ORIGINAL ARTICLE

Thoracoscopic epicardial ablation of the left and right atrium

Beating heart procedure in patients with atrial fibrillation

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KEY WORDS

atrial fibrillation, left atrium ablation, surgical treatment

ABSTRACT

INTRODUCTION Atrial fibrillation (AF) is a common arrhythmia affecting approximately 1% to 2% of the general population.

OBJECTIVES The aim of the study was to evaluate the efficacy and safety of thoracoscopic ablation in patients with AF.

PATIENTS AND METHODS A total of 25 patients aged from 42 to 77 years (mean 56.4 years) with persistent or long-standing persistent AF were scheduled for the procedure. Thoracoscopic epicardial ablation of the right atrium, pulmonary veins, and left atrium was performed on the beating heart using the Cox MAZE III-based diagram, via 3 ports and 2 cm incision below the xiphoid. Exit block was always assessed. Patients were prospectively followed for 12 months after the procedure. 24-hour electrocardiography (Holter monitoring) was used to confirm the results.

RESULTS Conduction block across ablation lines was achieved in 21 patients (84%). At 1 month of follow-up, the sinus rhythm (SR) was observed in 18 of 20 patients. At 3 months, the SR was observed in 19 patients (76%). Two patients had atrial flutter, while 3 still experienced AF. At 6 months, the SR was observed in 21 patients (84%); 2 patients still had AF, 1 patient atrial flutter, and 1 patient had a pacemaker implanted. Results of follow-up at 1 year did not differ from those at 6 months. No changes in the size of the left atrium and left ventricular ejection fraction, no deaths, stroke, transient ischemic attack, or infectious complications were observed.

CONCLUSIONS The efficacy of epicardial thoracoscopic ablation of the left and right atrium was high, reaching 84% during 1-year follow-up. No serious complications were observed in the postoperative period (except for the need for pacemaker implantation in 1 patient).

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INTRODUCTION Atrial fibrillation (AF) is a common arrhythmia affecting approximately 1% to 2% of the general population. The incidence of AF increases with age. It is diagnosed in less than 0.5% of the patients in the 5th decade of life and in about 5% to 15% of the patients at the age of 80.[1,2] AF is associated with increased mortality and morbidity rates. The mortality rate in AF is increased by the factor of 2.[3,4] In addition, AF leads to a 5-fold increase in the risk of stroke[5] and may cause tachyarrhythmic cardiomyopathy,[6] congestive heart failure,[7] and reduction in the quality of life.[8] Moreover, the majority of patients with AF require anticoagulation to reduce the risk of thromboembolic complications.[9-11] Due to the limited efficacy of pharmacological treatment, non-pharmacological methods have been developed in recent years, particularly transcatheter ablation,

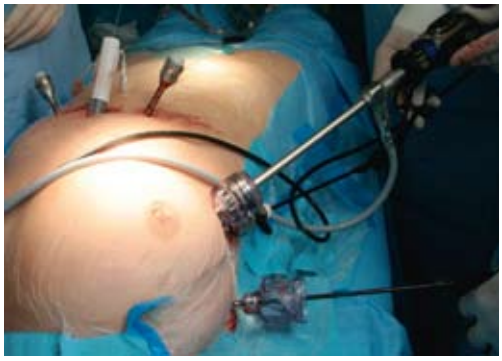

FIGURE 1 Surgical thoracoscopic approach (own picture)

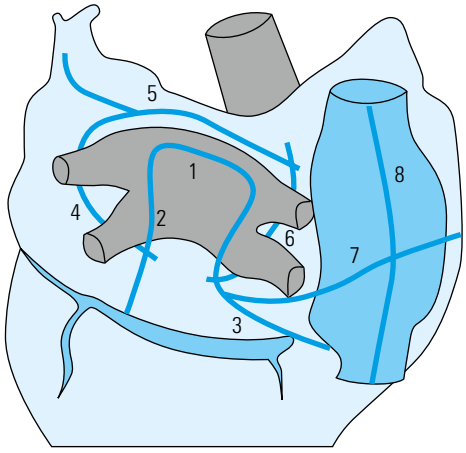

FIGURE 2 Modified Ex-MAZE III ablation lesion set (according to Cox JL, et al.)[28]

which is characterized by ever-increasing efficacy. Transcutaneous radiofrequency (RF) ablation or cryoablation allows for the restoration of the sinus rhythm (SR) in 66% to 89% of the patients over a 12-month follow-up. However, it must be noted that reablation is required to achieve a favorable result in about 12% to 26% of the patients, and some patients still require administration of antiarrhythmic drugs.[12-14] An interesting alternative in a selected group of patients with symptomatic AF after percutaneous ablation failure is minimally invasive surgical ablation. Although it is a relatively novel treatment, it has already been included in recent standards of care for AF patients with class IIb indication.[6] Current knowledge on the efficacy of this method is limited, particularly in long-term follow-up,

FIGURE 3 Left atrium ablation device

which encouraged us to start our own research. Thus, the objective of our study was to evaluate the efficacy and safety of thoracoscopic ablation in AF patients.

PATIENTS AND METHODS **Surgery** All surgeries were performed under general anesthesia for better patient comfort and protection in case of potential complications. The entire procedure was performed on the beating heart without extracorporeal circulation.[15,16] In all cases, intubation was performed using a double-lumen intubation tube to allow one-lung ventilation during ablation of the right atrium, right pulmonary veins, and left atrial roof. The left atrium was accessed through the diaphragm via a small, 2-cm incision below the xiphoid cartilage, which allowed for the insertion of a cannula for the introduction of an RF epicardial ablation electrode and thoracoscope. The right atrium, right pulmonary veins, and left atrial roof were accessed via two 5 mm ports and one 10 mm port on the right side of the thorax. A video channel and thoracoscopic tools were required for the procedure, which allowed to perform all ablation lines under visual control (FIGURE 1).

Being the most effective, the Cox-MAZE III procedure was adapted for the above surgical access. The goal was to achieve the most complete treatment possible. FIGURE 2 shows the full outline of the epicardial ablation lines. Lines 1, 2, 3 and partially lines 4 and 7 were performed from the transdiaphragmatic access via a cannula with a diameter of 2 cm. Lines 5, 6, 8 and the remaining parts of lines 4 and 7 were performed via 3 ports located on the right side of the thorax. All ablation lines were performed under visual control using the nContact Inc. vision channel – a monopolar, irrigated, RF-current system (nContact Inc., United States). The channel is equipped with integrated suction, ensuring constant contact between the ablated tissue and the electrode. This allows the operator to perform a fully transmural ablation line. Irrigation ensures proper cooling of the electrode during ablation and prevents the tissue from overheating. The RF current generator working with the electrode is complete with a specially developed program for continuous measurement of tissue impedance, applied power, and temperature of the ablated tissue. In addition, the program can automatically turn the electrode off if the contact between the electrode and the heart tissue is broken. This protects against performing an ablation line without contact between the electrode and the tissue. The surgeon is also provided with the possibility of continuous monitoring of all data, which allows to evaluate the efficacy (transmurality) of the ablation line in a particular location within the heart. If needed, ablation lines may be repeated, ensuring they are performed properly (FIGURE 3).

We always tried to confirm isolation of the pulmonary veins (exit block) by 15 mA stimulation with an epicardial electrode attached in the region

TABLE Baseline characteristics of the patients (n = 25)

age, y		42–77 (mean 56.4)
EHRA class		II–IV (mean 2.7)
type of AF	persistent	21
	recurrent	4
duration of disease, y		2–25 (mean 8.6)
ejection fraction, %		45–65 (mean 55.6)
left atrium dimension, mm		3.2–5.4 (mean 4.6)
treatment with vitamin K antagonists, n		25
antiarrythmic treatment, n	propafenone (300–450 mg/d)	22
	amodarone (200 mg/d) and sotalol (80–160 mg/d)	3

Abbreviations: AF – atrial fibrillation, EHRA – European Heart Rhythm Association

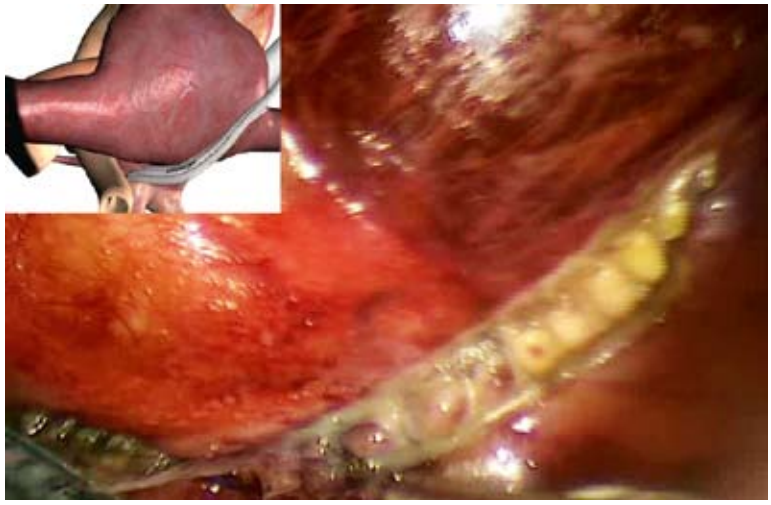

FIGURE 4 Epicardial ablation line operative picture and scheme (own picture)

of the pulmonary veins, distally from the cardiac walls. If an exit block was not achieved for some reason, the ablation line was performed again.

After the procedure, the diaphragm and the pericardial site were closed with an EndoStitch auto suture, ensuring restoration of the continuity of the pericardial structures. A pleural cavity drain discharging through one of the access port holes located on the right side of the thorax allowed for decompression of the right lung and evacuation of collected blood and possibly the pleural fluid.

Patients The method of thoracoscopic ablation of the left and right atrium was used in 25 patients with persistent or long-standing persistent AF after failure of earlier conservative treatment and endocardial ablation (TABLE). Patients aged from 42 to 77 years (mean 56.4 years). Symptomatic, persistent AF was diagnosed in 21 patients and recurrent AF in 4. Duration of AF in the study group was from 2 to 25 years (mean 8.6 years). Dimension of the left atrium before ablation ranged from 3.2 cm to 5.4 cm (mean 4.6 cm). LVEF was from 45% to 65% (mean 55.6%). Conservative treatment and endocardial ablation (repeated in some cases) had failed. Ten patients had undergone electroanatomical RF ablation using the CARTO XP system. The ablation procedure was repeated in 5 patients in this group (twice in 3 patients and 3 times in 3 patients).

Preoperative pharmacotherapy of 22 patients included propafenone at the dose of 300 to 450 mg/day and sotalol at the dose of 80 to 160 mg/day. The remaining 3 patients received amiodarone at the dose of 200 mg/day in combination with a β-blocker. Statins were administered in 16 patients, angiotensin-converting enzyme inhibitors in 8, and digitalis preparations in 3. No significant modifications were made during 1-year follow-up in pharmacotherapy regimens optimized in the preoperative period. Anticoagualtion was applied for 3 months after the ablation procedure.

Patients were prospectively followed up for 12 months after the procedure. Postoperative follow-up visits were scheduled at 1, 3, 6, and 12 months after thoracoscopic ablation and included medical history, physical examination, and surface 12-lead electrography (ECG). In addition, 24-hour ECG (Holter monitoring) was performed in all patients 1 year after the procedure. The accepted efficacy criterion was no AF in follow-up ECG records and no history of AF in the periods between the follow-up visits. The study was approved by the Jagiellonian University ethics committee.

RESULTS The performed ablation lines were always visible and transmural (FIGURE 4).

During the procedure, conduction block was achieved in 21 patients (84%). In the remaining 4 patients, conduction block could not be achieved despite repeated ablation procedure. In 5 patients, the SR was restored during the performance of the last ablation line. All the remaining patients were subjected to cardioversion, with the SR restored in 19 patients. Only 1 patient was not able to achieve steady rhythm despite several cardioversion attempts. No significant complications were observed in any of the patients in early postoperative course. Three patients experienced low output syndrome, which was controlled by conservative treatment, 2 patients required prolonged ventilation (over 7 h), and 5 patients experienced AF episodes, which were controlled by conservative treatment or cardioversion.

Only 20 of 25 patients presented for postoperative follow-up 1 month after the procedure because the remaining 5 were staying at sanatoriums. Steady SR was observed in the ECG recording in 18 patients of whom 1 was diagnosed with sinus bradycardia and AV block episodes, which resulted in implantation of a DDD pacemaker. Two other patients still experienced AF, but their ventricular rate was well controlled. The diameter of the left atrium was 3.1 to 5.4 cm, with the mean of 4.7 cm. LVEF was 45% to 63% with the mean of 54.6%. We do not have data on AF episodes, left

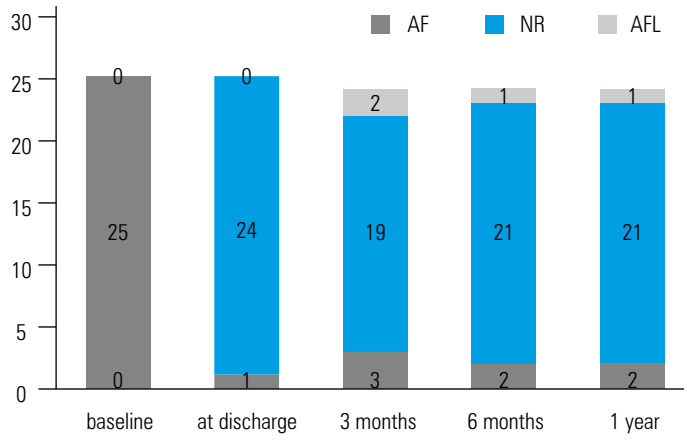

FIGURE 5 Cardiac rhythm at baseline, at discharge, and during follow-up
Abbreviations: AFL – atrial flutter, NR – normal rhythm, others – see TABLE

atrial size, ejection fraction, or any complications in 5 patients who were lost to follow-up.

All patients presented for postoperational follow-up at 3 months after the thoracoscopic ablation of both atria (FIGURE 5). Steady SR was observed in the ECG recording of 19 patients (76%). Two patients had atrial flutter, while 3 still experienced AF. As mentioned above, 1 patient presented with a cardiac pacemaker implant. The size of the left atrium was from 3.2 to 5.4 cm (mean 4.6 cm). Left ventricular ejection fraction (LVEF) was from 48% to 65% (mean 57%). No death, stroke, transient ischemic attack (TIA), or infectious complications were observed. At 6 months, steady SR was observed in outpatient ECG recording in 21 patients (84%), 2 patients still experienced AF, 1 patient experienced atrial flutter, and 1 patient had a pacemaker implant. The size of the left atrium was 3.0 to 5.6 cm (mean 4.7 cm). LVEF was 47% to 68% (mean 57.8%). No death, stroke, TIA, or infectious complications were observed.

At 1 year after the left atrial ablation, the results were the same as at 6 months: 21 patients (84%) had steady SR (FIGURE 5); 2 patients still experienced AF, 1 patient experienced atrial flutter, and 1 patient had a paced rhythm. The results were confirmed by a 24-hour Holter monitoring that complemented the outpatient ECG recording. The Holter monitoring showed no AF inserts in 21 patients (84%). The diameter of the left atrium and the ejection fraction did not change (3.1 to 5.8 cm, mean 4.7 cm and 47% to 68%, mean 58%, respectively). Due to a small sample size and no changes in the size of the left atrium and LVEF, statistical analysis of the results was not performed. No death, stroke, TIA, or infectious complications were observed. After 1 year of postoperative follow-up, the patient with atrial flutter underwent endocardial ablation with restoration of the SR, thus increasing the therapeutic success rate to 88%.

DISCUSSION The reported thoracoscopic ablation technique is a promising alternative treatment for patients with sustained AF. It is definitely less invasive and is associated with a lower risk of complications compared with earlier MAZE-type procedures, which required extracorporeal circulation.[17] High efficacy was observed in our study group as measured by the maintenance of the SR in 84% of the patients during 12-month follow-up. If one was to consider so called AF freedom, as proposed by several authors, 1 patient with a pacemaker might be included in the group in which therapeutic success was achieved, and then the therapeutic success rate would be 88%. However, we do not consider pacemaker implantation or atrial flutter a therapeutic success. In our opinion, only restoration of steady SR may be considered as such. Of note, the study group included patients with long-standing persistent or persistent AF. Most patients had already undergone transcutaneous ablation before without satisfactory effects. Therefore, it may be assumed that the procedures were performed in patients in whom AF treatment was problematic and in whom pharmacotherapy and invasive methods were ineffective. Our results may thus be considered as highly efficient.

Matsutani et al.[18] reported the presence of the SR in 90% of the patients during the mean follow-up period of 16.6 months after thoracoscopic mini-MAZE ablation. Beside isolation of the pulmonary veins, the procedural technique included ablation of the epicardial autonomic nervous system ganglion plexus and amputation of the left atrial appendage, which might account for slightly better results compared with our study. Szalay et al.[19] showed that 71% of the patients remained in the SR or under atrial stimulation 12 months after mini-MAZE ablation. Jeanmart et al.[20] performed mini-MAZE pulmonary vein isolation ablations in patients subjected to minimally invasive mitral valve surgery. They reported that 69.7% of the patients remained in the SR during the mean follow-up period of 17 months; 76.5% of the patients in this group continued antiarrhythmic therapy. In our study, all patients received antiarrhythmic medications after the ablation procedure. The diameter of the left atrium did not change significantly after the ablation procedure, probably due to advanced atrial remodeling, which did not resolve despite SR restoration. Studies conducted in a larger group of patients and with longer follow-up periods are necessary to evaluate the reversibility of atrial remodeling and the possibility of discontinuing antiarrhythmic treatment. Our results confirm the safety of the method. No significant complications were observed, except for AV conduction disorders requiring pacemaker implantation in 1 patient. One patient experienced typical atrial flutter after the procedure; the flutter was effectively eliminated by transcutaneous RF, as reported in the previous paper.[21] Matsutani et al.[18] reported atrial flutter in 1 patient (5%) following thoracoscopic ablation procedure, requiring transcutaneous ablation. Reddy et al.[22] described a case of simultaneous epicardial and endocardial ablation that allowed them to obtain full ablation line within the left atrial posterior wall. It appears that combined hybrid

procedures of epicardial and endocardial ablation could help increase the efficacy of the procedure in some patients, as confirmed by the results of Zeng et al.[23] who described mini-MAZE epicardial ablation in a group of 130 patients. Zeng et al.[23] performed transcutaneous CARTO ablation in 8 patients due to AF recurrence, atrial tachycardia, or atrial flutter originating in the left atrium within the mean period of 5 months after epicardial ablation.

To conclude, the efficacy of epicardial thoracoscopic ablation of the left and right atrium was high, reaching 84% during a 12-month follow-up period. No significant complications were observed in the postoperative course, except for the need for pacemaker implantation in 1 patient. Thus, we believe that our results may be considered promising. Reports from other authors, although scarce,[18,24] raise our hope that expanding the scope of thoracoscopic ablation (pulmonary vein isolation) by ablation of autonomic ganglia and amputation or ligation of the left atrial appendage[18,24,25] may increase the efficacy of SR restoration and maintenance in patients with long-standing persistent AF. Moreover, it has been demonstrated that intraoperative confirmation of conduction block across ablation lines[26] and endocardial ablation as part of a thoracoscopic procedure (hybrid cases)[27] significantly improves the results. Further randomized prospective studies on the safety and efficacy of these procedures are needed.

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ARTYKUŁ ORYGINALNY

Torakoskopowa epikardialna ablacja lewego i prawego przedsionka

Procedura na bijącym sercu u pacjentów z migotaniem przedsionków

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SŁOWA KLUCZOWE

ablacja lewego przedsionka, leczenie chirurgiczne, migotanie przedsionków

STRESZCZENIE

WPROWADZENIE Migotanie przedsionków (*atrial fibrillation* – AF) jest powszechnie występującą arytmią, która dotyczy ok. 1–2% populacji.

CELE Celem pracy była ocena skuteczności i bezpieczeństwa ablacji torakoskopowej u chorych z AF.

PACJENCI I METODY Do procedury zakwalifikowano 25 osób w wieku 42–77 lat (śr. 56,4 roku) z przetrwałym lub długo trwającym przetrwałym AF. Wykonano torakoskopową ablację prawego przedsionka, żył płucnych i lewego przedsionka na bijącym sercu, wykorzystując schemat naśladujący metodę Cox-MAZE III, poprzez 3 porty i 2 cm cięcie poniżej wyrostka mieczykowatego. Zawsze sprawdzano blok przewodzenia. Przez 12 miesięcy po procedurze chorzy byli poddani kontroli pooperacyjnej. W celu potwierdzenia wyników wykonano 24-godzinne monitorowanie EKG metodą Holtera.

WYNIKI Uzyskano blok przewodzenia poprzez linię ablacji u 21 (84%) chorych. Po miesiącu kontroli pooperacyjnej rytm zatokowy (*sinus rhythm* – SR) odnotowano u 18 z 20 osób, a po 3 miesiącach – u 19 chorych (76%). U 2 chorych wystąpiło trzepotanie przedsionków, a u 3 nadal utrzymywało się AF. Po 6 miesiącach pooperacyjnej obserwacji SR stwierdzono u 21 chorych (84%); u 2 pacjentów utrzymywało się AF, u 1 – trzepotanie przedsionków, a u 1 wszczepiono rozrusznik serca. Wyniki oceny po roku nie różniły się od tych po 6 miesiącach. Nie odnotowano zmian w rozmiarze lewego przedsionka, zmian frakcji wyrzutowej lewej komory serca, zgonów, udaru mózgu, napadów przemijającego niedokrwienia mózgu ani infekcji.

WNIOSKI Skuteczność epikardialnej ablacji torakoskopowej lewego i prawego przedsionka jest wysoka i wynosi 84% w rocznej obserwacji. W przebiegu pooperacyjnym nie stwierdzono poważnych powikłań (z wyjątkiem konieczności wszczepienia rozrusznika serca u 1 pacjenta).

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