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# Catheter ablation for atrial fibrillation – Update focused on the Czech Republic

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ABSTRACT

Today, catheter ablation has become a routine part of rhythm control in patients with atrial fibrillation (AF). In the Czech Republic (C.R.), these procedures are recorded in a nationwide registry, which is managed online and gives an overview on procedure rates and development trends. Palliative procedures, i.e. AV node ablation, are infrequently used nowadays and their rate did not change significantly within last 15 years. Contrary to that, the rate of selective ablation procedures of AF is steeply rising. In the C.R., these procedures are carried out in 10 centers, and 1,590 ablation procedures of AF were carried out in the year 2011. With its ablation rate per million inhabitants the C.R. ranks among the highest in Europe. For ablation, radiofrequency energy is used most frequently (93%), followed by cryoenergy (5% procedures), and laser energy (2% procedures). Of the 3-dimensional electroanatomical mapping methods the system Carto (66% ablations) and NavX system (22% ablations) are used most frequently. Real-time imaging using intracardiac echocardiography is widely used (73% ablation), which results in enhanced safety of the procedures. Mortality associated with AF ablation is 0.04% (3 cases out of the total of 7,300 ablation procedures in the registry).

*Klíčová slova:*
Česká republika
Fibrilace síní
Katetrizační ablace
Registr ablací

SOUHRN

Katetrizační ablace jsou dnes rutinní součástí kontroly srdečního rytmu u pacientů s fibrilací síní (FS). V ČR jsou tyto výkony sledovány v celonárodním registru, který je organizován online a podává přehled o počtech a vývojových trendech. Paliativní výkony v podobě ablace AV uzlu se dnes používají málo a jejich počet se v průběhu posledních 15 let téměř nezměnil. Počty selektivních ablací pro FS naopak prudce stoupají. V ČR tyto výkony provádí deset center, ve kterých bylo v roce 2011 provedeno 1 590 ablací pro FS. V přepočtu na milion obyvatel se tímto počtem ČR řadí na přední místo v rámci Evropy. K ablacím se používá nejčastěji radiofrekvenční energie (93 % výkonů), dále kryoenergie (5 % výkonů) a laserová energie (2 % výkonů). Z trojrozměrných elektroanatomických mapovacích metod se nejčastěji používá systém Carto (66 % ablací) a systém NavX (22 % ablací). Zobrazování v reálném čase pomocí intrakardiální echokardiografie je vysoce rozšířeno (73 % ablací), což se odráží ve zvýšené bezpečnosti prováděných výkonů. Mortalita spojená s ablací pro FS je 0,04 % (tři případy z celkem 7 300 ablací v registru).



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## Introduction

Catheter ablation has become a routine part of the AF management. The history of ablation started 30 years ago, in 1982, when the first patients with supraventricular arrhythmias have been applied direct current (DC) into the His bundle region. This resulted in complete AV block that prevented transmission of the electric impulse from the atria to the ventricles. At the end of 80's the DC bursts were replaced by a significantly friendlier application of the radiofrequency (RF) energy. Some ten years later, the first curative interventions of AF were introduced. Then the importance of palliative ablation of the AV junction fell significantly. Today this procedure is used for rate control in polymorbid patients or in patients after resynchronization therapy of heart failure.

Cardiac surgeons were the first to carry out treatment procedures to restore the heart rhythm. Until now, different modifications of the original surgical procedure of the type "maze" are used. The principle is to create multiple incisions in the atria, resembling a maze with just one correct way for impulse transmission. This prevents the reentry mechanism. At first, the cardiologists attempted to simulate these linear lesions in the atria by the catheter, however, with available methods and technologies the procedures were long and complicated, with a low success rate. A breakthrough in the catheter treatment of AF was made by the finding, that paroxysmal arrhythmia was frequently triggered by the ectopic activity from the pulmonary veins. After a temporary period of focal ablation, complete electrical pulmonary vein isolation has been widely introduced. Later on, ablation for persistent and even long-standing persistent forms of AF have been introduced. In these patients reentry circuits or rotors in the atria play a bigger role than foci. Although even in these patients pulmonary veins isolation remains the base of catheter treatment of AF, in order to achieve higher success rate, further lesions in the left or in both atria have to be carried out.

## Indication for ablation

AF is associated with symptoms, lower quality of life, higher morbidity and mortality. The hypothetic goals of ablation include elimination of the arrhythmia with resulting alleviation or diminishing of symptoms, better quality of life, lowering the risk of heart failure, stroke, peripheral embolism and lower mortality. However, until now, objective data have proven reliably only the symptom alleviation and the quality of life improvement. In the future, ablation may prove useful to achieve other goals. To this time, however, ablation is indicated mainly in symptomatic patients [1,2].

AF occurs frequently in patients with heart failure. The responsible mechanism is scarring and myocardial fibrosis, atrial dilatation and overload, and also the influence of neurohumoral upregulation. The high atrial rate *per se*, however, worsens atrial function and may lead to left ventricular dysfunction (i.e. tachycardic cardiomyopathy). Higher atrial rate, irregular ventricular rate, or even medication may add to the development of heart failure. Studies have shown, that after ablation of AV junction, as well as after elective ablation for AF, improvement or even normalization of the left ventricular function may occur. Thus, if AF is suspected to be the main mechanism of left ventricular dysfunction, selective catheter ablation should be considered.

Sinus rhythm restoration is usually associated with partial or complete restoration of the above mentioned changes, i.e., with reverse remodeling. Some changes, e.g. fibrosis or myocardial scarring, however, are irreversible. Generally, the longer the AF duration, the more pronounced are the remodeling changes in the atria. Therefore the success rate of the catheter ablation is primarily higher in the paroxysmal then persistent forms. Also, more data are available in the literature on paroxysmal AF ablation.

Many randomized and observational studies compared success rate of catheter ablation and pharmacological antiarrhythmic treatment of AF. In general, all of them proved that catheter ablation was significantly better than pharmacological treatment in sinus rhythm preservation. These data lead to the indications for catheter ablation (Table 1).

In the recently published Focused Update of the European Society of Cardiology [3], there is focus on safety of the catheter ablation for AF. These procedures are complex and associated with some risk of complication. Data on complication rate are shown in the newly finished EURObservational Research Programme that involved 10 European countries (including C.R.) and more than 1 000 procedures, carried out in specialized high-volume centers. Among severe complications, tamponade was in 1.3%, stroke in 0.6%, pericarditis in 2% and vascular complication in 1.3%. Some studies listed not only clini-

**Table 1 – Indications for catheter ablation in patients with atrial fibrillation (AF).**

| | | |
|---|---|---|
| **Symptomatic AF refractory or intolerant to at least one Class 1 or 3 antiarrhythmic medication** | | |
| Paroxysmal: Catheter ablation is recommended. | I | A |
| Persistent: Catheter ablation is reasonable. | IIa | B |
| Long-standing persistent: Catheter ablation may be considered. | IIb | B |
| **Symptomatic AF prior to initiation of antiarrhythmic drug therapy with a Class 1 or 3 antiarrhythmic agent** | | |
| Paroxysmal: Catheter ablation is reasonable. | IIa | B |
| Persistent: Catheter ablation may be considered. | IIb | C |
| Long-standing persistent: Catheter ablation may be considered. | IIb | C |

cally apparent but also silent embolizations, diagnosed by MRI or ultrasound. The clinical impact of the silent embolizations is not clear, however, this risk needs to be carefully considered, when selecting an ablation tool or technology.

Center selection also has to do with safety. As the risk of complication is lower in high-volume centers, the guidelines clearly state, they are valid only if procedures are carried out by experienced operators.

Ablation is associated with increased risk of thromboembolic complications. Therefore, there is a consensus on anticoagulation in the peri-ablation period. Several studies have shown, that ablation may be carried out with ongoing anticoagulation using vitamin K antagonists (VKA), with lower rate of complications. This is valid especially for local vascular entry complications. Therefore, in patient on VKA it is recommended not to interrupt the treatment before the procedure. The anticoagulation therapy should be kept in the therapeutic range (optimally INR 2.0–2.5) throughout ablation. The experience with novel anticoagulants is limited in this respect. Some data suggested higher complication rate of intervention on continuing dabigatran treatment. However, it should be stressed, that the net association of risk with continuing anticoagulant treatment is not known. However, it is probably sure to start these agents after the procedure [3].

## What is the role of ablation in patients with AF?

The control of heart rhythm, heart rate, and prevention of thromboembolic events are the three basic components of AF treatment. The majority of studies that compared rhythm vs. rate control did not find a significant difference in morbidity or mortality between these two methods. While the sinus rhythm is more favorable, the advantage of maintaining sinus rhythm is neutralized by the use of antiarrhythmics and their adverse effects. Therefore, today, individual approach is preferred. In younger patients, first rhythm control should be attempted, while in the older, often polymorbid or less symptomatic patients, rate control my be preferred.

In real life rhythm control seems to be a more favorable approach. This is suggested by the registry RECORD AF [4]. In the prospective study, rate vs. rhythm control was compared. The study was fuelled by data from physicians randomly selected from the global list of office- or hospital-based (university/nonuniversity, private/clinic) cardiologists. Finally, data from 5,604 patients with AF from 532 centers from 21 countries in Europe, America, and Asia were analyzed. The risk of cardiovascular events, stroke, and heart failure was lower with rhythm control.

The prevalence of AF is estimated 1–2% in the population. Based on the assumption, that half of the patients are symptomatic, excluding polymorbid patients, ablation would still be considered in a high percentage of patients. What is the percentage of patients with AF that really undergo the procedure?

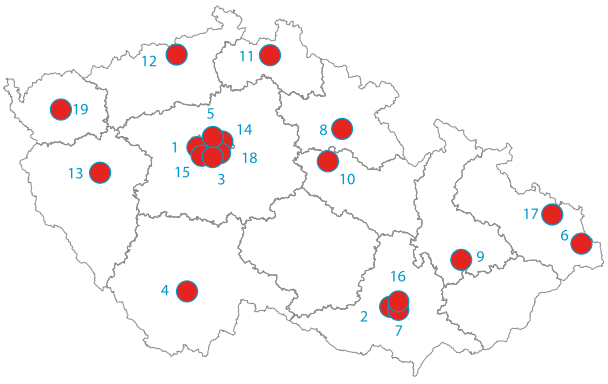
According to the registry RECORD AF, 2% of treated patients underwent the ablation, another 2% had pacemaker implantation and 0.3% patients undertook surgical treatment of AF. The prospective study ATRIUM (registry of the morbidity of outpatients with AF [5]) from a random sample of outpatient clinics in Germany, brings other data on the current treatment of patients with AF. The registry included data on 3,667 patients, mean age 72 years, 58% men. AF was paroxysmal in 27.1%, persistent or long-standing persistent in 25.7%, and permanent in the full 41.6%. The mean time since diagnosis was 61 months. The rate control was used in 75%, rhythm control in 33% patients, often added to the rate control. In the sample, 75% patients were treated with beta-blockers, 15% calcium antagonists and 29% with digoxin. Full 46% patients undertook cardioversion in the year pre-enrollment, of these one half had electric cardioversion. Catheter ablation was carried out in 5%, pacemaker or defibrillator implantation in 10%. It should be emphasized, that these data come from a country that belongs to the most productive in Europe concerning ablation rate per million inhabitants. In fact, catheter ablation is carried out in 2–5% of patients, that are followed and treated for AF in the developed countries of Europe.

## Which technologies are used in catheter ablation?

Knowledge of pathophysiology and mechanism of AF onset and preservation, and development of the catheter treatment of this arrhythmia was associated with significant technological development. The left atrium is approached transseptally. The ablation is most commonly carried out by a navigable catheter for mapping and application of radiofrequency energy point-by-point. Apart from point-by-point energy application, circular and semicircular catheters are used, that enable at one time energy application around the pulmonary vein orifice. Further, balloon catheters using cryoenergy, laser or circular/network catheters are used in practice, with radiofrequency energy aiming to achieve pulmonary vein isolation by one or a few ablation energy applications. Point-by-point ablation can also be used by all sources of energy. The main advantage of balloon and circular catheters is the possibility of pulmonary vein isolation by a low number of ablation energy applications. The disadvantage is a certain limitation by the anatomy of the left atrium. Further they may not be used for the AF sources localized beyond pulmonary veins or for linear ablation. The success rate of point-by-point and balloon technology ablation is similar, however, large comparative studies are lacking.

AF ablation may be carried with a simple fluoroscopic navigation or using three-dimensional mapping systems. The virtual maps obtained by these systems may be integrated with 3D images of the atria by CT, MRI or rotational angiography. The ablation may be easier using intracardiac echocardiography. The catheter may be navigated directly by the hand of the operator or through distal navigation by the magnetic field or by a robotic hand with navigable catheter sheath.

According to the EURObservational Research Programme [6], which includes data from 1,391 ablations




1. IKEM Praha – Klinika kardiologie
2. FN Brno – Interní kardiologická klinika
3. Nemocnice Na Homolce – Kardiologické odd.
4. Nemocnice České Budějovice – Kardiocentrum
5. VFN Praha – II. interní klinika kardiologie a angiologie
6. Třinec – Kardiocentrum
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8. FNHK – I. interní kardioangiologická klinika
9. FN Olomouc – I. interní klinika – kardiologická
10. Artur Koblitz, s r.o. – kardiologie
11. Liberec – Kardiocentrum
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19. Karlovy Vary – Kardiocentrum

**Fig. 1 – Centers that carry out ablation for arrhythmias in the C.R.**

carried out between 2009 and 2010 in 10 European countries, ablation was carried out for paroxysmal AF in 66.8% patients, for persistent AF in 27.6% and for long-standing persistent AF in 4.5%. Radiofrequency energy was used for ablation in 88.4%, the catheter with open cooling of the tip was used for application in 77.8%, and circular catheter in 4.4%. Cryoenergy is reported in 13.4% procedures and laser balloon in 0.8% procedures.

## AF ablation in the Czech Republic

The ablation rate in the C.R. has been recorded in the national registry since 1996. The data collection is managed by the Working Group on Arrhythmias and Cardiac Pacing of the Czech Society of Cardiology. Since 2010, the registry has been available in the online regime. In the registry, demographic data (patient's age and gender), indication for the procedure, their order, and parameters (ablation duration and fluoroscopic time) are recorded, as well as data on the technology used (type of energy, catheter), imaging and mapping methods and way of ablation (manual, robotical).

Catheter ablation for arrhythmia in the C.R. with population of 10.2 million inhabitants is carried out in 19 centers (Fig. 1). First ablation procedures in the C.R. were palliative, i.e. AV transmission interruption using DC impulse. Later, radiofrequency energy started to be used for this purpose. The number of AV node ablation procedures did not change during 15 years (Fig. 2), while the total number of ablation procedures rose more than fourtimes. Only in the last years the number of AV node ablation has been mildly rising, especially in patients with AF and resynchronization therapy of heart failure. In these cases the ablation allows full effect of biventricular stimulation.

The rate of selective ablation for AF is further increasing. Between 2000 and 2011 more then 7,300 AF ablation were carried out in the C.R. (Fig. 3). The spectrum of ablation is changing, so the percentage of AF ablation out of the total number of ablation procedures is rising (Fig. 4). In 2011, the ablation of AF constituted 36.5% of all ablation (Fig. 5). Full 66.3% were for paroxysmal AF, 22.8% for persistent AF, 5.8% for long-standing persistent AF a 5.1% for atrial tachycardias that arose after AF ablation.

AF ablation is carried out in ten centers with distinctly different numbers of procedures. In 2011, 1,590 AF ablation were carried out in the C.R. In one center the AF ablation rate was over 400 per year, it was 200 in other two

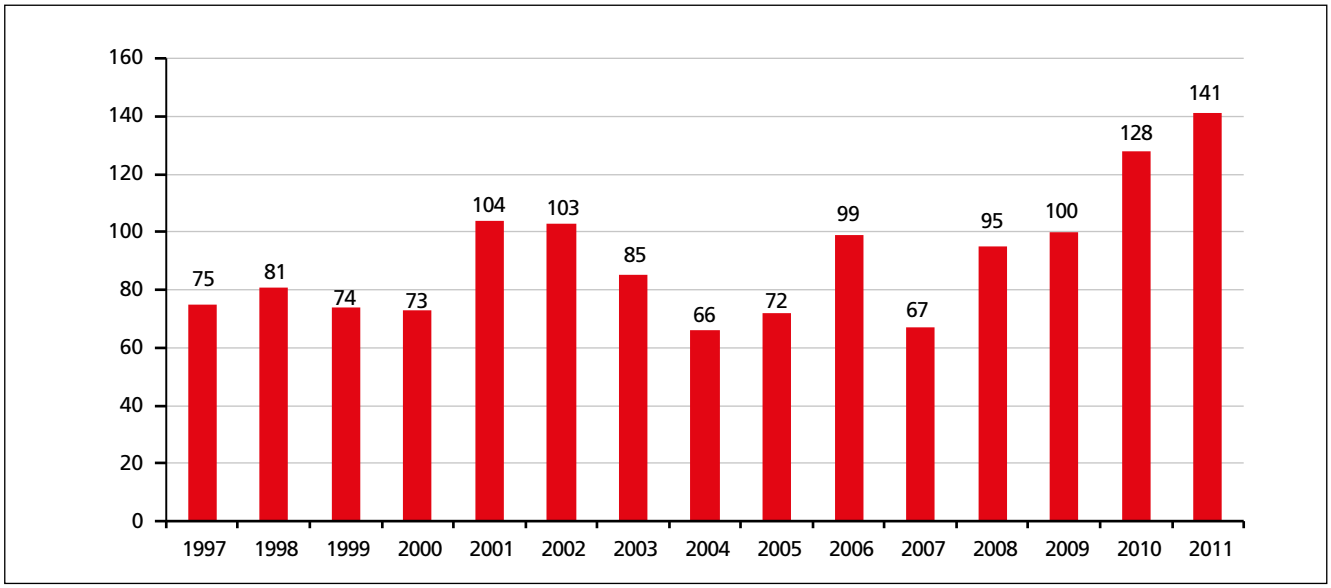


**Fig. 2 – Trend in the AV node ablation rate in the C.R., 1997–2011.**

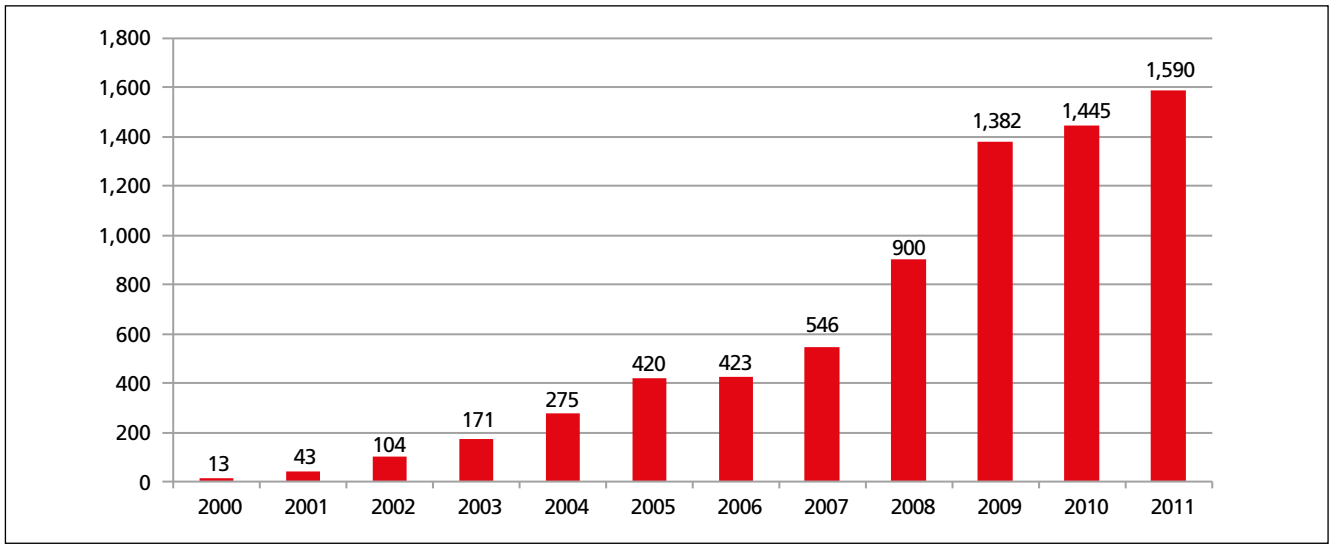


**Fig. 3 – Trend in the AF ablation rate in the C.R., 2000–2011.**

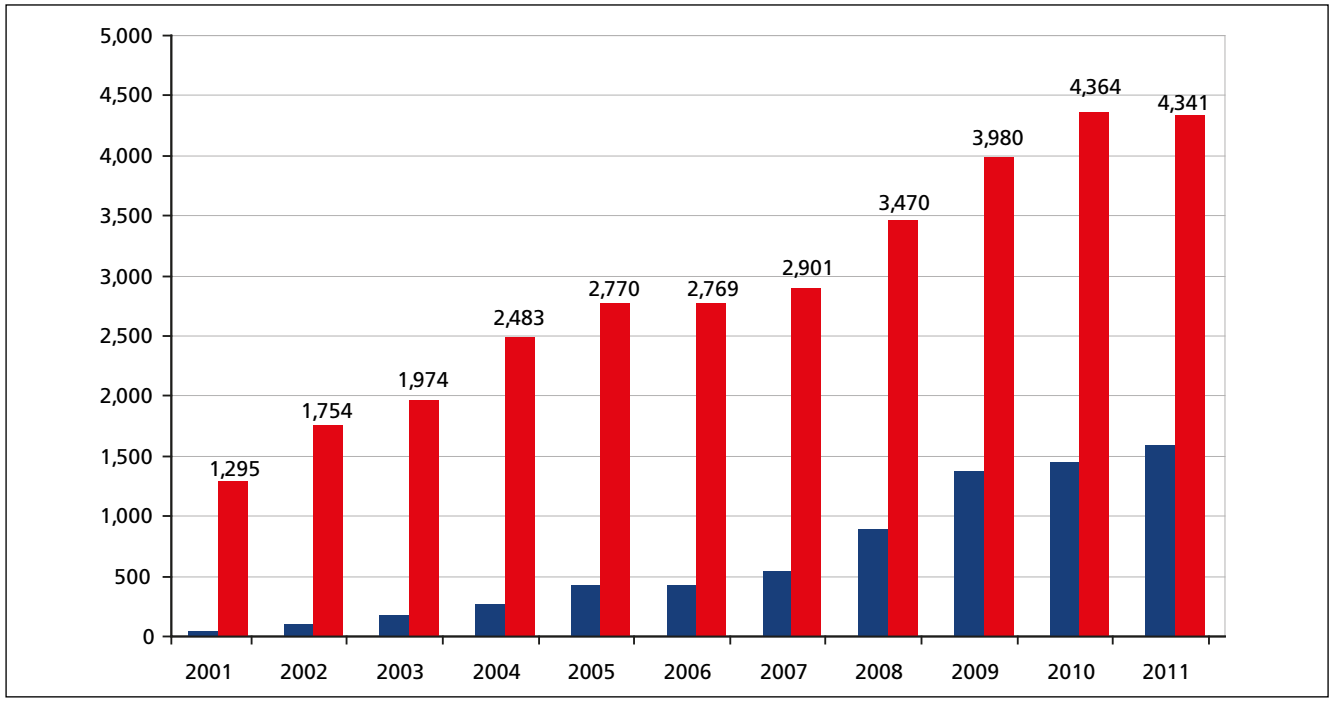


**Fig. 4 – Comparison of the total rate of ablation for all arrhythmias and AF ablation rate in the C.R., 2000–2011.**
**Red columns – ablation for all arrhythmias, including atrial fibrillation, blue columns – ablation for atrial fibrillation only.**

centers, and 100–200 in other three centers. The remaining centers made below 100 procedures per year (Fig. 6). In 2012 AF ablation started to be carried out in another 2 centers, thus newly, 12 centers will be involved in ablation.

Lack of data on follow-up and long-term success rate of the procedures is the main limitation of the registry. The success rate, however, can be estimated by the number of repeated procedures for a given diagnosis. Last two years, repeated procedures for AF have been carried out in 8% patients, with median time until repeated procedure 9 months. The mean duration of paroxysmal AF ablation (puncture – catheter removal) is 210 min, of persistent AF 249 min, and of long-standing persistent AF 287 min (Fig. 7). The fluoroscopic load in the C.R. is generally low, with median fluoroscopic time ranging from 15 min in paroxysmal AF ablation, to 20 min in persistent AF ablation (Fig. 8). This is probably due to frequent use of pulse skiascopy, 3D mapping methods and intracardiac echocardiography.

Radiofrequency energy is the most common energy for AF ablation, i.e., in 93%. Cryoenergy was used in 5% and laser energy in 2% of procedures. Among the 3D mapping methods, the Carto system was used in 66% and NavX in 22%. More than 60% of patients had cardiac CT before ablation.

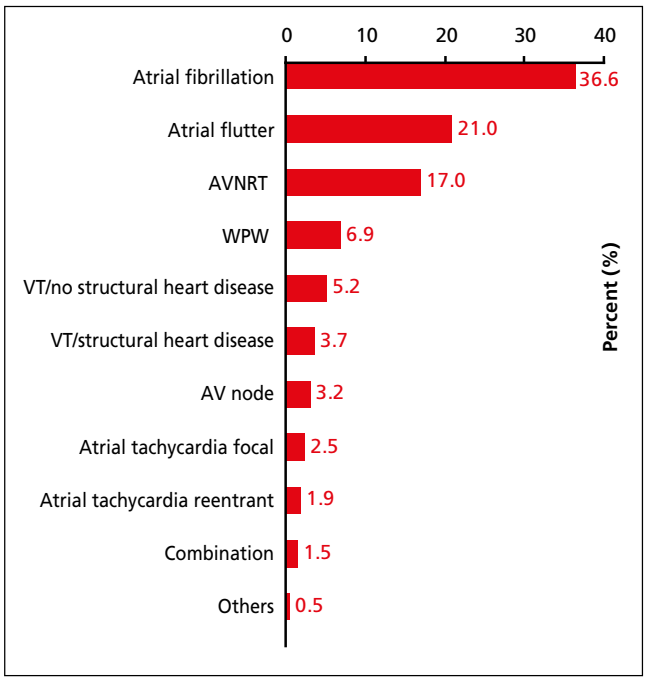


**Fig. 5 – Indications for catheter ablation in the C.R., 2011. The rates are given in percents.**

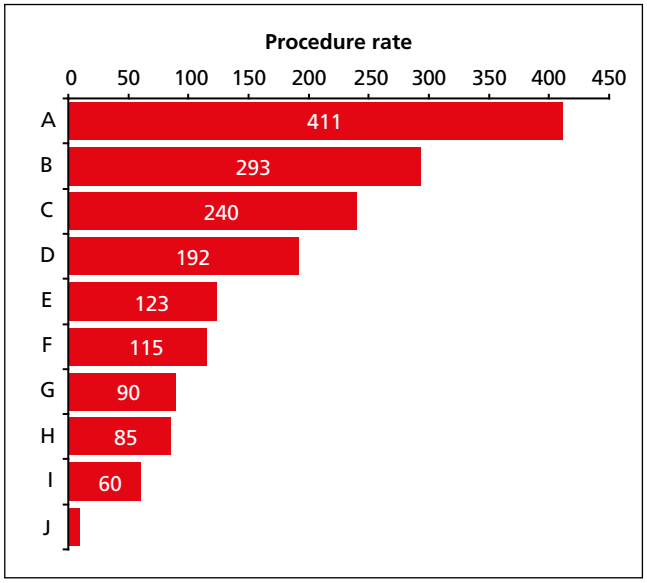


**Fig. 6 – AF ablation rate in different centers in the C.R., 2011.** The centers are marked by letters.

In the C.R. 73% of procedures have been carried out under intracardiac echocardiography control. It enables: 1) real time imaging of the heart anatomy, including pulmonary veins morphology and the position of the esophagus to the left atrium; 2) safe transseptal puncture; 3) navigation of the ablation and mapping catheter in the atrium; 4) energy titration, tracking of changes of the left atrial wall morphology during ablation; 5) early monitoring of the thrombus formation on the catheter, sheath or in the atrium and 6) early diagnosis of complications, e.g. pericardial effusion or tamponade.

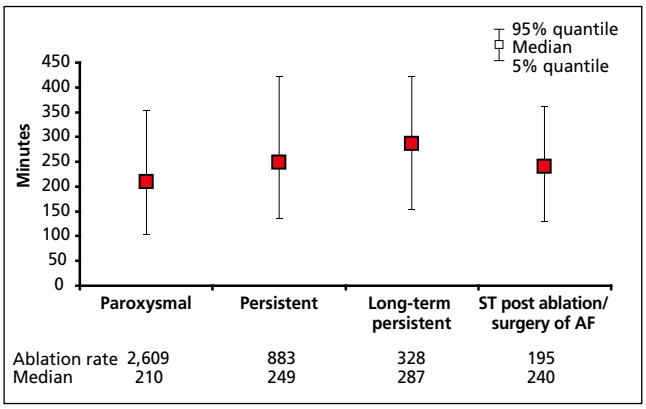


**Fig. 7 – Ablation procedure time by type of atrial fibrillation in the C.R., 2011. The time is given in minutes.**

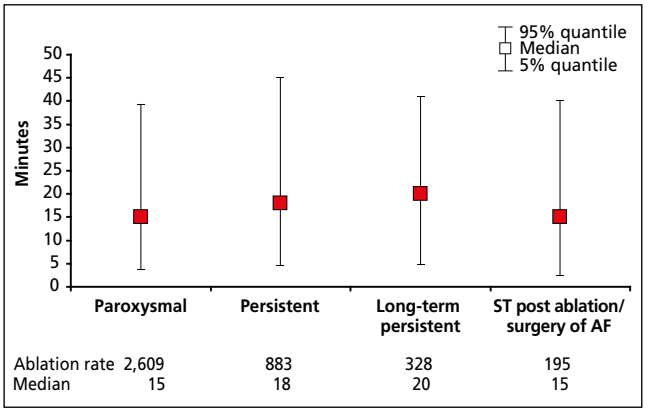


**Fig. 8 – The fluoroscopic time for ablation by type of atrial fibrillation in the C.R., 2011. The time is given in minutes**

However, intracardiac echocardiography does not fully replace transesophageal echocardiography in excluding left atrial thrombosis. At the time of joined European and American guidelines for ablation (EHRA/HRS/ECAS [3]) 50% of the panel reported routine use of this method. Thus, the use of intracardiac echocardiography in the C.R. is high above average.

The complication rate is also followed in the national registry, however, it is probably significantly underreported. Therefore, these data cannot be considered fully reliable. Even though ablation procedure is generally considered safe, it can be associated with mortality. In the C.R. there have been three reported deaths out of the total of more than 7,300 AF ablation procedures. (0.04%). This is less, than reported in the recent whole world overview, where death is reported in 32 out of 32,569 (0.1%) patients, who underwent 45,115 procedures for AF [7]. It is encouraging, that esophageal fistula, a severe complication with high mortality has not yet been reported. This is probably due to lower energy used for ablation in the C.R., i.e. maximum 25–30 W with radiofrequency ablation at the posterior wall.

## Comparison of the AF ablation rate between C.R. and Europe

In Europe, the rate of invasive procedures for arrhythmias, including catheter ablation is listed in a yearly

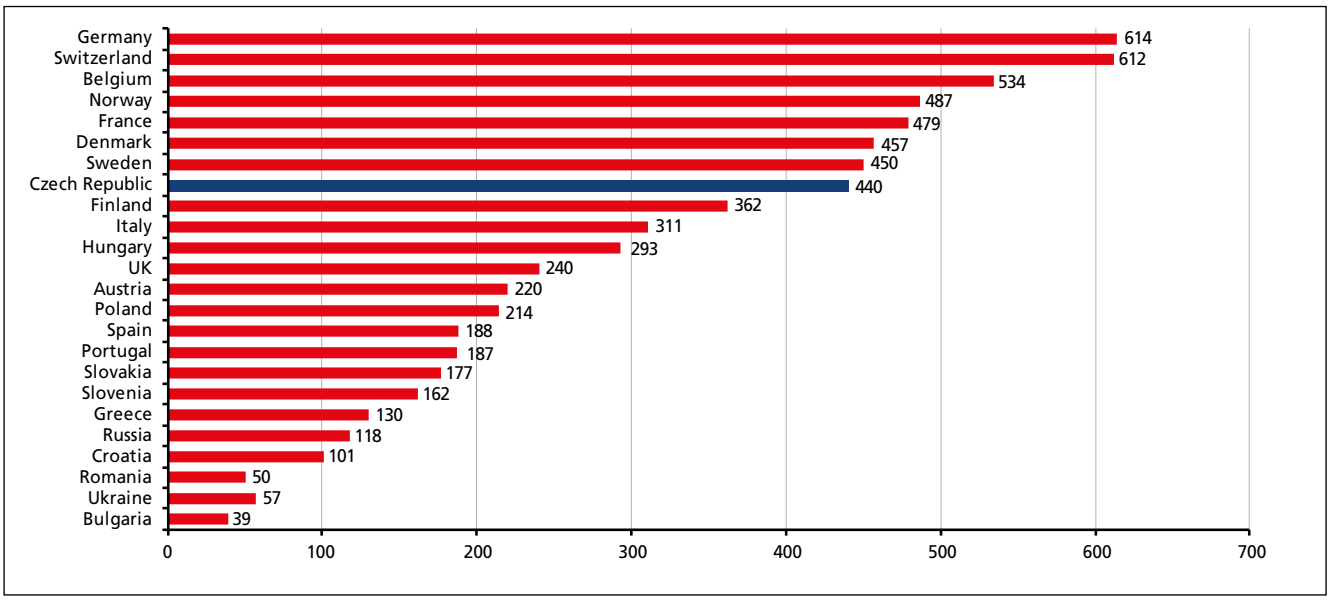


**Fig. 9 – The catheter ablation for arrhythmia rate per million inhabitants in selected European countries in the year 2011 (according to EHRA White book 2012 [8]).**

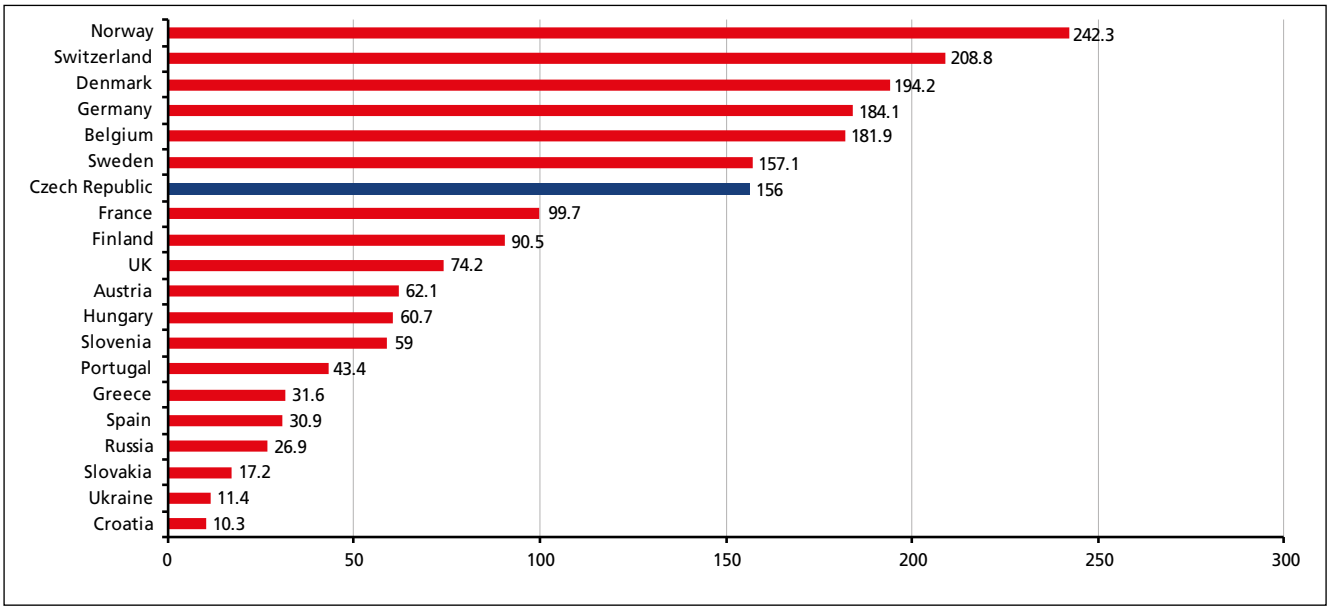


**Fig. 10 – The catheter ablation for atrial fibrillation rate per million inhabitants in selected European countries in the year 2011 (according to EHRA White book 2012 [8]).**

published overview called White book of the European Heart Rhythm Association (EHRA). In 2012 EHRA published the 5th edition, that included data from national organizations from 46 countries (out of total 54 member countries) of the European Society of Cardiology [8].

AF catheter ablation has been only recently followed separately. Some national organizations, however, have no data available or with delay. Other countries only estimate their numbers. In many countries that provide data for the White book AF ablation is carried out rarely or not at all. The total rate of ablation for arrhythmias in selected European countries is shown in the Fig. 9. With the ablation rate of 440 per million inhabitants C.R. belongs to the countries with the highest number of the procedures. The situation is similar for AF ablation (Fig. 10). The calculation of procedure rate per health care expenditure in a given country is also interesting. With the expenditure equivalent 1,590 USD per person and year the C.R. is deep below the European average which was 2,786 USD. On the contrary, with the rate of arrhythmia procedures (implantation of pacemakers, defibrillators, ablation for arrhythmia including AF) per health care expenditure, the C.R. ranks among the best in Europe, that suggests very effective use of resources.

## Conclusions

Catheter ablation has become a routine part of heart rhythm control in patients with AF. Currently 2–5% of treated patients undergo these procedures, however, this depends on the number of interventions in each country. Approximately two thirds of ablation are for paroxysmal AF and one third for persistent and long-standing persistent AF. Comparison of the Czech registry data with other countries is difficult, as detailed data are lacking. Relevant summary data are brought together only by the White book EHRA. With the AF ablation rate 156 per million inhabitants, C.R. belongs to the highest ranking countries in Europe. The technologies used and parameters of the procedures correspond with findings from large centers that carry out ablation.

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