

# Totally thoracoscopic ablation with autonomic ganglia ablation and left atrial appendage exclusion for persistent atrial fibrillation

Całkowicie torakoskopowa ablacja przetrwałego migotania przedsionków z ablacją zwojów autonomicznych i usunięciem uszka lewego przedsionka

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**Abstract.** Introduction. Atrial fibrillation (AF) is the most frequent supraventricular arrhythmia of high morbidity. Antiarrhythmic drugs and percutaneous catheter ablation procedures have moderate efficacy. Aim. The aim of the study was to evaluate midterm results of totally thoracoscopic ablation for persistent and long-standing persistent AF. Methods. 34 patients in mean age of 60 ( $\pm 9.5$ ) years underwent totally thoracoscopic ablation with left atrial appendage (LAA) occlusion. Mean duration of AF was 87 ( $\pm 76$ ) months, left atrial dimension was 45 ( $\pm 9.4$ ) mm and LVEF was 59 ( $\pm 8$ )%. In all patients bidirectional block across ablation lines around pulmonary veins was achieved. After 3, 6, 12 and 24 months 48-hour ECG-Holter recordings and echocardiography were performed. Results. No mortality, stroke or TIA were observed. 97% patients were in sinus rhythm on discharge from hospital. One patient required sternotomy for effectively managed bleeding from left atrium. In 6, 12 and 24 months follow-up, 86%, 84% and 100% of patients, respectively, remained in stable sinus rhythm. Conclusion. Totally thoracoscopic AF ablation with autonomic ganglia ablation with left atrial appendage (LAA) occlusion show high efficacy and low risk of complication in midterm follow-up.

**Key words:** ablation, atrial fibrillation, left atrial appendage occlusion, totally thoracoscopic, left atrial appendage exclusion

**Streszczenie.** Wstęp. Migotanie przedsionków (AF) jest najczęstszą arytmia nadkomorową, związaną z dużą chorobowością. Leki przeciwaritmiczne oraz ablacje przezcewnikowe wykazują ograniczoną skuteczność. Cel. Celem badania była ocena średnio odległych wyników całkowicie torakoskopowej ablacji przetrwałego i przetrwałego długotrwałego AF. Metody. 34 pacjentom w średnim wieku 60 ( $\pm 9,5$ ) lat wykonano całkowicie torakoskopową ablację AF z usunięciem uszka lewego przedsionka. Średni czas trwania arytmii wyniósł 87 ( $\pm 76$ ) miesięcy, średni wymiar lewego przedsionka wyniósł 45 ( $\pm 9,4$ ) mm, a frakcji wyrzucana i lewej komory 59 ( $\pm 8$ )%. U wszystkich pacjentów uzyskano dwukierunkowy blok przewodzenia przez linię izolacji żył płucnych. Po 3, 6, 12 i 24 miesiącach wykonywano badanie 48-godzinne holterowskie i echokardiograficzne. Wyniki. W trakcie obserwacji nie stwierdzono śmiertelności, udaru ani TIA. 97% pacjentów przy wypisie ze szpitala miało rytm zatokowy. Jeden pacjent wymagał sternotomii z powodu krwawienia z lewego przedsionka, skutecznie zaopatrzonego. Po 6, 12 i 24 miesiącach obserwacji u odpowiednio 86%, 84% i 100% pacjentów stwierdzano stabilny rytm zatokowy. Wnioski. Całkowicie torakoskopowa ablacja migotania przedsionków z ablacją zwojów autonomicznych i usunięciem uszka lewego przedsionka wykazuje dużą skuteczność i małe ryzyko powikłań w obserwacji średnio odległej.

**Słowa kluczowe:** migotanie przedsionków, ablacja, całkowicie torakoskopowo, zamknięcie uszka lewego przedsionka

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## Objective

The significant development in medical care and improved living conditions are favorable for increased life expectancy in developed and developing countries. However, longer lifespan is connected with greater morbidity. Atrial fibrillation (AF) is recently the most prevalent arrhythmia in senescent population and has become a growing problem because of its complications and high economic costs [1-3]. Many clinical trials and metaanalyses show that pharmacological treatment has poor long-term results and catheter ablation is moderately effective only in a selected group of patients with paroxysmal AF [4-6]. Surgical ablation shows superior results and the Cox-Maze III procedure is considered a gold standard for treatment of the drug-refractory symptomatic AF with success rate exceeding 90% [5,7]. However, because of its complexity and requirement of full sternotomy, it is not widely used especially for lone AF. Technological progress with continuous increase in knowledge of pathophysiology of AF allowed for creating systems for minimally invasive ablation without need for cardiopulmonary bypass and even sternotomy [7-9]. The aim of the study was to evaluate midterm results of totally thorascopic and autonomic ganglia ablation for persistent and long-standing persistent AF.

## Methods

### Patients' recruitment

Between November 2011 and December 2013, 34 consecutive patients in mean age 60 ( $\pm 9.5$ ) years with persistent and long-standing persistent AF underwent totally thorascopic ablation of AF with left atrial appendage (LAA) stapling. Eleven patients (32%) had previously at least one failed percutaneous catheter ablation for atrial fibrillation. The study was approved by the Institutional Review Board.

### Operative technique

Ablation was performed using Isolator Synergy Ablation System (AtriCure, Inc., West Chester, Ohio, USA). Patient under general anesthesia was intubated with double lumen intratracheal tube and placed in supine position. Firstly, three thorascopic ports were placed through the 4<sup>th</sup> (for camera) and the 6<sup>th</sup> (working ports) intercostal spaces in the midaxillary line into the right pleura. At this stage right lung was deflated. The pericardium was opened above the phrenic nerve giving good exposure of the right pulmonary veins together with the Waterstone's groove. The oblique and transverse sinuses were bluntly opened to enable placing

of the AtriCure Lumitip Dissector (AtriCure, Inc., West Chester, Ohio, USA) with rubber-leader around both upper and lower pulmonary veins (PV). Using rubber-leader bipolar radiofrequency AtriCure Isolator Synergy Clamp (AtriCure, Inc., West Chester, Ohio, USA) was placed around PV. At least three overlapping ablation lesions are performed at the antrum of the veins. Bidirectional acute conduction block was confirmed by both absence of sensed atrial potentials in the PV and pacing conduction from PV to left atrium. In case of any doubt, an extra ablation lesion around pulmonary veins was made. Next additional box-like lesions on the posterior wall of left atrium and trigonal line between the roof of the LA and the non-coronary sinus were made with bipolar linear device (Fig. 1). Subsequently, along the Waterston's groove identification of the autonomic ganglia was performed using a high-frequency (1000 hz, 18V) pacing induced vagal response (transient asystole by A-V block >3 seconds). The stimulation was performed with the Isolator Multifunctional Pen (AtriCure, Inc., West Chester, Ohio, USA). Active GP were mainly found anteriorly near superior vena cava.

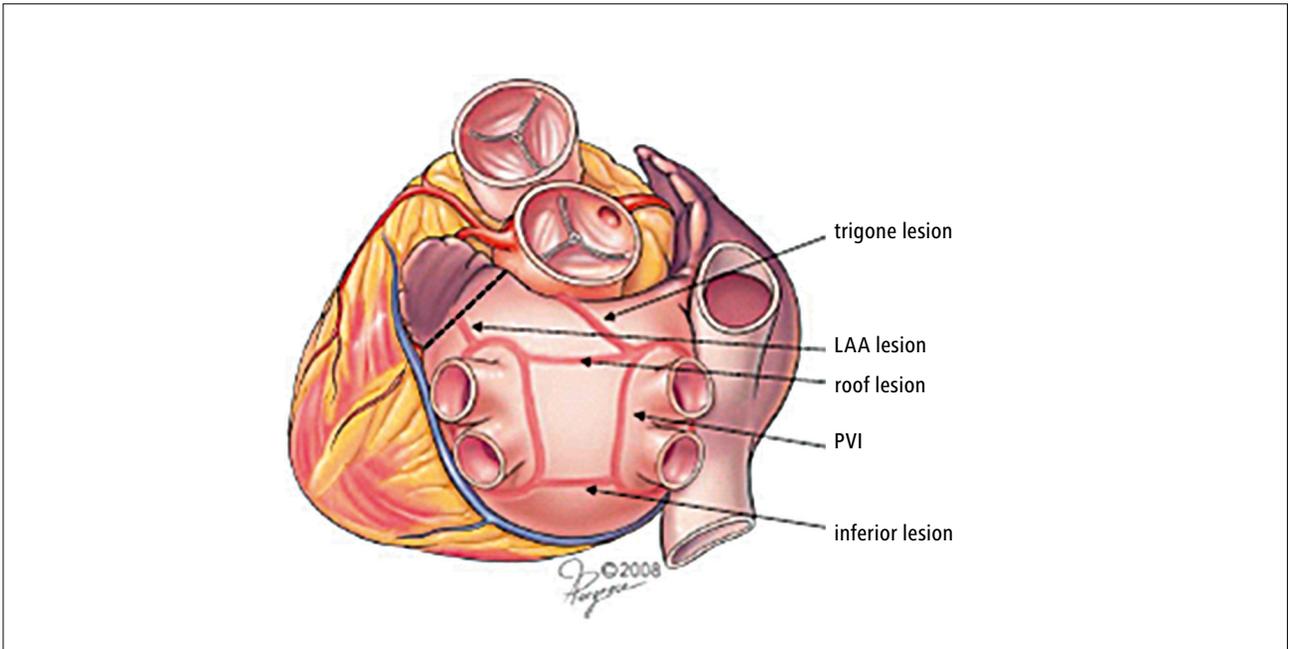
In the second step, three thorascopic ports were placed in a similar way as on the right side in to the left pleural cavity (Fig. 2). Pericardium was opened above the phrenic nerve to visualize left pulmonary veins, left atrium and the ligament of Marshall. The ligament of Marshall was carefully dissected with electrocautery. Left PVs were encircled and isolated like on the right side with at least 3 overlapping applications of energy (Fig. 3). After confirmation of the bidirectional block, connecting lines on the posterior wall of left atrium were performed and connected with lines made on the right side and create box-like lesion pattern.

### Left atrium appendage stapling

On the left side, left atrial appendage amputation was performed. Before procedure and also intraoperatively transesophageal echocardiography (TEE) was performed to rule out thrombus in the left atrial appendage. LAA was excised with endoscopic Endo-GIA stapler with the novel Tri-Staple (Covidien, Mansfield, USA) reloads (Fig. 4). The stapler was introduced through the 6<sup>th</sup> intercostal space above the diaphragm. While clamping the appendage the stapler must be placed very cautiously and precisely, preferably under TEE control, in order not to leave any stump. In case of a stump exceeding 1 cm, additional "green" reload or big endo-clip can be placed to exclude it.

### Follow-up

Baseline characteristics, in-hospital and follow-up data were collected prospectively. In perioperative period patients were under continuous heart rhythm monitoring.



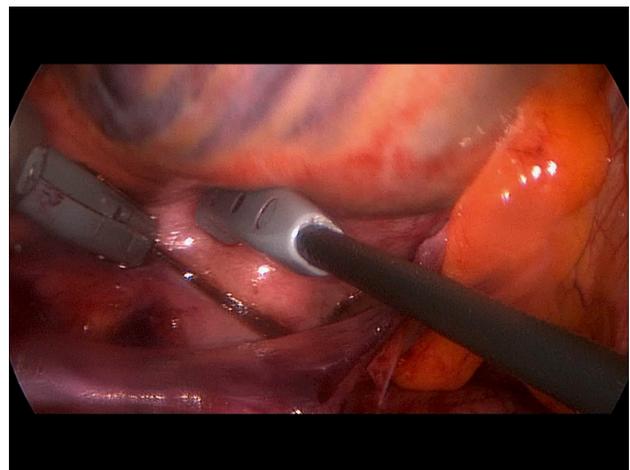
**Figure 1.** Modified ablation lesion set on the left atrium performed during totally thoracoscopic ablation (courtesy of AtriCure)

**Rycina 1.** Zmodyfikowany układ linii ablacyjnych w obrębie lewego przedsionka wykonywany podczas całkowitej torakoskopowej ablacji (za zgodą AtriCure)



**Figure 2.** Thoracoscopic set-up on the left side

**Rycina 2.** Układ torakoskopów po stronie lewej

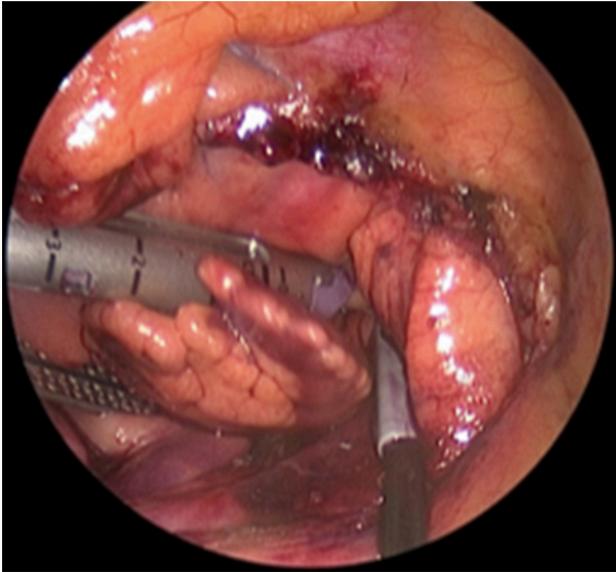


**Figure 3.** Ablation line around right pulmonary veins

**Rycina 3.** Linia ablacyjna wokół prawych żył płucnych

In 3, 6, 12 and 24 months, 48-hour Holter-monitoring and echocardiography (TTE) were performed. After ablation, patients were usually discharged on amiodarone or sotalol for 3–6 months. Anticoagulation was administered for at least six months. Decision to discontinue anticoagulation was based on history, confirmation of stable sinus rhythm in two consecutive Holter examinations, CHA2DS2-VASc score below 2 and positive

assessment of the atrial transport function. AF episodes after a 3-month follow-up, lasting longer than 30 seconds irrespectively of symptoms and amount, were considered a failure of ablation.



**Figure 4.** Left atrial appendage stapling

**Rycina 4.** Wykluczenie uszka lewego przedsionka z użyciem staplera

## Results

### Patients' characteristics

Detailed clinical characteristics are shown in Table 1. Patients were in mean age of 60 ( $\pm 9.5$ ) years, 13 of them were females (38%). Twenty five patients (85%) had persistent and 5 patients (15%) had long-standing ( $>12$  months) persistent atrial fibrillation. Six patients (18%) were in arrhythmia on admission to the hospital. All patients had no significant structural heart diseases. Mean time of duration of arrhythmia was 87 ( $\pm 76$ ) months. Mean EUROScore II and CHA2DS2-VASc score were 0.96 ( $\pm 0.59$ )% and 1.9 ( $\pm 1.3$ ), respectively. Mean serum level of NT-proBNP, troponin I (Tnl) and high sensitive troponin I (hsTnl) were 375.7 ( $\pm 477$ ) pg/ml, 0.014 ( $\pm 0.029$ ) ng/ml and 0.009 ( $\pm 0.009$ ) ng/ml, respectively. Mean left atrial dimension and LVEF were 45 ( $\pm 9.4$ ) mm and 59 ( $\pm 8$ )%, respectively. Two patients (6%) reported stroke prior the procedure. Three patients (9%) had implanted pacemaker or implantable cardioverter-defibrillator. Eleven patients (32%) had at least one previous failed percutaneous catheter ablation. Thirteen patients (45%) were in EHRA class 3, and eleven (38%) in EHRA class 2b.

### Procedural performance and outcome

The protocol was performed in 34 cases and completely achieved in 33 cases. In one female, left-sided ablation and LAA stapling was not feasible due to morbid obesity. In one patient (3%), we did not excise the LAA because

**Table 1. Demographic data**  
**Tabela 1. Dane demograficzne**

variable	N	$\pm$ SD or (%)
age (years)	60	$\pm 9.5$
sex (male)	21	61
persistent afib (%)	25	73
long-standing persistent (%)	5	15
time of duration (months)	87	$\pm 76$
arterial hypertension (%)	26	76
diabetes mellitus (%)	7	20
stable coronary artery disease (%)	11	32
chronic obstructive pulmonary disease (%)	1	3
chronic renal disease (%)	2	6
prior hypothyroidism (%)	6	18
prior hyperthyroidism (%)	3	9
cardiomyopathy (%)	1	3
prior stroke/TIA (%)	2	6
pacemaker/ICD (%)	3	9
	<b>mean</b>	<b><math>\pm</math>SD</b>
NT-proBNP (pg/ml)	375.7	$\pm 477$
Tnl (ng/ml)	0.013	$\pm 0.02$
hsTnl (ng/ml)	0.0098	$\pm 0.0099$
EUROScore II	0.96	$\pm 0.60$
CHA2DS2	0.82	$\pm 0.98$
CHA2DS2-VASc	1.97	$\pm 1.31$
LVEF (%)	58	$\pm 9$
left atrial dimension (cm)	45	$\pm 9.6$

of its small size with a very wide base. Mean number of identified GP in a patient was 4 (range 3–6). There was no operative mortality, no stroke or transient ischemic attack, no early or late bleeding requiring revision. One early patient required sternotomy for bleeding from left atrium without further morbidity. After ablation, 31 patients (91%) were in sinus rhythm on admission to the Intensive Care Unit and 33 (97%) on discharge from hospital. Thirteen patients (38%) required electrical cardioversion due to AF. In one case (3%), atrial flutter was observed, also successfully cardioverted to SR.

### Follow up

In 6, 12 and 24 months follow-up, 19/22 (86%), 11/13 (84%) and 6/6 of patients remained in stable sinus rhythm, respectively 3/22 (13%), 5/13 (38%) and 2/6 (33%) were off antiarrhythmic drugs (Table 2; Fig. 5). One patient (3%) had an episode of atrial flutter after 6 months, treated with electrical cardioversion. Three

**Table 2. Sinus rhythm (NSR) maintenance, incl. patients off-antiarrhythmic drugs (AAD) in follow-up**  
**Tabela 2. Utrzymanie rytmu zatokowego (NSR) w obserwacji, w tym u pacjentów bez leków przeciwarrytmicznych (AAD)**

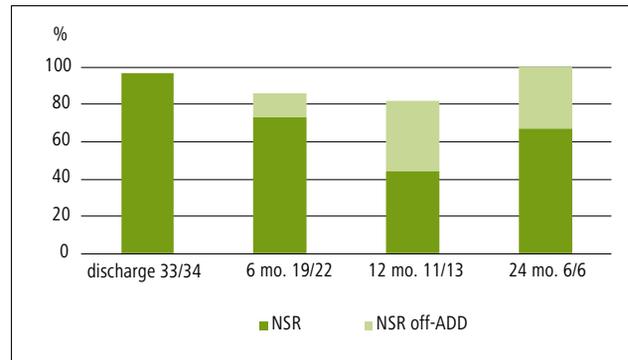
6 months		12 months		24 months	
NSR	NSR off-AAD	NSR	NSR off-AAD	NSR	NSR off-AAD
19/22 (86%)	3/22 (13%)	11/13 (84%)	5/13 (38%)	6/6 (100%)	2/6 (33%)

patients had episodes of atrial fibrillation in 48-hour ECG-Holter. They were referred to the electrophysiological examination. During the entire follow-up, no incidence of stroke or TIA was noticed. After index procedure in different time points, two patients (6%) required implantation of pacemaker. One patient with sick sinus syndrome (tachycardia-bradycardia) was electively qualified to a staged procedure with ablation as the first step and pacemaker implantation as a continuation of the treatment. Another patient required early pacemaker implantation because of prolonged episodes of bradycardia postoperatively. However, sinus rhythm returned before discharge. In echocardiography, increase in the left ventricle ejection fraction during follow up ( $59 \pm 7\%$ ,  $64 \pm 1\%$ ,  $62 \pm 5\%$  and  $63 \pm 1.5\%$  in 3, 6, 12 and 24 months, respectively) was observed. Also good left atrial transport function and its restoration in cases with continuous AF before ablation were observed (median E/A =  $1.68 \pm 0.5$  cm/s and DT =  $207 \pm 61$  ms). Left atrial dimension was  $46 (\pm 0.5)$  mm,  $44 (\pm 0.4)$  mm,  $43 (\pm 0.5)$  mm and  $46 (\pm 0.2)$  mm, respectively. Mean levels of NT-proBNP in FU were  $564 (\pm 935)$  pg/ml,  $258 (\pm 237)$  pg/ml,  $255 (\pm 225)$  pg/ml and  $81 (\pm 20)$  pg/ml, respectively for the time points. No mortality, no stroke or TIA were observed during follow-up.

## Discussion

AF is one of the most problematic diseases in developed countries, affecting almost 2% of the population [1,2]. It causes a high rate of absence at work, economical costs and decreased quality of life. In longer perspective, the patients have higher risk of cerebrovascular complications, higher rate of heart failure and mortality [3]. Many clinical trials and meta-analysis proved, that pharmacological treatment has poor long-term results and the catheter ablation is moderately effective in patients with persistent forms of arrhythmia [4-6]

MAZE procedure, proposed by James Cox in 1995, is considered a gold standard for the treatment of drug-refractory symptomatic AF due to its excellent success rate exceeding 90% [5]. However, because of its complexity and requirement of full sternotomy, it is not widely used, especially for lone AF [7]. To make the procedure easier and feasible for larger cohort of patients,



**Figure 5. Sinus rhythm (NSR) maintenance, incl. patients off-antiarrhythmic drugs (AAD) in follow-up**

**Rycina 5. Utrzymanie rytmu zatokowego (NSR) w obserwacji, w tym u pacjentów bez leków antyarytmicznych (AAD)**

a number of minimally invasive techniques from bilateral or unilateral minithoracotomy or totally thoracoscopic access have been recently introduced [7-10]. Although, in order to obtain similar results new technologies must fulfill a few crucial conditions, mainly regarding ablation pattern protocol and transmuralty, especially in epicardial beating heart setup. Gillinov et al. showed that a sole bilateral pulmonary vein isolation is inferior to both left-sided and complete MAZE operation in persistent AF [14]. The technique described above allows to perform extended left-atrial ablation pattern including not only pulmonary vein isolation but also additional lines on the posterior wall of left atrium and trigonal line relevant to the left isthmus line [15,16]. Employment of bipolar radiofrequency energy assures the transmuralty of the ablation lines.

The autonomic ganglia are located epicardially on the left atrium. It is well known that they can act like a trigger for atrial fibrillation onset [17,18]. As solely GP ablation cannot be sufficient for restoration of stable SR, however its destruction along with ablation on the left atrium can significantly increase the success rate [18]. In patients with multiple GP with significant response (transient A-V block) after surgical ablation stable SR was observed, often with sinus tachycardia lasting for the next few weeks. In some cases we actually saw return of sinus rhythm during the GP ablation.

Exclusion of the left atrial appendage (LAAE) is gaining additional importance as a prevention of thromboembolic events and improving result of ablation in patients with AF. Recent studies indicate, that it is not inferior to oral anticoagulation [20]. Thoracoscopic stapling is a safe and reproducible method, however, it is very important to precisely excise the LAA at its base in order not to leave any stump over 1cm. The routine LAAE might contribute to no cerebrovascular incidences in our cohort. Also, the emerged role of LAA in arrhythmia induction and its electrical isolation as a treatment option may explain very high effectiveness of our ablation protocol with routine LAAE [21].

Moreover, current guidelines require HEART-TEAM management strategy in patients with persistent AF or patients after failed percutaneous catheter ablation. Therefore, the role of surgical ablation or hybrid procedures is becoming the modern standard for management of AF patients.

## Limitations

The main limitation of this study is a small number of patients and a non-randomized trial. The decision regarding further antiarrhythmic and anticoagulation therapy was often managed by a referring physician. Although we obtained multiple 48-hour ECG-Holter recordings, the universal continuous monitoring would be optimal. Moreover, the effects of GP ablation was not investigated.

## Conclusion

In our experience, totally thoracoscopic ablation with autonomic ganglia ablation and LAAE for persistent and long-standing persistent AF is safe, feasible and gives good midterm results of the maintenance of the sinus rhythm. It allows to restore atrial transport function after the operation what can improve heart function. Longer follow-up and further studies in this group of patients are necessary.

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