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The effectiveness of a high output/short duration radiofrequency current application technique in segmental pulmonary vein isolation for atrial fibrillation

Brian Nilsson*, **Xu Chen, Steen Pehrson, and Jesper Hastrup Svendsen**

Medical Department B, Department of Cardiology, The Heart Centre, Cardiac Catheterization Laboratory, Rigshospitalet, Copenhagen University Hospital, 9 Blegdamsvej, DK-2100 Copenhagen, Denmark

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KEYWORDS
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Aims Segmental pulmonary vein (PV) isolation by radiofrequency (RF) catheter ablation has become a curative therapy for atrial fibrillation (AF). However, the long procedure time limits the wide application of this procedure. The aim of the current study was to compare a novel ablation technique with a high power output and short application time vs. a conventional technique using a low power output and long application time.

Methods and results The study included 90 consecutive patients (age 53 $\pm$ 10 years; 66 men). Segmental PV isolation was performed by irrigated RF catheter ablation in both groups. In the conventional group (Group 1, 45 patients), the power output was limited to 30 W with a target temperature of 50°C and an RF preset duration of 120 s. In the novel group (Group 2, 45 patients), the maximum power output was preset to 45 W, with a target temperature of 55°C and duration of 20 s. In Group 2, a significant reduction in the PV isolation time (127 $\pm$ 57 vs. 94 $\pm$ 33 min, $P < 0.02$), mean fluoroscopy time (73 $\pm$ 23 vs. 55 $\pm$ 16 min, $P < 0.001$), and radiation dose was observed. According to the application time and number, Group 2 showed a reduction in RF application time, but a higher number of RF applications were required for creation of complete PV isolation. During a mean follow-up of 15 $\pm$ 7 months, a total of 74% of patients in Group 1 and 76% of patients in Group 2 demonstrated stable SR.

Conclusion Segmental PV isolation using a high power output and short application time is safe and effective in PV isolation in patients with AF. This technique can significantly reduce the procedure and fluoroscopy time compared with a low-power output technique.

Introduction

Radiofrequency (RF) catheter ablation to isolate the pulmonary veins (PVs) has become an increasingly common treatment option for patients with atrial fibrillation (AF). However, this technique includes ablation of an extensive area in the left atrium and ostia of the PVs. It is time-consuming with a substantial radiation exposure even in experienced centres. In addition, lack of experienced operators and the long procedure time preclude the widespread application of this procedure, overall increasing the potential for complications like thrombo-embolic events. Thus, significant reduction in the procedure time becomes a major challenge in performance of the catheter isolation of PVs. Currently, in most centres, segmental ostial RF application is applied in a temperature-controlled mode with low power output and a long application time with the intention to reduce the risk of PV stenosis and thrombus formation.[1–3] However, a few centres are now using a high output technique during extra-ostial ablation, apparently without increased complication rates.[2,4,5]

In the present study, we demonstrate a new RF application technique using a high power output and short RF application time. The aim of this retrospective study was to compare the conventional technique using a low power output and a long pulse duration (Group 1) with this new RF application technique (Group 2) in terms of procedure time, RF time, radiation exposure time, and complications in patients referred for segmental ostial PV isolation of AF.

* Corresponding author. Tel: +45 3545 8449; fax: +45 3545 2705.
E-mail address: brni@dadlnet.dk

Methods

Study patients

The study included 90 consecutive patients (age 53 ± 10 years, 66 men) who had undergone one segmental PV isolation of drug-refractory paroxysmal (59 patients) or persistent AF (31 patients) at the Rigshospitalet, Copenhagen University Hospital. Patients fulfilling at least one of the following criteria were excluded from the study: congenital heart disease, younger than 18 years, significant valve disease, left ventricular ejection fraction < 20 %, NYHA class IV, and prior ablation for AF.

RF ablation

The same experienced operator (XC) performed all catheter ablations. The PVs were mapped after transseptal catheterization with two catheters: a circular mapping catheter (Lasso, Biosense Webster, Diamond Bar, CA, USA) and a 5 mm tip quadripolar saline-irrigated mapping/ablation catheter (Celsius thermo-cool, Biosense Webster). PV angiograms were performed before and after PV isolation. RF energy was applied at ostial sites with the earliest PV activation guided by the circular catheter. The RF energy was delivered from an RF generator (Cordis, Stockert) in temperature-controlled mode with an irrigation rate of 2 mL/min. In the first 45 patients (Group 1), the RF power output was limited to 30 W, with a target temperature of maximal 50°C, and a preset duration of 120 s. In the last 45 patients (Group 2), the maximum power output was preset to 45 W, a target temperature of 55°C, and duration of 20 s. The procedure endpoint was complete elimination of electrical conduction into the PV. Thirty minutes following the final RF application, PV isolation was confirmed by recording no potentials by the Lasso catheter.

Post-ablation care and follow-up

Patients were discharged the day after the ablation procedure unless complications occurred. Follow-up was obtained by outpatient clinical visits or by telephone interview. Arrhythmia events within the first month following the ablation were not included in the final results. All antiarrhythmic medication was stopped 1 month after the ablation. However, in the case of symptomatic recurrent AF, the patients were offered another (and final) ablation or resumption of antiarrhythmic drug therapy. At study initiation, patients with low risk of thrombo-embolic complications were only treated with aspirin. However, for safety reasons (discussed subsequently), this was changed to comprise anticoagulant therapy for the last 35 patients, starting 2 months prior to the ablation and discontinued 3 months following the ablation in patients without recurrent AF.

Statistical analysis

Continuous variables are expressed as mean ± SD and analysed using the unpaired Student's *t*-test. In the case of data not normally distributed, the Mann–Whitney *U* test was used. Categorical data were analysed by Fisher's exact test. Statistical significance was established at $P < 0.05$.

Results

The patient characteristics and clinical history, including antiarrhythmic medication, are summarized in *Table 1*. No significant difference was found between the groups with regard to age, gender, structural heart disease, AF type, and duration. However, more antiarrhythmic drugs had been tried in Group 2, but no difference was observed with respect to the use of amiodarone. In addition, a trend towards older patients and patients with known persistent AF were seen in Group 2 compared with Group 1.

Table 1 Clinical characteristics

	Group 1	Group 2	*P*-value
n	45	45	—
Age (years)	51 ± 11	55 ± 10	0.060
Sex, M/F (*n*)	36/9	30/15	0.133
AF, paroxysmal/persistent, *n* (%)	71/29	57/43	0.156
AF duration (years)	6.4 ± 6.6	4.6 ± 3.7	0.136
Number of AA drugs used before ablation	3.0 ± 1.4	3.7 ± 1.1	0.020
Amiodarone, *n* (%)	30	33	0.166
Cardiovascular disease, n (%)			
None	75	73	0.507
Hypertension	20	21	0.594
Ischaemic heart disease	6	9	0.850
Heart failure	4	2	0.465

Group 1: conventional ablation technique using a power output limited to 30 W with a target temperature of maximal 50°C and a preset duration of 120 s of each RF pulse. Group 2: ablation technique using a maximum power output of 45 W with a target temperature of 55°C and a preset duration of 20 s. AA, antiarrhythmic drug. Data are expressed as mean value ± SD.

Procedure results

Complete isolation was achieved in all targeted PVs except in four patients, three patients in Group 1 and one in Group 2 ($P = 0.355$, *Table 2*). Significantly more PVs were isolated in Group 2 (3.0 ± 0.8 vs. 3.4 ± 0.7, $P = 0.002$). According to the application time and energy used, Group 2 showed a reduction in RF time (19 ± 14 vs. 36 ± 17 min, $P < 0.001$) and total amount of energy (51.1 ± 37.2 vs. 65.5 ± 29.9 kJ, $P = 0.06$). However, a higher number of RF applications (53 ± 20 vs. 28 ± 12, $P < 0.001$) were required for creation of complete PV isolation. No audible pop occurred in any of the groups.

In comparison of the low and high output ablation techniques, Group 2 showed a 26% reduction in the ablation procedure time, defined as the time between the first and last RF application (94 ± 33 vs. 127 ± 57 min, $P < 0.019$) (*Figure 1*). In addition, Group 2 showed a 25% reduction in mean fluoroscopic time (55 ± 16 vs. 73 ± 23 min, $P < 0.001$) (*Figure 2*) and a 33% reduction in radiation dose (67 ± 49 vs. 100 ± 51 Gy/cm^2, $P = 0.004$).

Clinical outcome

During a mean follow-up of 15±7 months (range 5–25 months), a total of 74% of patients in Group 1 and 76% of patients in Group 2 demonstrated stable SR (ns) without symptomatic recurrent AF. However, 46 and 44% of patients required additional antiarrhythmic drug therapy in Groups 1 and 2, respectively (ns). Two patients experienced a transient cerebral ischaemic episode, one in each group. In the first patient, the symptoms of left-sided hemiparesis appeared just following the ablation. In the other patient, symptoms of reduced and blurred vision appeared within a

Table 2 Results of RF PV isolation

	Group 1	Group 2	*P*-value
Number of isolated PVs	3.0 ± 0.8	3.4 ± 0.7	0.002
Patients with complete isolation of targeted PVs, *n* (%)	42 (93)	44 (98)	0.312
RF time (min)	36 ± 17	19 ± 14	<0.001
RF applications (*n*)	28 ± 12	53 ± 20	<0.001
Total amount of energy (kJ)	65.5 ± 29.9	51.1 ± 37.2	0.060

Groups 1 and 2 are as in *Table 1*. Total amount of energy was calculated by: RF time (s) × power output (W).

RF applications, number of applications of radiofrequency current required to achieve complete PV isolation. Data are expressed as mean value ± SD.

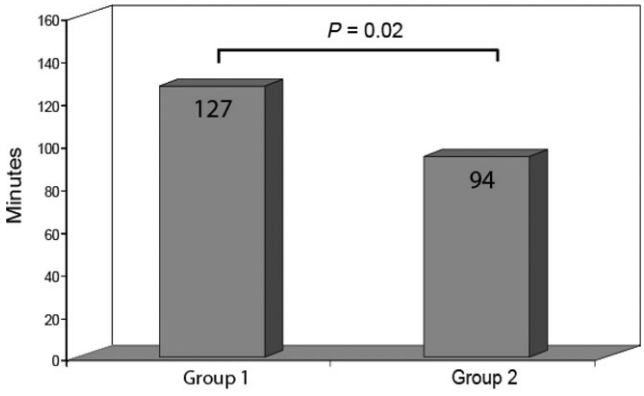

Figure 1 Comparison of the procedure times in Groups 1 and 2 (time between the first and last RF applications).

few hours following the ablation. Both patients recovered within 24 h. No other major complications, especially no PV stenosis, were observed acutely or during follow-up.

Discussion

To avoid PV stenosis, a low power output has been used to create PV isolation in patients with AF.[2,3,6] However, even though irrigated catheter ablation is used, a long RF time is still required to achieve PV block, particularly in areas with thick myocardial tissue. In the present study, we demonstrate the use of a novel RF application technique with a high power output and short application time in PV isolation. To the best of our knowledge, this is the first study comparing a high output/short application time with a low output/long application time. In comparison with the conventional method, this technique significantly reduces the procedure and radiation exposure time, radiation dose, and RF time. In addition, no significant difference was found in overall success (possibly due to identical procedure endpoints) and complication rate, without occurrence of PV stenosis in either groups.

Even though high output was used, the total amount of energy was far lower compared with the conventional ablation method before achieving PV isolation. An explanation for this could be that a major part of the energy during

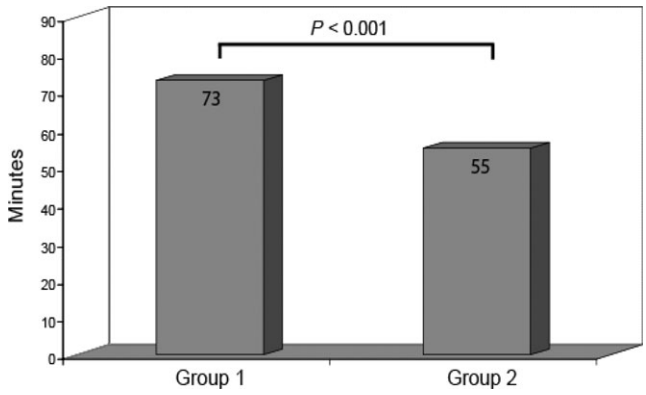

Figure 2 Comparison of the fluoroscopy times in Groups 1 and 2.

the low output/long duration ablation technique will be absorbed in the tissue surface and surroundings (blood), before creating a lesion deep enough (unless long duration RF is used) to achieve PV entrance block. Even though, irrigated-tip ablation is known to create lesions, which are deeper and wider beneath the surface with little damage to the intima,[7,8] this greater amount of energy may eventually increase the risk of complications, especially thrombo-embolism. Another explanation could be that an application for 2 min at the wrong place would not be efficient. More applications (with a shorter duration) may increase the likelihood of destroying the principal conduction sites between the left atrium and the PVs.

In a few reports, a similar ablation technique (high output/short duration) has been used to the one described in the present study;[4,5] however, this was only used in circumferential (extra-ostial) ablation with a non-irrigated catheter technique, thus the current study is the first describing this technique in segmental PV isolation. In a study by Mansour *et al.*,[4] a total of 80 consecutive patients underwent circumferential or segmental PV isolation using irrigated-tip ablation. In the circumferential approach, RF energy was delivered with a maximum temperature of 60°C and 50 W power limit for 12–15 s at each site. In the segmental approach, RF energy was delivered with a target temperature of 50°C and a power limit of 25–30 W for 30 s at each site. Cardiac tamponade occurred in two patients in the circumferential ablation group (5%) and one patient in the segmental ablation group (2.5%). One patient in each group (2.5%) had a cerebrovascular accident. In another study by Pappone *et al.*,[5] 560 patients with AF underwent circumferential extra-ostial catheter ablation of the PVs. RF energy was applied for up to 30 s with a limit of 100 W and a target temperature of 60°C. During repeat procedures, RF energy was delivered with a limit of 80 W and a target temperature of 60°C at each site. In 563 procedures, only two cases of pericardial tamponade occurred, and there were no thrombo-embolic events or cases of PV stenosis. As opposed to the technique described in the present study, usually the catheter was dragged around the PVs while continuously applying RF energy. Presumably, if the catheter stayed for a long time at the same site, this could increase the risk of atrial perforation with subsequent life-threatening complications such as atrio-oesophageal fistula,[9] especially in view of the close anatomical relationship between PVs and the oesophagus.[10]

In contrast to the above-mentioned studies using a high output technique,[4,5] we did not experience any perforations or PV stenosis, probably due to the limited application time of 20 s. Finally, some other laboratories using irrigated catheters have reported application times of 30–60 s,[11–13] longer times than reported in the current study.

In conclusion, this new ablation technique with a high power and short application time seems safe in segmental PV isolation and has now been used in our laboratory for ~2.5 years with good results. If these initial findings were confirmed in larger randomized clinical trials, this technique may be attractive worldwide, due to the potential advantages of reduced procedure and fluoroscopy times.

Limitations

The present study is a retrospective analysis. Although our results are highly significant, they need to be further validated in experimental and clinical prospective randomized studies. The influence of a learning curve on the results cannot be definitely excluded. However, the same operator, who had performed more than 150 PV isolation procedures before this study performed all procedures.

In Group 2, a trend was seen towards including older patients and those with persistent AF. In addition, more PVs were isolated compared with Group 1. Overall, we believe that these differences reflect development in ablation strategy extending the indications including older patients with higher AF burden and going from isolation of arrhythmogenic PVs only to that of today, with isolation of all PVs. Overall, this suggets that our results may be an underestimation of the real difference.

No systematic Holter monitoring of the patients was performed, thus the reported recurrence rate may be an underestimation. However, in the current study, a successful ablation procedure was defined as a complete entrance block into the PVs. This was achieved in all but four patients with no difference between Groups 1 and 2, indicating no major difference in clinical success rates between the two ablation techniques. Apart from venography, we did not perform any systematic imaging procedures of the PVs prior to and following catheter ablation. However, no patient complained of pulmonary symptoms necessitating further investigation of PV stenosis.

Conclusions

This present study demonstrates that PV isolation using a high power output and short RF pulse duration approach significantly reduces the procedure and radiation exposure times compared with the conventional low power output technique in segmental PV isolation for AF. If prospective randomized studies are able to confirm these findings, this application technique may become attractive to perform worldwide.

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