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Electrophysiological findings after bilateral thoracoscopic atrial fibrillation ablation using irrigated bipolar radiofrequency energy – a pilot study

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SOUHRN

Úvod: Torakoskopická ablace fibrilace síní (TARAFS) s použitím bipolární radiofrekvenční energie (Medtronic Cardioblate Gemini-S) by měla vést k antrální izolaci plicních žil (PŽ) a izolaci zadní stěny levé síně (LS). Elektrofyziologické nálezy po ablaci touto technikou ale nejsou známy.
Metody a výsledky: U 22 pacientů s recidivou fibrilace síní (FS) po oboustranné TARAFS provedené pro perzistující FS byla zvolena radiofrekvenční katetrizační ablace s odstupem alespoň tří měsíců po TARAFS.
Výsledky: Z 22 pacientů nebyla izolace zadní stěny LS nalezena u 15 (68,2 %) pacientů. U 12 pacientů nebyly endokardiálně zjištěny známky žádné předchozí ablace, u dvou pacientů byly izolovány pravé PŽ a u jednoho pacienta byly izolovány levé PŽ. Na konci ablace byla izolace zadní stěny LS dokončena u všech 15 pacientů. U 18 z celkových 22 pacientů bylo katetrizační ablací dosaženo nevyvolatelnosti FS.
Závěr: U značného počtu pacientů s recidivou FS po TARAFS není izolace plicních žil ani zadní stěny LS dokončena a na elektroanatomické voltážové mapě nejsou nalezeny žádné známky předchozí ablace, které by usnadnily následnou katetrizační ablaci. U většiny pacientů je k dosažení nevyvolatelnosti FS kromě izolace zadní stěny LS nutná další ablace.

Keywords:
Box lesion
Hybrid ablation
Persistent atrial fibrillation
Thoracoscopic ablation
Voltage map

ABSTRACT

Background: Thoracoscopic atrial fibrillation ablation (TARAFS) using irrigated bipolar radiofrequency energy (Medtronic Cardioblate Gemini-S) should result in wide isolation of the pulmonary veins (PVs) and posterior left atrial (LA) wall (the box-lesion technique). Electrophysiological findings after this technique using this instrumentation are not known.
Methods and results: 22 patients with AF recurrence after bilateral TARAFS for persistent AF had a radiofrequency catheter ablation (CA) at least three months after TARAFS.
Results: Out of 22 patients, the box lesion was not completed in 15 (68.2%) patients. 12 had no endocardial signs of any prior ablation, 2 had right pulmonary PVs isolated and 1 had left PVs isolated. At the end of CA, box lesion was finished in all 15 patients and AF non-inducibility was achieved in 18 patients.
Conclusion: In a considerable number of patients with AF recurrence after TARAFS box lesion is not finished and no signs of prior ablation to guide a touch-up catheter ablation are found on electroanatomical voltage map. In majority of patients, additional ablation beside box lesion is needed to achieve AF non-inducibility.

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Introduction

There are several approaches to non-pharmacological treatment of atrial fibrillation (AF). Pulmonary vein isolation (PVI) is the cornerstone of all available techniques with a satisfactory efficacy in paroxysmal AF but with limited efficacy in patients with persistent and long-standing (LS) persistent AF.[1] Therefore, additional catheter ablation techniques targeting thoracic veins, linear ablation lesions, and ablation of complex fractionated potentials are used for the treatment of AF.[2] However, the biggest issue of contemporary catheter ablation techniques is the difficulty to differentiate local oedema from transmural necrosis and thus achieve a transmurality in all ablation lesions. Other techniques are thus sought to achieve durable transmural lesions. One of these approaches are thoracoscopic epicardial techniques using radiofrequency (RF) ablation via irrigated bipolar ablation devices to isolate PVs and the entire posterior wall of the LA (the box--lesion technique).[3] The most used instruments for mini--invasive surgical ablation is AtriCure (Ohio, USA).[4] Using these instruments, a stand-alone surgical thoracoscopic ablation cannot achieve transmural lesions in a considerable number of patients.[5] These insufficiently performed lesions can be found especially when the second stage (catheter ablation) of a hybrid procedure is postponed so local oedema and stunning of atrial myocardium recedes.[6] Similar findings can be anticipated using different surgical tools but so far EP findings from a staged hybrid procedure using Medtronic instruments (Medtronic Cardioblate Gemini-S clamps) are unknown.

Methods

Study goals

We aimed to prospectively evaluate EP findings during a staged hybrid procedure after bilateral thoracoscopic atrial fibrillation ablation (TARAFS) using Medtronic instruments. Secondary, we sought to find the extent of catheter ablation after box-lesion was finished necessary to achieve AF non-inducibility.

Patient group

Patients that underwent TARAFS for persistent or LS persistent AF using Medtronic instruments and had a symptomatic recurrence of atrial fibrillation and/or flutter and/or sustained atrial tachycardia were indicated for electrophysiological study and a subsequent catheter ablation. Totally, 22 patients were included in the study.

Surgical procedure

All surgical procedures were performed under general anaesthesia with the trachea intubated using a double--lumen endotracheal tube for selective lung ventilation. The entire procedure was performed on the beating heart without the use of extracorporeal circulation. The patient was placed in the supine position with both arms alongside the body and slightly below table level. The inflatable pressure bag was placed under the right and left shoulder enabling rotation of the patient's chest. The procedure started on the right side. After right lung deflation three ports were introduced into the pleural cavity. The port for the camera (11 mm) was introduced into the fifth intercostal space at the mid-axillary line. The second port (5 mm, working port) was placed into the fourth intercostal space in the anterior-axillary line and the third port (11 mm working port) was placed into the sixth intercostal space in the anterior-axillary line. Lung collapse was facilitated by continuous carbon dioxide insufflation into the pleural cavity at 8 to 10 mmHg. Visualization was accomplished with a 10.0 mm 0-degree endoscope. On the right side, the pericardium was widely opened at 1.5–2.0 cm anterior to the phrenic nerve. Pericardial retraction sutures were used to aid visualization. Blunt dissection was performed to open the oblique and transverse sinus. Flexible Gemini-s guides (Medtronic, Inc., Minneapolis, USA) were passed through the transverse and oblique sinus. After that three ports were introduced into the left pleural cavity in a similar fashion as to the right pleural cavity. The pericardium on the left side was opened just below the phrenic nerve. The flexible guides were retrieved out of the left thorax. The Gemini-s clamps were attached to the end of the guides outside the left chest. Using the guides, the Gemini-s was inserted across the left PVs and the LA. The left part of the box-lesion was performed. The clamps were closed proximal to the confluence of the PVs and the RF energy for ablation was applied. After the first ablation, the RF clamps were opened and placed approximately 3–5 mm away from the first ablation line. Four ablation lines were placed; the Gemini-s was switched and attached to the end of the guides outside the left chest in the opposite manoeuvre. Four ablation lines were also placed there. The right PV ablation lines were completed through the right-sided ports. The pericardium was approximated on the right side. A single chest drain was inserted through the scope port on each side of the chest and the wounds were closed and dressed in a standard way. If the patient was in AF and did not convert to SR during the ablation procedure, an attempt was made to restore sinus rhythm using external cardioversion.[7]

Electrophysiological study and catheter ablation

The procedure was initiated by placing a decapolar catheter and intracardiac echocardiography (ICE) catheter from the left femoral vein into the coronary sinus and right atrium, respectively. If AF was present at the beginning of the procedure, patients were cardioverted to SR. In patients with SR, RF ablation of the cavotricuspid isthmus (CTI) was performed first before moving to the left atrium. A bidirectional block of conduction across the isthmus was confirmed using the standard criteria. Two long steerable sheaths (8,5-F, Agilis™ NxT, St. Jude Medical) were introduced from the right femoral vein into the LA through a transseptal puncture. Systemic anticoagulation with intravenous heparin was initiated just before the transseptal puncture, and activated clotting time was checked every 20 minutes for a target level of 300 to 350 seconds. Lasso catheter (Biosense Webster, Inc.) was introduced into the PVs to confirm isolation or electrical reconnection by demonstrating the presence of both entry and exit blocks. A three-dimensional reconstruction of the LA and PVs was created with an 3,5-mm irrigated-tip

ablation catheter (ThermoCool, Biosense Webster, Inc.) and CARTO 3 system (Biosense Webster Inc., Diamond Bar, CA, USA). Image integration with computed tomography was performed. A bipolar voltage map of the LA was subsequently performed during SR in all patients. Low voltage areas (LVAs) were defined as areas with bipolar peak-to-peak voltage amplitudes of <0.5 mV.[8] LVAs were considered to reflect previous epicardial lines created by surgeons. Subsequently, if it was not done, the PV isolation was completed. RF energy was applied with the output of 25 W up to 30 W (cool flow 20 mL/min). This was repeated until all gaps had been closed and electrical silence inside the circumferential ablation line was observed. After achieving isolation of all PVs, the posterior LA wall was mapped in detail. For such purposes, a Lasso catheter was placed so that it touched the posterior wall perpendicularly. If no potentials were recorded and the LA could not be captured when stimulating anywhere at the LA posterior wall, a complete box lesion was deemed present. If any potential was recorded, both the superior and inferior connecting lines were meticulously mapped to look for gaps, which were subsequently ablated. After completion of PV isolation and box lesion, incremental atrial pacing from the coronary sinus, up to 300 beats/min, was conducted to test arrhythmia inducibility. If AF was induced, the mitral line was targeted. This line started close to the left inferior PV and extended toward the mitral annulus. In addition, to complete the conduction block over the mitral line, extensive coronary sinus ablation was performed. If AF persisted, complex fragmented atrial electrograms mapping in both atria was performed. The target sites were defined as the fastest local repetitive electrical activity, multiple component fragmented signals, or activation delay between the distal and proximal bipolar electrodes covering the majority of the cycle length. If any AT was induced, a detail activation map was performed, and the arrhythmia was targeted by RF ablation. The endpoint of ablation was non-inducibility of AF/AT with rapid atrial pacing. If AF persisted, patients were DC cardioverted to SR.

Results

Baseline patients' characteristics are shown in Table 1.

Surgical thoracoscopic atrial fibrillation ablation

Box isolation of LA posterior wall was acutely achieved in 21 patients. In one patient, we have found a severe pleural obliteration precluding further ablation and the procedure was ended. 20 patients had no complications during and after the surgery. One patient had urinary infection and a local inflammation at the place of central venous cannula. One patient developed cardiac tamponade early after surgery that led to reoperation. The source of bleeding was a defect in ascending aorta. After this reoperation, there were no additional issues and the patient recovered well.

Electrophysiological study before catheter ablation

Out of 22 patients after TARAFS with clinical arrhythmia recurrence, a complete isolation of the posterior LA wall (box lesion) was present only in 7 patients (31.8 %). In the remaining 15 patients without box isolation, 12 had no signs of any prior ablation in endocardium (voltage >0.5mV), and so we were not able to recognize any gaps. Out of these 15 patients, 13 had no PV isolated, two patients had right PVs isolated and one had left PVs isolated. In 1 patient, a roof line was completed without a complete box lesion. 12 of 22 patients had AF, atrial flutter (AFL) or atrial tachycardia (AT) at the beginning of the electrophysiological study. Ten patients were in SR.

Table 1 – Baseline patients' characteristics

BMI	32.4±3.5
LVEF (%)	55±12.2
LAd (PLAX) (mm)	47±6.9
LAA velocity (cm/s)	40±17.7
LAVi (ml)	37.5±15.3
CHA_2DS_2-VaSc	2.0±1.3
Age	62.5±6.0
Men	59.1%
Heart failure	36.4%
Arterial hypertension	90.9
Diabetes mellitus	9.1%
Stroke/TIA	27.3%

BMI – body mass index; LAA – left atrial appendage; LAd – left atrium diameter; LVEF – left ventricle ejection fraction; PLAX – parasternal long-axis projection; TIA – transient ischemic attack.

Catheter ablation

All PVs were isolated and box lesion was achieved in all 15 patients that did not have PVs isolated and box lesion completed. Cavotricuspid isthmus ablation was successfully performed in all patients. The next step was induction of AF. In 7 patients, AF was not induced after cavotricuspid isthmus (CTI) ablation and box isolation and the procedure was ended. In 15 patients, a sustained AF, AFL and/or AT was inducible and so mitral line and extensive CS ablation was targeted. In 14 of those 15 patients, bidirectional block was achieved. Seven patients needed more extensive ablation, focally targeting complex fractionated electrograms (CFAEs). The main target of ablation was non-inducibility of AF. This was achieved in 18 of 22 patients. In 4 patients AF was terminated using electrical cardioversion. No serious adverse events were documented during and/or after ablation.

Discussion

This is the single-centre retrospective observational pilot study of the EP findings after TARAFS for persistent AF. We have investigated patients with AF recurrence after TARAFS only. We thus do not provide EP findings in patients that were without AF recurrence.

There are 3 main findings of our study. First, there was a low box-lesion completion solely using epicardial

ablation. Second, it was impossible to determine the locations of electrical reconductions (gaps) in the ablation lines after TARAFS using just a voltage map. Third, it was important to add additional ablations beside box lesion to achieve non-inducibility of arrhythmias.

The surgical treatment of AF has undergone dramatic development over the last years and thoracoscopic ablation is the most widely used minimally invasive approach. Sabgas et al. showed that ablation technique using the Medtronic instruments eliminates AF in 72% of patients with persistent AF.[9] Others found an even lower success rate using this instrumentation (62.9% at 1 year using 4-times 24-hours Holter EKG monitoring).[10]

However, EP findings after the thoracoscopic ablation using these instruments are not known. But there are several studies that have investigated EP results and midterm durability of thoracoscopic ablation using the other types of mini-invasive ablation devices in patients with persistent AF. Osmancik et al. evaluated the effects of a surgical ablation using the COBRA Fusion radiofrequency catheter carried out via a thoracoscopic approach. An electrophysiology study was done 2–3 months later. Box isolation, based on the EP study, was incomplete in 18 patients (60%). A total of 39 gaps in these 16 patients were identified.[5] Bulava et al. found that several months after surgery (using the AtriCure ablation system), all four PVs and the left atrial posterior wall were isolated in 68.6% and 22.9% of patients, respectively. In other words, the box isolation was incomplete in 77.1% of patients after surgery.[6] A single-stage surgical approach is very limited in its efficiency to perform complete and durable PVA ablation and box-lesion.

A subsequent catheter ablation can fill the gaps left by the surgeons. Mapping the locations of electrical reconductions in the ablation lines after thoracoscopic ablation should facilitate the completion of ablation lines and has been published in several studies. Osmancik et al. found that typical gap locations were the anterior-superior part of the superior pulmonary veins and the roofline. Fat thickness along the roofline was substantially higher than that along the inferior line (4.58±1.61 mm vs 2.37±0.76 mm; p <0.001).[5] Bulava et al. found that most of the gaps around left PVs were localized in the superior and anterior quadrants, whereas in right PVs, the gaps were found predominantly on the roof and posterior wall. A typical site of reconduction on the inferior connecting line was the segment adjacent to the right inferior PV. No typical reconduction sites were found on the roof line.[6] In our study we were not able to identify the typical locations of electrical reconductions in the ablation lines. In 12 patients (54.5%), in whom no signs of previous ablation were evident, we were forced to perform a completely new box-lesion set. The knowledge of the previous TARAFS procedure did not help us to place the ablation lesions nor did it shorten the procedure.

Reconnections of the PVs after thoracoscopic ablation are a common source of AF recurrence. However, especially in patients with persistent AF, non-PV foci are known to be also important.[11] The mitral and cavotricuspid isthmus lines, which are often needed in persistent AF patients, are difficult to create from the epicardium with bipolar radiofrequency clamps. On et al. adopted cavotricuspid isthmus ablation as a routine staged hybrid procedure to prevent late occurrence of atrial flutter because of the high incidence of atrial flutter immediately after thoracoscopic ablation.[12] Furthermore, it has been hypothesized that mitral isthmus line ablation targets additional arrhythmogenic triggers arising from the ligament of Marshall, affecting the intrinsic cardiac autonomic nervous system and eliminating local reentry while preventing perimitral macroreentry.[13] Inducibility of arrhythmias despite completion of a full lesion set may suggest an extensive arrhythmogenic substrate in persistent AF patients.[6] However, the necessity of low voltage ablation in addition to the box-lesion for persistent AF with low voltage areas is less clear.[14] Patients without LVAs did not need further substrate modification and could avoid excessive ablation. Therefore, box-lesion ablation alone may be adequate in persistent AF patients without LVAs.[14,15] In our study in 15 patients (78.2%), a sustained AF, AFL, and/or AT was inducible after box-lesion completion and CTI line ablation, and so additional ablation was required to achieve non-inducibility of AF. Of these patients, CFAEs ablation was performed in 7 (46.7%) of them. These results underline the need for a patient-tailored approach in the treatment of persistent AF patients. EP confirmation after thoracoscopic ablation might be helpful to improve outcomes and decrease the prevalence of atrial arrhythmias.

New technologies currently emerge in the field of catheter ablation of AF. The most promising is the use of electroporation that preferentially affects myocardial tissue, allowing rapid PV isolation with excellent durability and safety.[16] Long-term data on outcome of patients after catheter ablation of persistent AF using electroporation are still needed. However, since we already have data about PV isolation durability and an outstanding safety of this method and given these suboptimal results in a significant portion of patients that undergo a far more invasive surgical AF ablation, it would seem that indications for a standalone surgical thoracoscopic AF ablation will be reduced significantly.

Study limitations

This is a single-centre and retrospective study. These are just pilot data and thus the sample size of this study is small and the results may not represent all AF patients undergoing thoracoscopic ablation because of differences in study populations, ablation techniques, and surgical skills. It still remains to be elucidated whether endocardial ablation aimed at completing epicardial surgical ablation lines should be performed routinely in all patients. A prospective trial is needed to confirm our findings with a rigorous follow-up in all patients.

Conclusion

A minimally invasive thoracoscopic box-lesion ablation is considered to be a safe and effective method of stand--alone AF treatment. However, in a considerable number of patients with AF recurrence a durable PV isolation and box lesion are not achieved and a completely new complex ablation must be done. In a lot of patients, additio-

nal ablation is needed besides box lesion to achieve AF non-inducibility. A staged catheter ablation should be strongly considered in all patients with AF recurrence after thoracoscopic ablation.

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Conflict of interest
None declared.

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