Induction of supraventricular tachycardias in patients undergoing pulmonary vein isolation for paroxysmal atrial fibrillation is safe and reasonable

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Aims. Patients with atrial fibrillation (AF) may experience other supraventricular tachycardias (SVT) that can trigger AF and cause similar symptoms. The aim of this study was to assess the safety and effectivity of inducing SVT in patients undergoing catheter ablation (CA) for AF.

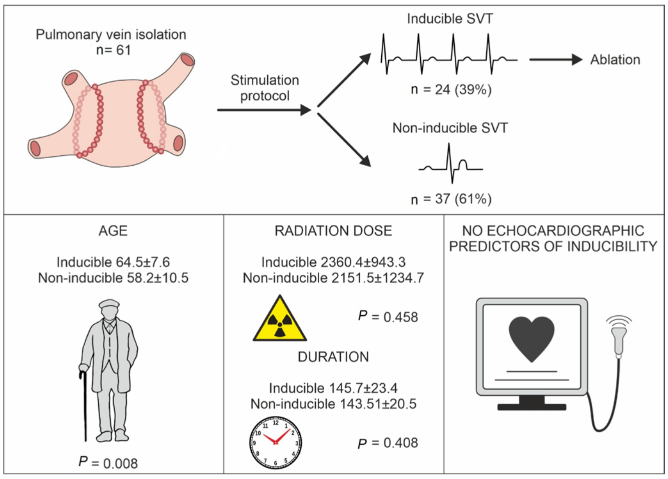
Methods. In 61 patients with paroxysmal AF undergoing CA between January 2022 and March 2023, an electrophysiological study was performed after pulmonary vein isolation (PVI) to induce SVT. Induced arrhythmias were mapped and ablated. All patients were followed up at 3, 6, and 12 months after the procedure; seven-day ECG Holter monitoring was carried out 6 and 12 months after the procedure.

Results. In 24 patients (39%) an SVT was induced during the stimulation protocol. There was no significant difference in procedure time (*P*=0.408) or fluoroscopy dose (*P*=0.458) between patients with and without inducible arrhythmia. Further, none of the echocardiographic variables such as left atrial volume index (LAVI) (*P*=0.936), left ventricular ejection fraction (LVEF) (*P*=0.586), or right atrial (RA) area (*P*=0.716), differed significantly in these subgroups. Age was a significant factor in patients with arrhythmia inducibility compared with those without (64.5 ± 7.6 and 58.2 ± 10.5, *P*=0.04).

Conclusion. SVT inducibility after successful PVI was 39%. Ablation of nonclinical arrhythmia is safe and did not prolong the total procedure or fluoroscopy time.

INDUCIBILITY OF SUPRAVENTRICULAR ARRHYTHMIAS IN PATIENTS UNDERGOING PULMONARY VEIN ISOLATION IS SAFE AND REASONABLE

Patients with atrial fibrillation may experience other supraventricular arrhythmias that can cause similar symptoms and trigger atrial fibrillation. The aim of this study was to assess the safety and effectivity of inducing arrhythmias in patients undergoing pulmonary vein isolation for paroxysmal atrial fibrillation.



Supraventricular arrhythmias inducibility after pulmonary vein isolation was 39%. Ablation of arrhythmia was safeand did not prolong total procedure or fluoroscopy time.

Vrtal J. et al., doi: 10.5507/bp.2024.037

Graphical Abstract

Biomedical Papers
https://biomed.papers.upol.cz

Key words: atrial fibrillation, supraventricular tachycardias, inducibility, ablation

Received: August 10, 2024; Revised: October 21, 2024; Accepted: November 5, 2024; Available online: November 12, 2024
https://doi.org/10.5507/bp.2024.037

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INTRODUCTION

Atrial fibrillation (AF) is the most common supraventricular arrhythmia, with a prevalence of 2–4% in the unselected population; it increases dramatically with age and comorbidities[1]. The trigger is often located in pulmonary veins[2]. Catheter ablation (CA) for pulmonary vein isolation (PVI) is an established rhythm control treatment modality for drug-refractory symptomatic AF or as a patient-preferred treatment approach and for patients with heart failure[3,4]. Some patients with AF may experience other supraventricular tachycardias (SVT) that can trigger AF and may cause similar symptoms[5-7]. Numerous reports indicate that during electrophysiological studies, induced atrioventricular nodal reentrant tachycardia (AVNRT) can rapidly degenerate into atrial fibrillation[5,6]. Atrial fibrillation in the Wolff-Parkinson-White syndrome may be related to microreentry in the accessory pathway[7]. CA is also often a recommended treatment option for most patients[8]. Those with inducible SVT may be scheduled for simpler ablation procedures instead of pulmonary vein isolation[9-11]. The strong association between atrial flutter and AF is also well described[12,13]. This study aimed to analyse the inducibility of supraventricular arrhythmias in patients undergoing CA for AF and evaluate its safety and efficacy.

METHODS

Patient group

In patients with paroxysmal atrial fibrillation undergoing CA for AF between January 2022 and March 2023, an electrophysiological study was performed after PVI to induce SVT. All patients signed informed consent according to the procedure. The study was approved by the institutional review board and conducted according to the latest Helsinki Declaration. The inclusion criteria were age ≥18 years at the time of the screening, the paroxysmal form of atrial fibrillation, sinus rhythm before procedure, and signed written informed consent. The exclusion criteria were persistent or long-standing persistent AF, severe valve disease, history of valve repair or replacement or any other previous cardiac surgery, left ventricular ejection fraction <35%, chronic use of amiodarone, the presence of intra-cardiac thrombi as documented by transesophageal echocardiography, uncontrolled thyroid disorders, pregnancy, breastfeeding and severe renal dysfunction.

Procedures before catheter ablation

All patients underwent transesophageal and transthoracic echocardiography within 24 hours before ablation. Using transthoracic echocardiography, the left atrium diameter (LAD), left atrium volume index (LAVI), right atrium area (RA), and left ventricle ejection fraction (LVEF) were determined. Transesophageal echocardiography was performed to exclude the presence of intracardiac thrombi. All patients discontinued antiarrhythmic medication at least 3 days before ablation. That applied to beta blockers as well.

Ablation procedure

Catheter ablation was performed in conscious sedation with the use of sufentanil citrate (Sufentanil) and midazolam (Dormicum). Two sheaths were introduced via the left femoral vein under a direct ultrasound guide for an intracardiac echocardiography probe (AcuNav ultrasound catheter, Siemens Healthineers, USA) and decapolar diagnostic coronary sinus catheter (Inquiry, St. Jude Medical). One steerable transseptal sheath (Agilis NxT Steerable Introducer, St. Jude Medical) and one Swartz SL1 8.5 Fr sheath were introduced via the right femoral vein, also under direct ultrasound guidance. A double transseptal puncture was performed under visual control of intracardiac echocardiography. After transseptal puncture, a 3D electro-anatomical map was created using EnSite Precision (St. Jude Medical). A point-by-point radiofrequency wide-antral pulmonary vein isolation was done in all patients similarly. Ablation energy was set to 30-35W on the anterior wall and 20–25W on the posterior wall of the left atrium in all patients, with a cool flow of 20 mL/min. A duodecapolar Lasso catheter (Biosense Webster) was used to validate PVI (entry and exit block) electrical isolation in all patients. After confirmation of PVI isolation, an electrophysiological study with a predefined protocol was performed to evaluate the inducibility of supraventricular arrhythmias.

Electrophysiological induction protocol

All patients underwent a predefined stimulation protocol from a single site.

1. Atrial extra stimuli testing. Multiple electrical impulses were administered from the proximal coronary sinus at a fixed cycle length of 500 ms, followed by a premature beat. The coupling interval of the premature beat was progressively shortened by 10 ms, from 300 ms to 200 ms or until the refractory period was reached.
2. Incremental ventricular pacing. The pacing was delivered from the right ventricular apex. The minimum cycle length of ventricular pacing was 300ms.
3. Atrial burst pacing (a 15-beat drive train) was performed from the proximal coronary sinus with cycle lengths of 300 ms, 250 ms, and 200 ms.

The pacing output was set to 20 mA, with a pulse width of 1.0 ms.

Ablation of arrhythmias induced during stimulation protocol

If any of the following arrhythmias occurred during the stimulation protocol, they were mapped and ablated:

1) Regular sustained atrial tachycardia
2) Typical atrial flutter and atypical atrial flutter
3) Atrioventricular nodal re-entry tachycardia
4) Atrioventricular re-entry tachycardia with a concealed accessory pathway

After these arrhythmias were ablated, the stimulation protocol was performed again.

STATISTICAL ANALYSIS

Continuous variables are expressed as mean ± standard deviation and compared by t-test or Mann-Whitney U test as appropriate. Categorical variables are expressed as percentages and compared using the chi-square test, Fisher's exact test, or logistic regression, as appropriate. We investigated the association of supraventricular arrhythmia inducibility with echocardiographic, periprocedural, and procedural parameters by the chi-square test, Fisher's exact test, and binary logistic regression. A two-tailed $\alpha<0.05$ was considered statistically significant, except in the test for equality of covariance matrices, for which $P<0.005$ was considered significant. All analyses were carried out in IBM SPSS for Mac version 23 (IBM, New York, USA) and R studio posit cloud version 4.3.2 (Posit software, PBC, Boston, USA). The data visualization was done exclusively in R studio 4.3.2.

RESULTS

A total of 61 patients were enrolled. All patients completed one year of follow-up. Baseline clinical and procedural characteristics are shown in Table 1. In 24 patients (39%) a supraventricular tachycardia was induced during the stimulation protocol. Six patients (10%) were inducible for atrial fibrillation; in only one it did not terminate spontaneously and necessitated a direct-current (DC) cardioversion. In 12 (20%) patients typical atrial flutter was induced and in 6 patients (10%) a typical slow-fast AVNRT, all of which were subsequently ablated. Since the voltage map in all patients with induced AF was in the normal range (bipolar voltage of 0.5 to 1.5 mV), no additional ablations lesions were performed. PVI entry and exit block were achieved in all patients. No major complications, including cardiac tamponade, stroke, atrioesophageal fistula, or PV stenosis, were documented in the study sample. Two patients each presented with a large groin hematoma, which extended their hospital stay by 2 days. One had inducible arrhythmia and the other did not. Both were treated conservatively without consequences. All patients were followed up at 3, 6, and 12 months after the procedure; 7-day ECG Holter monitoring was carried out after 6 and 12 months from the procedure. The procedure time (P=0.408) or fluoroscopy dose (P=0.458) did not differ between patients with and without inducible arrhythmia (Fig. 1, 2). Furthermore, there was no difference in the complication rate (P=0.759). Age differed significantly between patients with arrhythmia inducibility and those without (64.5 ± 7.6 and 58.2 ± 10.5, P=0.04; Fig. 3). There was no age-related difference in induction of classical paroxysmal supraventricular tachycardia and macroreentrant or focal arrhythmia (P=0.969). None of the echocardiographic variables, such as LAVI (P=0.936), LVEF (P=0.586), or RA area (P=0.716), differed meaningfully between patients with or without inducibility. In total, during ECG monitoring, significant episodes of arrhythmia were recorded in 20 patients (33%) during whole follow-up: 5 of them had inducible arrhythmia during the procedure, and 12 out of 20 were asymptomatic. AF was detected in 18 patients (29.5%) and atrial tachycardia in 2 cases (3.3%). No other supraventricular tachycardias were observed during the follow-up.

DISCUSSION

The main findings of our study can be summarized as follows: (1) supraventricular arrhythmia inducibility

Table 1. Baseline characteristics of study population.

	Total population n=61	Non-inducible n=37	Inducible n=24	*P*
Age (years)	60.7±10	58.2±10.5	64.5±7.6	0.008
Males (%)	69%	70.3%	66.7%	
Body weight (kg)	91.7±22.4	91.3±23.9	92.4±20.3	NS
Body height (cm)	175.5±9.6	176.1±9.7	174.5±9.7	NS
Body mass index (kg/m^2)	30.3±5.9	30.3±5.8	30.3±6	NS
Body surface area (m2)	2.08±0.24	2.09±0.23	2.07±0.25	NS
CHA2DS2-VASc score	1.79±1.2	1.65±1.3	2±1.1	NS
LV ejection fraction (%)	58.87±6.2	59.22±6.9	58.33±4.8	NS
Left atrium volume index (mL/m^2)	35.2±9.5	35.2±10.1	35.2 ±8.5	NS
Right atrium area (cm^2)	17.2±4.2	17±4.2	17.5±4.3	NS
Hypertension (%)	65.6	67.6	62.5	NS
Heart Failure (%)	6.5	5.4	8.3	NS
Diabetes Mellitus (%)	9.8	5.4	16.7	NS
Previous stroke/TIA (%)	4.9	5.4	4.1	NS
CAD (%)	6.6	8.1	4.2	NS
Procedure time (min)	145.7±23.4	143.51±20.5	148.96±27.3	NS
Fluoroscopy dose	2233.7±1125.4	2151.5±1234.7	2360.4±943.3	NS
Ablation time (min)	50.3±13.1	51.8±15.2	47.9±9	NS

Indices are shown per procedure as mean ± standard deviation or proportion in percentages and compared for non-inducible and inducible.

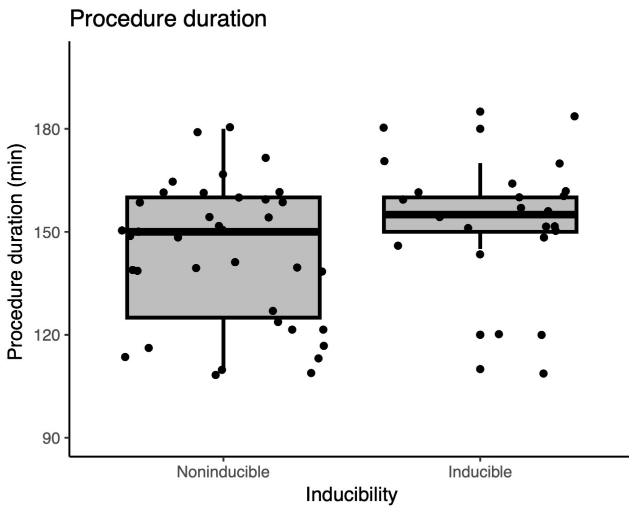

Fig. 1. Box-plot with whiskers displaying difference between patients with and without arryhmia inducibility according to procedure duration. Black scatter dot represents individuals measurements.

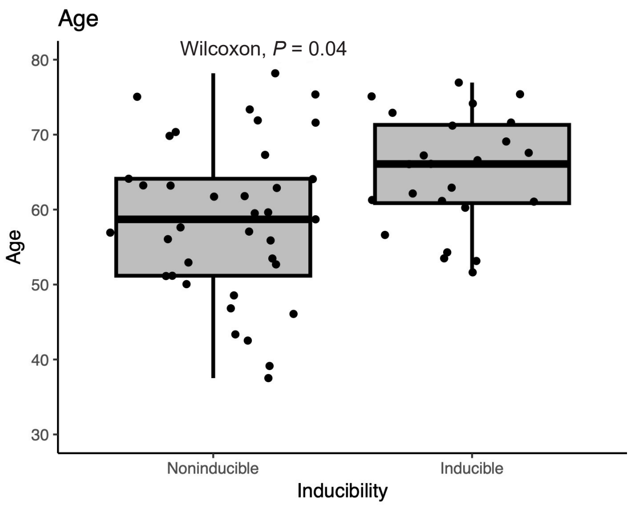

Fig. 2. Box-plot with whiskers displaying difference between patients with and without arryhmia inducibility according to fluoroscopy dose. Black scatter dot represents individuals measurements.

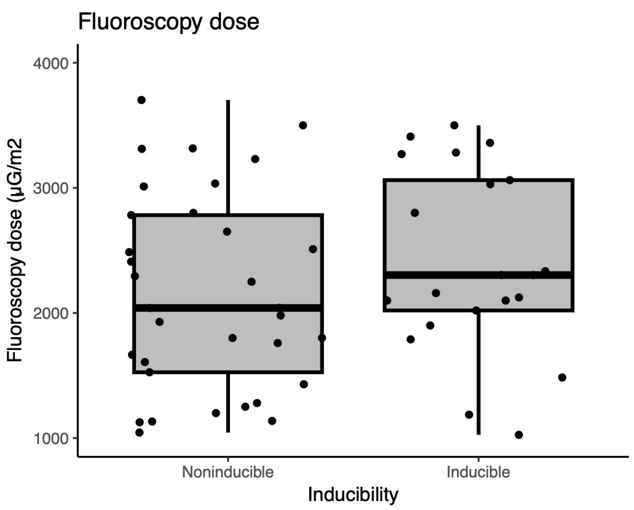

Fig. 3. Box-plot with whiskers displaying difference between patients with and without arryhmia inducibility according to age. Black dots representing individual measurements.

occurred more frequently among older patients, (2) inducibility of arrhythmia with subsequent ablation was not associated with longer procedure time, higher fluoroscopy dose, or more complications, and (3) no echocardiographic variable was found to predict the inducibility of any arrhythmia.

Age as predictor of arrhythmia inducibility

Testing for inducibility of supraventricular tachycardia is not common after successful CA for AF, but can be performed prior to PVI. Sciarra et al. found that inducibility of supraventricular tachycardias in patients referred for ablation of AF was more frequent in younger patients (43.4 ± 13.3 vs. 57.3 ± 11.2, P<0.01) and that ablation of induced-only SVT instead of PVI had a preventive effect on AF recurrences[11]. Another study also demonstrated a higher inducibility rate of SVT among younger patients (42 ± 11 vs. 58 ± 14, P<0.01) (ref.[9]). That study also demonstrated that targeted ablation of induced SVT instead of PVI decreased AF recurrences. A higher rate of inducibility in younger patients was also reported by Jang et al.[14]. In these trials, patients with inducible SVT also had less frequent structural heart disease. The idea behind performing a stimulation protocol prior to performing PVI was to shorten the procedure time with ablation of only induced SVT. Ablation of these arrhythmias may sometimes not require continuous administration of anticoagulation drugs during the procedure; this can reduce the rate of bleeding complications and shorten the whole procedure. According to Scharf et al., age is not a predictor of inducibility in the case of typical atrial flutter[12]. Our data, in contrast, demonstrate that SVT inducibility was significantly higher in older patients (64.5 ± 7.6 vs. 58.2 ± 10.5, P=0.04). These patients did not differ in terms of concomitant comorbidities such as arterial hypertension (67.6% and 62.5%, P=0.693) or coronary artery disease (8.1% and 4.2%, P=0.525). Most often, testing for inducibility is done in younger patients with fewer comorbidities, as in the aforementioned trials[9,11]. Our data suggest that it is reasonable to test for SVT inducibility after CA for AF, irrespective of comorbidities and age.

Safety of the procedure

Performing additional ablation in a patient with induced nonclinical supraventricular tachycardia after PVI can raise concerns about prolonging the procedure time and increasing the complication rate. According to Gupta et al., in patients undergoing CA for AF, complication rates tend to be numerically higher with increasing procedure duration; however, this trend was not significant[15]. Also, as reported by Baman et al., we found no association between the duration of radiofrequency energy application (P=0.2) or total procedure time (P=0.8) and the probability of developing complications in patients treated with CA for AF (ref.[16]). According to our data, comparing patients with inducible SVT and subsequent ablation and those without, there was no difference in procedure time

(P=0.408, Fig. 1), ablation time (P=0.205), or fluoroscopy dose (P=0.458, Fig. 2). Therefore, testing for SVT inducibility with additional ablation of induced arrhythmia after successful PVI is safe and does not prolong the procedure or increase radiation exposure.

Echocardiographic parameters as a predictor of inducibility

According to Vaziri et al., risk of atrial fibrillation can be predicted from left atrial enlargement[17]. In patients with pulmonary arterial hypertension, enlargement of the right atrial area was also associated with increased risk of various types of supraventricular tachycardias[18]. We do not have enough data to establish a connection between right atrial area and the incidence of supraventricular tachycardia in patients without pulmonary arterial hypertension or another condition affecting the right ventricle and right atrium. In our study there was no difference in inducibility according to echocardiographic factors such as LAVI (P=0.936), LVEF (P=0.589), and RA area (P=0.716). Therefore, echocardiographic variables should not guide the decision to test for SVT inducibility after successful PVI.

Limitations

Firstly, it is a unicentric, non-randomized study of quite a small sample of patients. Secondly, the study is not well balanced for sex with a predominantly male population.

CONCLUSIONS

SVT inducibility after successful PVI is 39%. Ablation of non-clinical arrhythmia is safe and may not prolong the total procedure or fluoroscopy time.

ABBREVIATIONS

AF, atrial fibrillation; AP, accessory pathway; AT, atrial tachycardia; AVNRT, atrioventricular nodal re-entry tachycardia; AVRT, atrioventricular re-entry tachycardia; CA, catheter ablation; CAD, coronary artery disease; CTI, cavotricuspid isthmus; DC, dirrect-current cardioversion; LA, left atrial; LAVI, left atrium volume index; LVEF, left ventricle ejection fraction; PV, pulmonary vein; PVI, pulmonary veins isolation; RA, right atrium; SVT, supraventricular arrhythmias; SVES, supraventricular extrasystoles, TIA, transient ischaemic attack.

Author contributions: JV: study design, performing CA, complete patient FU, data analysis, data interpretation, manuscript writing and literature search; JP: study design, performing CA, data interpretation, critical revision of the manuscript; DS, TS, VC: performing CA; JV, JD: critical revision of the manuscript.

Conflict of interest statement: None declared.

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