Catheter ablation for cardiac arrhythmias: A 14-year experience with 5330 consecutive patients at the Quebec Heart Institute, Laval Hospital

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BACKGROUND: Catheter ablation is a curative treatment with excellent success and minimal complication rates for patients with supraventricular or ventricular arrhythmias.

METHODS: The acute outcomes and complications of all catheter ablation procedures for supraventricular and ventricular arrhythmias performed at the Quebec Heart Institute (Sainte-Foy, Quebec) during a 14-year period from January 1, 1993, to December 31, 2006, were prospectively assessed. The ablation procedures were classified according to the arrhythmias induced using standard electrophysiological techniques and definitions. Immediate success and complication rates were prospectively included in the database.

RESULTS: A total of 5330 patients had catheter ablation performed at the Institute during the period assessed. The mean (± SD) age of patients was 50±18 years (range four to 97 years), and 2340 patients (44%) were men. Most of the patients were younger than 75 years (group 1), and 487 (9%) were 75 years of age and older (group 2). Indications for ablations were as follows: atrioventricular nodal re-entry tachycardia (AVNRT) in 2263 patients, accessory pathways in 1147 patients, atrioventricular node ablation in 803 patients, typical atrial flutter in 377 patients and atrial tachycardia in 160 patients; 580 patients had other ablation procedures. The overall success rates were 81% for atrial tachycardia, 92% for accessory pathways or flutter, and 99% for AVNRT or atrioventricular node ablation. There was no difference in the success rates of the younger (group 1) and older (group 2) patients. Seventy-seven patients (1.4%) had complications, including 11 major events (myocardial infarction in one patient, pulmonary embolism in three patients and permanent pacemaker in seven patients). In patients undergoing AVNRT ablation, two had a permanent pacemaker implanted immediately after the procedure and three had a permanent pacemaker implanted at follow-up.

CONCLUSIONS: The results confirm that radiofrequency ablation is safe and effective, supporting ablation therapy as a first-line therapy for the majority of patients with cardiac arrhythmias.

Key Words: *Arrhythmia; Catheter ablation; Electrophysiology*

L'ablation par cathéter des arythmies cardiaques : Une expérience sur 14 ans auprès de 5 330 patients consécutifs à l'Institut de cardiologie de Québec, à l'Hôpital Laval

HISTORIQUE : L'ablation par cathéter est un traitement curatif à l'excellent taux de succès et au taux de complications minime pour les patients atteints d'arythmie supraventriculaire ou ventriculaire.

MÉTHODOLOGIE : Les auteurs ont procédé à l'évaluation prospective des issues et complications cliniques de toutes les interventions d'ablation par cathéter d'arythmies supraventriculaires et ventriculaires effectuées à l'Institut de cardiologie de Québec (à Sainte-Foy, au Québec) pendant la période de 14 ans écoulée entre le 1er janvier 1993 et le 31 décembre 2006. Ils ont classé les interventions d'ablation d'après les arythmies induites au moyen de techniques et définitions électrophysiologiques standard. Ils ont inclus prospectivement dans la base de données les taux de succès immédiats et de complications.

RÉSULTATS : Au total, 5 330 patients ont subi une ablation par cathéter à l'Institut pendant la période évaluée. L'âge moyen (±ÉT) des patients était de 50±18 ans (fourchette de quatre à 97 ans), et 2 340 patients (44 %) étaient des hommes. La plupart des patients avaient moins de 75 ans (groupe 1), et 487 (9 %) avaient 75 ans et plus (groupe 2). Les indications d'ablation s'établissaient comme suit : tachycardie nodale auriculoventriculaire de réentrée (TNAVR) chez 2 263 patients, voies accessoires chez 1 147 patients, ablation du nœud auriculoventriculaire chez 803 patients, flutter auriculaire classique chez 377 patients et tachycardie auriculaire chez 160 patients. Enfin, 580 patients ont subi une autre intervention d'ablation. Le taux de succès global était de 81 % pour les tachycardies auriculaires, de 92 % pour les voies accessoires ou les flutters et de 99 % pour les TNAVR ou les ablations du nœud auriculoventriculaire. On n'a remarqué aucune différence dans le taux de succès des patients plus jeunes (groupe 1) et plus vieux (groupe 2). Soixante-dix-sept patients (1,4 %) ont souffert de complications, y compris 11 événements majeurs (infarctus du myocarde chez un patient, embolie pulmonaire chez trois patients et installation d'un stimulateur permanent chez sept patients). Chez les patients qui subissent une ablation en raison d'une TNAVR, deux se sont fait implanter un stimulateur permanent dès la fin de l'intervention, et trois s'en sont fait implanter un au moment du suivi.

CONCLUSIONS : Les résultats confirment que l'ablation par radiofréquence est sécuritaire et efficace et soutient le fait que le traitement par ablation est la thérapie de choix pour la majorité des patients atteints d'arythmies cardiaques.

Catheter ablation is a curative treatment with excellent success and minimal complication rates for patients with supraventricular or ventricular arrhythmias. Success rates for eliminating atrioventricular nodal re-entry (AVNRT) and atrioventricular (AV) re-entry involving accessory pathways (APs) have been reported to exceed 90% to 95% (1-3). The rate of successful ablation of the AV node to control rapid ventricular rates in atrial fibrillation also exceeds 95% (4). Complications associated with these ablative procedures occur at a low incidence of 2% to 5% (5,6).

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TABLE 1
Patients' characteristics and indications for ablation (n=5330)

	AVNRT	APs	AV node	Atrial flutter	AT	Others
Patients, n (%)	2263 (42)	1147 (22)	803 (15)	377 (7)	160 (3)	580 (11)
Men, %	30	56	43	73	27	–
Age, years*	49±17	37±17	69±12	58±14	47±17	–
Age range, years	5–92	4–83	20–97	14–89	6–79	–

**Mean ± SD. APs Accessory pathways; AT Atrial tachycardia; AV Atrioventricular; AVNRT Atrioventricular nodal re-entry*

The current study prospectively collected the acute success and complication rates from a large, single-centre series of patients undergoing catheter ablation.

METHODS

The acute outcomes and complications of all catheter ablation procedures for supraventricular and ventricular arrhythmias performed at a single teaching institution with an active fellowship program during a 14-year period from January 1, 1993, to December 31, 2006, were prospectively assessed.

The ablation procedures were classified according to the arrhythmias induced using standard electrophysiological techniques and definitions. The arrhythmia types included AVNRT (both typical and atypical); AV re-entrant tachycardia involving an AP, either concealed or manifest; atrial flutter, including clockwise or counter-clockwise right or left atrial flutter; atrial tachycardia, including inappropriate sinus tachycardia and focal or macro-re-entrant atrial tachycardia; atrial fibrillation with AV node ablation for ventricular rate control; and pulmonary vein isolation (PVI) and ventricular tachycardia (VT) ablation in patients with and without structural heart disease.

Ablation procedures were performed using standard mapping and ablative techniques. In greater than 99% of cases, radiofrequency was the energy source applied through a 4 mm tip ablation catheter. For atrial flutter, an 8 mm tip catheter was used for most procedures. For PVI, an irrigated catheter was used. Radiofrequency energy was typically delivered at a power required to achieve a set temperature of 50°C to 65°C. Radiofrequency energy was applied for 30 s to 2 min during continuous electrocardiography, intracardiac electrogram monitoring and intermittent fluoroscopic monitoring. Additional monitoring using transesophageal echocardiography imaging or catheter navigation systems (CARTO, Biosense Webster Inc, USA, or ESI, St Jude Medical, USA) was used in complex cases (PVI, VT or congenital ablation).

Patients were brought to the electrophysiology laboratory in a fasting state. Sedation using intravenous propofol (Diprivan, AstraZeneca Canada Inc), midazolam (Versed, Hoffmann-La Roche Limited, Canada) and fentanyl (Sublimaze, Janssen Pharmaceutical, Canada) was administered under the supervision of an anesthesiologist with continuous blood pressure monitoring, oxygen saturation and body surface electrocardiography. Coronary sinus access was routinely performed with a decapolar catheter from the right internal jugular vein. His and right ventricular catheters were advanced from the femoral vein. Detailed electrophysiological evaluation was performed using standard stimulation and recording techniques to establish the correct diagnosis and identify the appropriate ablation site. The retrograde aortic approach via the femoral artery was routinely used for left-sided APs. Right-sided APs were approached via the femoral veins using the anteroposterior or left anterior oblique view. Slow pathway ablation was performed in patients with AVNRT, usually in the right anterior oblique view. Patients were routinely monitored for 24 h after the procedure. A 12-lead electrocardiogram was obtained before discharge.

Acute ablation success was defined based on arrythmia type as follows: AVNRT – inability to initiate more than single AV node echo beat with and without isoproterenol challenge; atrial tachycardia – inability to reinitiate the tachycardia; AV re-entry – absence of antegrade and/or retrograde AP conduction; atrial flutter – bidirectional isthmus block demonstrated following ablation with a multipolar electrode catheter; and AV node ablation – complete AV block. Programmed stimulation was also performed during isoproterenol infusion in patients without structural heart disease.

Complications and follow-up

The patients were followed for four to 12 weeks after ablation. Complications were grouped into the following three categories according to the seriousness or permanence of the event, and were prospectively included in the database:

1. Major or life-threatening complications: death, myocardial infarction, embolic stroke involving transient or permanent neurological alteration, persistent unintentional heart block (second- or third-degree), valve disruption and pulmonary embolism;
2. Serious complications: deep venous thrombosis, pericardial effusion requiring drainage, pseudoaneurysm, lead dislodgement following AV node ablation and transient heart block; and
3. Minor complications: hematoma, pericarditis without tamponade and pericardial effusion.

Statistical analysis

Results are presented as the mean ± SD where appropriate. For all continuous variables, the comparisons between the two study groups (group 1 – patients younger than 75 years; group 2 – patients 75 years or older) were performed using one-way analysis of variance.

RESULTS

From January 1, 1993, to December 31, 2006, catheter ablations were performed on 5330 patients at the Quebec Heart Institute (Sainte-Foy, Quebec). Patients' characteristics are presented in Table 1. The mean (± SD) age of patients was 50±18 years (range four to 97 years), and 2340 patients (44%) were men. Three hundred seventy-five patients (7%) were 18 years of age or younger and 487 (9%) were 75 years of age or older (group 2). The indications for ablation were AVNRT (n=2263), APs (n=1147), AV node ablation (n=803), isthmus-dependant atrial flutter (n=377) and atrial tachycardia (n=160); 580 patients had other ablation procedures (eg, PVI, VT and congenital procedures [data not shown]).

Table 2 shows the short-term success rates and the procedural parameters according to ablation type. The overall success rates varied between 81% (atrial tachycardia) and 99% (AVNRT or AV node ablation). Two years after the beginning of the Institute's ablation program in 1993 (learning curve), the success rate was stable over time for patients undergoing ablation for AVNRT, AV node, flutter and APs. There was no difference in the success rates between the younger and older patients (group 1 versus group 2 [data not shown]).

TABLE 2
Short-term success rates and procedural parameters according to ablation type

	AVNRT	APs	AV node	Atrial flutter	AT
Patients, n (%)	2263 (42)	1147 (22)	803 (15)	377 (7)	160 (3)
Fluoroscopy time, min*	12±10	26±22	9±10	24±14	20±14
RF lesions, n*	6±6	11±10	6±6	18±10	7±5
Success rate, %	99	92	99	92	81

**Mean ± SD. APs Accessory pathways; AT Atrial tachycardia; AV Atrioventricular; AVNRT Atrioventricular nodal re-entry; RF Radiofrequency*

Seventy-seven patients (1.4%) had complications, including 11 major, 42 serious and 24 minor complications. There was no difference in the complication rates among the various ablation types (Table 3) and among older patients (group 2, 75 years or older [data not shown]). Among patients undergoing AVNRT ablation, five had a permanent pacemaker implanted. Two patients had their pacemakers implanted immediately after ablation, and three patients had them implanted during the months following ablation. None of the patients with hematomas required a blood transfusion. No patient had a stroke, and one patient had a limited myocardial infarction after an AP ablation 2 cm within the coronary sinus.

TABLE 3
Complications according to ablation type

	AVNRT (n=2263)	APs (n=1147)	AV node (n=803)	Atrial flutter (n=377)	AT (n=160)
Major, n (%)					
Death	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Myocardial infarction	0 (0)	1 (0.09)	0 (0)	0 (0)	0 (0)
Embolic stroke	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Persistent unintentional heart block	5 (0.22)	2 (0.17)	0 (0)	0 (0)	0 (0)
Valve disruption	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pulmonary embolism	3 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)
Total major complications	8 (0.35)	3 (0.26)	0 (0)	0 (0)	0 (0)
Serious, n (%)					
Deep venous thrombosis	0 (0)	1 (0.09)	0 (0)	1 (0.26)	0 (0)
Tamponade	0 (0)	1 (0.09)	0 (0)	0 (0)	0 (0)
Pseudoaneurysm	1 (0.04)	7 (0.61)	1 (0.12)	0 (0)	0 (0)
Lead dislodgment	0 (0)	0 (0)	4 (0.49)	0 (0)	0 (0)
Transient heart block	20 (0.88)	2 (0.17)	0 (0)	1 (0.26)	2 (1.3)
Total serious complications	21 (0.93)	12 (1.05)	5 (0.62)	2 (0.53)	2 (1.3)
Minor, n (%)					
Hematoma	3 (0.13)	7 (0.61)	3 (0.37)	2 (0.53)	1 (0.63)
Pericarditis without tamponade	4 (0.18)	2 (0.17)	0 (0)	0 (0)	2 (1.3)
Total minor complications	7 (0.31)	9 (0.78)	3 (0.37)	2 (0.53)	3 (1.9)
Total complications, n (%)	36 (1.6)	24 (2.1)	8 (1.0)	4 (1.06)	5 (3.12)

APs Accessory pathways; AT Atrial tachycardia; AV Atrioventricular; AVNRT Atrioventricular nodal re-entry

DISCUSSION

The present study confirms the safety and efficacy of radiofrequency catheter ablation (RFA) for cardiac arrhythmias. We found a high acute success rate (from 81% to 99%) and a relatively low complication rate (1.6%), which included the need for unexpected, permanent cardiac pacing (0.15%).

During the past decade, several studies have reported results of RFA for cardiac arrhythmia. The success rate and incidence of major complications reported in the present study are similar or superior to the results from published reports (3,5,7-11). To the best of our knowledge, the present study is the largest prospective, single-centre study ever reported. Interestingly, our results showed that the learning curve rates were rapidly achieved (within two years), with success rates remaining stable over time. Of note, our electrophysiology laboratory is located in a university teaching hospital, with cardiology residents and electrophysiology fellows rotating within laboratories.

Over time, we documented that the patient population in our laboratory is aging. However, this factor did not result in an increase in the complication rate or in ablation failure compared with other published studies (12).

RFA improves health-related quality of life to a greater extent than medical treatments (13,14) and is less expensive than medical therapy over time among patients who have frequent symptomatic episodes of tachycardia.

Study limitations

The present study was a database analysis. All procedures were prospectively included from January 1993 to December 2006. Complications were collected in the database during each hospitalization and also at the time of follow-up (four to 12 weeks postablation). Some complications may not have been reported for a minority of patients who were not seen for postablation follow-up.

CONCLUSIONS

The results of this large, single-centre study, which included patients with a wide age range, showed results similar or superior to those of previous studies. Our results confirm that RFA is safe and effective, supporting ablation therapy as a first-line therapy for the majority of patients.

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