CLINICAL RESEARCH

Single-centre experience with an 8-mm tip catheter for radiofrequency catheter ablation of outflow tract ventricular ectopic beats

Traitement des ESV infundibulaires idiopathiques par cathétér 8-mm de radiofréquence. Étude monocentrique

Antoine Da Costa a,b,*, Lila Khris a, Abdallah Nadrouss a, Pierre Chafiotte a, Cécile Romeyer-Bouchard a, Laurence Bisch a, Alexie Gate-Martinet a, Karl Isaaz a

a Department of Cardiology, Jean-Monnet University, Faculty of Medicine J.-Lisfranc, avenue Albert-Raimond, 42000 Saint-Étienne, France
b Service de cardiologie, hôpital Nord, CHU de Saint-Etienne, 42055 Saint-Étienne cedex 2, France

Received 3 September 2011; received in revised form 11 November 2011; accepted 21 November 2011
Available online 9 February 2012

Summary

Background. — Radiofrequency ablation (RFA) of outflow tract ventricular ectopic beats (OTVEBs) can be performed using a 4-mm or externally-cooled tip RFA catheter, but no data are available concerning the safety and efficacy of a large-tip (8-mm) catheter.

Aims. — To evaluate the feasibility of using an 8-mm tip catheter in patients with OTVEBs.

Methods. — In this prospective cohort study, the 8-mm tip catheter was tested in patients who were referred to our centre for RFA of symptomatic OTVEBs.

Results. — The mean age of the 16 patients recruited between September 2008 and March 2010 was 53 ± 18 years and 56.3% were male. Mean left ventricular ejection fraction was 62 ± 9%, mean ventricular ectopic beat width was 144 ± 21 ms, and all patients had left bundle branch block. Fourteen patients had inferior axis QRS morphology and two had superior. The main symptoms were palpitations and pre-syncope. RFA parameters were: procedure time 94 ± 35 min;

Keywords

Radiofrequency ablation; Outflow tract ventricular ectopic beats; 8-mm catheter

Abbreviations: AAD, Antiarrhythmic drug; ECG, Electrocardiogram; ESV, End-systolic volume; LBBB, Left bundle branch block; LVEF, Left ventricular ejection fraction; LVOT, Left ventricular outflow tract; MRI, Magnetic resonance imaging; NSVT, Non-sustained ventricular tachycardia; OTVEB, Outflow tract ventricular ectopic beat; PVC, Premature ventricular complex; SD, Standard deviation; RF, Radiofrequency; RFA, Radiofrequency ablation; RV, Right ventricle; RVOT, Right ventricular outflow tract; VEB, Ventricular ectopic beats; VT, Ventricular tachycardia.

* Corresponding author. Fax: +33 4 77 82 84 51.
E-mail address: dakosta@aol.com (A. Da Costa).

© 2012 Elsevier Masson SAS. All rights reserved.
Background

Ventricular ectopic beats (VEBs) are commonly seen in clinical practice. In most cases, they are largely asymptomatic, but may cause upsetting symptoms in some patients [1,2]. In normal hearts, VEB occurrence is usually of no clinical relevance. However, in some patients, VEBs may cause significant symptoms that need to be addressed by medical treatment or cured using catheter ablation [1–5]. In such a clinical setting, outflow tract ventricular ectopic beats (OTVEBs) are the most common idiopathic ventricular tachycardias (VTs), accounting for nearly 10% of all patients referred for VT evaluation [1–5]. In the absence of overt structural heart disease, these rhythm disturbances are classified as “idiopathic” or “normal heart” VTs, mainly arising from the right ventricular outflow tract (RVOT). VEBs originating from the RVOT have a distinctive electrocardiogram (ECG) appearance, with wide QRS complexes mimicking a left bundle branch block (LBBB) with inferior axis morphology [1,2].

Several reports have suggested that the long-term prognosis in patients with truly idiopathic OTVEBs is excellent, despite frequent VT episodes, and that radiofrequency ablation (RFA) should only be considered in highly symptomatic patients [1–5]. RFA results have been shown to be favourable, especially if VEBs arise from the RVOT, but only minimal data exist regarding the influence of the catheter used [3–5]. Original publications have reported variable results with 4-mm tip catheters, with success rates ranging from 65% to 97% and a recurrence rate of 5% [6]. Using a cuffed-tip catheter is only recommended after failed RFA with a 4-mm tip catheter, but series concerning the safety in this indication are lacking [4–14].

RFA success rates appear to be lower in daily practice than in clinical trials, while serious complications, mainly due to cardiac perforation, have been reported in 1% of patients [4]. For this reason, this prospective cohort study aimed to evaluate the feasibility, safety and efficacy of an 8-mm tip catheter for OTVEB RFA.

Methods

Study population

We evaluated consecutive patients with presumed OTVEBs who were referred to our laboratory for electrophysiological evaluation. Reasons for referral included arrhythmias noted on resting ECG, telemetry monitoring, or exercise stress testing, as well as symptomatic ventricular arrhythmias.
overnight cine-angiography.

**Clinical classification**

Patients were classified according to the index clinical arrhythmia on presentation: non-sustained ventricular tachycardia (NSVT) (lasting ≥ 3 beats and ≤ 30s) or repetitive ventricular ectopies.

**Non-invasive evaluation**

Patients underwent evaluation of cardiac structure, function and ectopy burden, mostly by cardiac magnetic resonance imaging (MRI), 24-hour Holter monitoring, or inpatient telemetry. If necessary, the presence of coronary artery disease was assessed by stress testing or cardiac catheterization (≥ 70% stenosis of any major epicardial vessel). Left ventricular systolic function was quantified using echocardiography, radionuclide ventriculography, or ventricular cine-angiography. Structural heart disease was defined as the presence of coronary artery disease (as defined above), left ventricular ejection fraction (LVEF) less or equal to 50%, or moderate to severe valvular disease. Patients with structural heart disease or coronary artery disease were excluded from participating in the study.

**Electrophysiological testing**

Patients underwent electrophysiological testing after an overnight fast. Patients were locally anaesthetized with 0.25% bupivacaine and minimally sedated with intravenous midazolam or fentanyl if necessary. Quadripolar 6-F catheters were advanced to the high right atrium, His bundle position, and right ventricular apex, or outflow tract. Bipolar intracardiac electrograms were filtered at 30–500 Hz.

If further mapping in the left ventricle was required, a retrograde aortic approach could be used. The stimulation protocol included burst atrial and ventricular pacing, as well as introduction of single atrial extrastimuli and up to triple ventricular extrastimuli from one or two right ventricular sites. Stimuli were delivered as rectangular pulses of 2 ms duration at four-fold diastolic threshold. To facilitate induction of sustained tachycardia, programmed stimulation was repeated if necessary during isoproterenol infusion at a rate that decreased sinus cycle length by approximately 20–30%. The ventricular stimulation protocol was performed in order to eliminate outflow tract sustained VTs. Three-dimensional mapping was not performed.

**Mapping and RFA**

After all antiarrhythmic drugs had been withdrawn; electrophysiological evaluation and catheter RFA were performed [4]. If clinical VEBs did not occur spontaneously, intravenous isoproterenol administration was infused. During a clinical arrhythmia episode, activation mapping was performed. Initial mapping sites were determined by detailed analysis of the QRS morphology during VEBs. Mapping of VEBs with an inferior axis was started in the RVOT region or directed by premature ventricular complex (PVC) morphology. If suitable ablation sites were not found in the RVOT, pulmonary artery, or right ventricle, left ventricular outflow tract (LVOT) endocardium could be mapped. For mapping and RFA, an 8-F quadripolar bidirectional deflectable catheter with an 8-mm tip electrode (BLAZER II large curve XP 4500 TK2 Boston EP-technologies, San Jose, USA) was used, with a maximum power output of 60 W and maximum target temperature of 65 °C. The site of RFA was identified using:

- bipolar pace mapping. Pace mapping was performed at the cycle length of the targeted VEBs or at the coupling interval of the targeted ventricular ectopic beats. The

![Figure 1](image1.jpg)

**Figure 1.** Endocardial recording during left bundle branch block-like ventricular tachycardia. Note the 8-mm RF bipolar ablation catheter recording at the site of the earliest activation time.
Outflow tract tachycardia and ablation catheters

The site of the VEBs origin was defined as the site where earliest ventricular activation was recorded or a perfect pace map was obtained, and RF energy was then applied at that site. Each RF energy application lasted 90–120 s. The location of the ablation catheter was verified by multi-plane fluoroscopic views. No mapping (cartography) system was used in our cohort study. Catheter RFA was considered successful when there was: an absence of spontaneous or induced clinical VEBs (both in the absence and presence of isoproterenol) at the end of the procedure; an absence of

The morphology of the pace map was compared with the spontaneous VEBs or VT. The score for the pace map was considered 'good' if 11 or 12 of 12 leads during pacing were identical to the targeted VEBs or NSVTs;

- local bipolar ventricular electrogram, usually 10–60 ms earlier than the onset of the surface QRS (Fig. 1);
- local unipolar ventricular electrogram, usually 10–60 ms earlier than the onset of the surface QRS with a sharp QS deflection (Fig. 2);
- the presence of pre-systolic potentials (Fig. 3).

Figure 2. Endocardial recording during left bundle branch block-like ventricular tachycardia. Note the 8-mm RF unipolar ablation catheter recording at the site of the earliest activation time.

Figure 3. Endocardial recording during left bundle branch block-like ventricular tachycardia. Note the 8-mm RF bipolar ablation catheter recording at the site of ablation (Presystolic recording).
any clinical arrhythmias during 48-hour ECG monitoring in the absence of antiarrhythmic drugs; and no recurrence of symptomatic arrhythmias in the absence of any antiarrhythmic drugs during ≥ 3 months of follow-up (Fig. 4).

Follow-up

All antiarrhythmic drugs were discontinued after RFA. Patients were seen in an outpatient clinic at three, six and 12 months after the procedure, and a 24-hour Holter monitoring was repeated in three months or more after the procedure.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation (SD) and categorical variables as percentages.

---

Figure 4. A. Example of Holter monitoring in a symptomatic 62-year-old woman who presented 36,994 VEBs per day before RFA. B. Three months later, the Holter monitoring did not show any VEBs. RFA: radiofrequency ablation; VEB: ventricular ectopic beat.
Results

Study population

From September 2008 to March 2010, 16 consecutive patients were considered eligible and included in the study, and patient characteristics are summarized in Table 1. LBBB VEB morphology was present in all patients; while QRS morphology was inferior in 14 patients and superior in two patients. The most common symptoms were palpitations \((n = 8)\) and pre-syncpe \((n = 6)\). Patients with pre-syncpe or syncpe had either VEBs or NSVTs. Antiarrhythmic drugs had failed in all patients, with a mean of 2.2 \(\pm\) 0.5 drugs tried per patient. The last medications used were beta blockers \((n = 7)\), sotalol \((n = 5)\), calcium channel blockers \((n = 2)\), flecainide \((n = 1)\), and amiodarone \((n = 1)\).

OTVEB mapping and RFA parameters

Mapping an RFA data are shown in Table 2. VEB localization in the right outflow tract was lateral in six patients and septal in nine patients; while the VEB origin was the LVOT in one and RFA was initially considered successful in 15 over 16 patients (93.8%), and no complications were observed. One procedure failed despite using an externally cooled tip catheter. After a mean follow-up of 11 \(\pm\) 6 months, 14 of 16 patients (87.5%) were still free from symptomatic arrhythmias, while one recurrence was observed in one patient, requiring a new procedure, which proved successful.

Discussion

Major findings

This preliminary study of a small series of patients suggests that an 8-mm tip catheter may be used for RFA in patients with OTVEBs. Consequently, in this subset of patients, a large 8-mm catheter tip may be used as an alternative in case of primary 4-mm tip failure.
Experimental data concerning large- and cooled-tip catheters

In experimental studies, multiple factors affecting the lesion size have been investigated, such as tissue contact, impedance, temperature at the tissue–electrode interface, blood flow at the catheter–tissue interface, power and duration of energy application, catheter orientation (perpendicular or parallel), intracavitary blood flow, electrode–target distance, electrode tip size, and irrigation design [15–23]. OTVEBs are mainly localized in the right outflow tract, where the circulating blood flow is relatively poor, as well as in some regions of the right ventricle [4]. Consequently, open externally-cooled irrigated catheters may be more effective than large 8-mm tip solid electrodes as they dissociate the power produced from the local convective effect, thus allowing for higher delivery and more stable power, thereby producing larger and deeper lesions [18–21]. However, larger 8-mm tip electrodes may be an alternative option in view of the following properties reported in experimental studies [15–18,22,23]:

- increased convective cooling due to the larger surface area exposed to the blood flow, which maintains a lower electrode–tissue interface temperature, thus allowing for greater power to be delivered, resulting in higher tissue current density and deeper direct resistive heating;
- increased electrode–tissue interface area.

Table 1 Population characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53 ± 18</td>
</tr>
<tr>
<td>Men</td>
<td>9 (56.3)</td>
</tr>
<tr>
<td>VEB morphology</td>
<td></td>
</tr>
<tr>
<td>LBBB</td>
<td>16 (100)</td>
</tr>
<tr>
<td>VEB QRS morphology</td>
<td></td>
</tr>
<tr>
<td>Inferior axis</td>
<td>14 (87.5)</td>
</tr>
<tr>
<td>Superior axis</td>
<td>2 (12.5)</td>
</tr>
<tr>
<td>QRS width (ms)</td>
<td>144 ± 21</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>62 ± 9</td>
</tr>
<tr>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>Palpitations</td>
<td>8 (50.0)</td>
</tr>
<tr>
<td>Pre-syncope</td>
<td>6 (37.5)</td>
</tr>
<tr>
<td>Syncope</td>
<td>1 (6.3)</td>
</tr>
<tr>
<td>Dyspnoea</td>
<td>1 (6.3)</td>
</tr>
<tr>
<td>ESV coupling interval (ms)</td>
<td>495 ± 68</td>
</tr>
<tr>
<td>Number of ineffective AADs</td>
<td>2.2 ± 0.5</td>
</tr>
<tr>
<td>Holter VEBs per 24 hours</td>
<td>21,244 ± 19,460</td>
</tr>
</tbody>
</table>

AAD: antiarrhythmic drug; ESV: end-systolic volume; LBBB: left bundle branch block; LVEF: left ventricular ejection fraction; VEB: ventricular ectopic beat.

Data are mean ± standard deviation or number (%).

Table 2 Mapping and RFA data.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacemapping (% of obtainment)</td>
<td>16 (100)</td>
</tr>
<tr>
<td>Local bipolar endocardial activation time (ms)</td>
<td>−46.3 ± 11</td>
</tr>
<tr>
<td>Local unipolar endocardial activation time (ms)</td>
<td>−46.3 ± 11</td>
</tr>
<tr>
<td>VEBs acceleration during application</td>
<td>5 (31.3)</td>
</tr>
<tr>
<td>Isolated presystolic potentials</td>
<td>2 (12.5%)</td>
</tr>
<tr>
<td>Anatomical topography</td>
<td></td>
</tr>
<tr>
<td>RVOT</td>
<td>13 (81.3)</td>
</tr>
<tr>
<td>RV tricuspid annulus</td>
<td>2 (12.5)</td>
</tr>
<tr>
<td>LVOT</td>
<td>1 (6.3)</td>
</tr>
<tr>
<td>RF application time (min)</td>
<td>11 ± 10</td>
</tr>
<tr>
<td>Power (W)</td>
<td>46 ± 17</td>
</tr>
<tr>
<td>Impedance (Ω)</td>
<td>81 ± 12</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>50 ± 5</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>94 ± 35</td>
</tr>
<tr>
<td>Acute success</td>
<td>15 (93.8)</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>11 ± 6</td>
</tr>
<tr>
<td>Recurrence</td>
<td>1 (6.3)</td>
</tr>
</tbody>
</table>

LVOT: left ventricular outflow tract; RF: radiofrequency; RFA: radiofrequency ablation; RV: right ventricle; RVOT: right ventricular outflow tract; VEB: ventricular ectopic beat.

Data are mean ± standard deviation or number (%).

On flat tissue or structure pieces in order to achieve a linear lesion with an 8-mm tip catheter requires a parallel position, with the large electrode tip lying on its side. This optimizes the electrode–tissue interface, with a larger volume of resistive heating and a greater convective cooling effect, thus improving the power delivered [15–18,22]. This kind of anatomy, which may be expected in patients with OTVEBs, has previously been described [24]. Although numerous limitations with large-tip electrodes have been described, including a lack of mapping accuracy compared to 4-mm tip catheters [22], we did not encounter this problem in our small cohort of patients. Moreover, the risks of steam pops and tamponade exist, and seem to be higher compared to a 4-mm tip catheter [20,22,24]. Larger randomized studies are therefore warranted to evaluate this serious potential risk.

The potential advantages of externally irrigated catheters have been demonstrated when low local convective cooling was obtained with lower power output [19–21]. As electrode cooling is provided by irrigation in an externally-cooled tip catheter, the voltage or power can be chosen and maintained independently of the local blood flow ("extrinsic cooling"), leading to a more consistent and predictable lesion size [20,22,24]. In addition, the usually smaller (3.5-mm) electrode tip found on irrigated catheters "recorders" a smaller amount of signal under the tip, thus potentially yielding a high electrographic resolution. Therefore, selecting an externally irrigated tip catheter might be clinically useful when deeper lesions are required, but perhaps not when treating ventricular ectopies located in a thin structure such as the outflow tract (1–2 mm wall thickness, compared to 3–5 mm in the right ventricle [25]). Therefore, when using an externally irrigated tip catheter, the risk of perforation is theoretically higher for this kind of structure [26]. Recently, Wood et al. demonstrated that a horizontal electrode orientation reduced lesion volumes for irrigated catheters [24]. For treating OTVEB, the anatomical orientation of the catheter should be parallel to the RVOT because of the tube-like portion of the right ventricle.
cavity. Therefore, non-irrigated catheters should be the first choice, as based on experimental studies [24–26]. Moreover, steam pops are often, but not always, audible when using an irrigated-tip catheter, and although the risk of perforation is low in areas of ventricular scar, this risk is likely higher when performing RFA in the thin-walled RVOT, which is approximately 3 mm thick [25].

Clinical data concerning RFA catheter choice in OTVEBs

Clinical series dealing with RFA treatment of OTVEBs have reported high success and low recurrence rates with only minimal complications when using a 4-mm tip catheter [4]. The main complication was the increased risk of perforation [4]. A recent literature review has reported acute procedural success rates of 93% and a recurrence rate of 5% [4]. However, RFA success rates appear to be lower in real-life practice as compared to published series. This phenomenon may be explained by factors such as: modest resolution of pace mapping, small number of reported cases, operator experience, and diversity of locations and catheter types used [4,6]. As a result, some electrophysiologists have changed their approach and systematically use an externally irrigated cooled catheter despite its lack of validation in this clinical setting. Based on experimental studies, outflow tract structure, and 8-mm catheter tip properties, we wished to examine whether a large-tip catheter could be used safely in patients with OTVEBs. To our knowledge, this is the first prospective report evaluating a large 8-mm tip RF catheter in patients with OTVEBs that demonstrates that this catheter may be used safely. The procedures performed with an 8-mm tip catheter resulted in lesions large enough to facilitate OTVEB treatment, but larger randomized studies are needed to confirm these results.

Limitations

The major limitations of this study are the use of a non-randomized study design and the limited number of patients. However, randomized studies are difficult to conduct due to the low number of patients requiring RFA. No comparative, prospective studies have been published on catheter safety and efficacy in patients presenting with OTVEBs. However, due to these limitations, our encouraging results need to be confirmed in a large multicentre randomized comparative study. Furthermore, the safety of the 8-mm tip catheter for treating OTVEBs in the right outflow tracts or tricuspid annulus cannot be extrapolated to the aortic valve due to the inherent risk of this particular zone.

Conclusions

This preliminary study of a series of patients suggests that an 8-mm tip catheter may be used for RFA in patients with OTVEBs, and may represent an alternative in case of primary 4-mm tip failure. However, larger, randomized studies are required to confirm these findings.

Disclosure of interest

Professor Da Costa is a consultant for St. Jude Medical, Medtronic, Biotronik, and Boston Scientific, having received research support from St. Jude Medical, Medtronic, Biotronik Boston Scientific, and Sorin Group.

References


