI[12] compared with patients with lower BMI and could be protective with regard to oesophageal wall injury caused by ablation. Importantly, BMI was <26 in all patients with EL after PVI. This strongly suggests that as patients with lower BMI seem to be at higher risk for oesophageal wall injury, BMI must be considered when PVI is performed with RNS.

Oesophageal temperature monitoring

Although the optimal technique for avoiding oesophageal wall injury has not yet been determined, the use of a temperature probe is encouraged[13] in the current guidelines. Moreover, recently published data have shown that the use of an oesophageal

temperature probe might be associated with a significantly lower incidence for EL when compared with patients having undergone PVI with the same energy settings but without temperature monitoring.[5] The incidence of significant oesophageal temperature rise during PVI using the RNS was comparable to the incidence described in PVI using a manual approach.[14] A significant rise in temperature during ablation at the posterior wall is commonly seen when using an RNS for PVI (75.9% of the patients). Although a significant oesophageal temperature rise was not associated with oesophageal mucosal injury in this study, mean maximal temperature levels showed a higher trend in patients with EL (*Table 3*). Though not statistically significant, in patients with a location at the mid-posterior wall and mid-to-left posterior wall no EL occurred. Therefore, the risk for EL might be higher in patients with an oesophageal course behind the left and right pulmonary veins; this underlines the value of a visualization of the oesophageal course (i.e. by an oesophageal temperature probe).

Limitations

This evaluation was performed in a prospective but non-randomized fashion; thus, a randomized comparison is necessary to determine the incidence of EL when comparing RNS to manual open irrigated tip ablation.

An oesophageal temperature probe was not successfully placed in all patients and therefore information on temperature monitoring could not be obtained from all patients. However, no patients either with or without temperature monitoring showed any significant differences with regard to their baseline characteristics (*Table 1*) and consequently a selection can be ruled out. Furthermore, endoscopy was performed only after PVI and therefore it cannot be proved that oesophageal mucosal changes were due to the ablation procedure itself. Nonetheless, no patient reported symptoms indicative of reflux oesophagitis before the ablation procedure, and all oesophageal mucosal changes were seen at the anterior oesophageal wall directly posterior to the left atrium and showed brisk healing in repeat endoscopy within 2 weeks. Therefore, it is reasonable to conclude that the EL were due to the ablation procedure itself.

Conclusion

In patients undergoing PVI using RNS, the incidence of EL is 14.3% when using power settings comparable to settings used in manual ablation. Patients with lower BMI seem to be at higher risk for EL especially when BMI is <26. The optimal power setting for ablation at the posterior wall using the RNS has to be determined in future controlled studies.

Conflict of interest: none declared.

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