Radiofrequency Energy: Irrigation and Alternate Catheters

Andreas Pflaumer
Irrigated tip RF ablation

- Irrigated tip
  - How does it work?
  - Potential benefits?
  - Potential risks?
  - How is this relevant to pediatric and congenital patients
Biophysics of RF Ablation

Open and closed irrigation

Navarro 2013
Influences on lesions size and quality (experimental studies)

• Higher saline flow increases the lesion size (“magic number” 17ml/min) for up to 30 W

• Higher contact pressure increases lesion size

• Parallel instead of perpendicular orientation decreases lesion volume by 25%
Potential complications

- Steam pop – higher probability with closed loop catheters
- Thrombus formation (again higher probability with closed looped catheters)
- Injury of coronary arteries, esophagus and phrenic nerve
- Increased mural swelling, especially in scarred / infarcted area
Better effectiveness proven in

- Endocardial ablation for VT (Soejima, E. *Circulation*, vol. 103, no. 14, pp. 1858–1862, Apr. 2001.)

80 patients randomized to 4 groups, irrigated (internal and external), and conventional 8mm with different sensor technique

Endpoint CTI block after 12min of ablation

The differences were statistically significant for the following comparisons: externally irrigated versus internally cooled and internally cooled versus 8-mm single sensor
No difference in conventional and irrigated catheters:

  Irrigated-tip vs. conventional-tip catheters for primary ablation of postero-septal and right free-wall accessory pathways: a prospective randomized study.

- Circulation 2004;110:1030-1035
  - Effect of Isthmus Anatomy and Ablation Catheter on Radiofrequency Catheter Ablation of the Cavotricuspid Isthmus
A Prospective Randomized Single-Center Study on the Risk of Asymptomatic Cerebral Lesions Comparing Irrigated Radiofrequency Current Ablation with the Cryoballoon and the Laser Balloon

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Asymptomatic Cerebral Lesions in AF Ablation. Background: Asymptomatic cerebral lesions (ACL) may occur during atrial fibrillation (AF) ablation. We sought to compare the ACL incidence between 3 contemporary technologies: (1) irrigated radiofrequency current (RFC), (2) the single big cryoballoon (CB), and (3) the endoscopic laser-balloon (LB) in a prospective randomized pilot study.

Methods and Results: Ninety-nine patients were treated in 3 groups. Diffusion weighted MRI was acquired pre- (n = 20) and 24–48 h postablation (n = 99). After ablation, new ACL were detected in 22% of patients without significant differences between groups (RFC 8/33; CB 6/33; LB 8/33; P = 0.8). The presence of hypertension was identified as the only independent predictor of ACL by univariate regression analysis. During LB ablation, more ablation lesions (140 ± 19 vs 119 ± 18; P = 0.007) were applied during longer procedures (166 ± 36 vs 143 ± 32 min; P = 0.05) in patients with ACL. Univariate analysis revealed that a higher number of ablation lesions predicted ACL (P = 0.02).

Conclusion: In this prospective, randomized, single-center pilot study, ablation technology did not influence the occurrence of ACL during AF ablation. (J Cardiovasc Electrophysiol, Vol. pp. 1-6)
What about the use in pediatrics?

Safety and Efficacy of Open Irrigated-Tip Catheter Ablation of Wolff-Parkinson-White Syndrome in Children and Adolescents

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**Background:** Irrigated-tip catheter technology has been used for the elimination of resistant accessory pathways (AP) in adults with Wolff-Parkinson-White (WPW) syndrome. However, there are persistent concerns regarding the safety of irrigated catheters in the pediatric population. In this report we present our experience, in terms of effectiveness and safety, of irrigated catheter technology in children and adolescents who underwent ablation of WPW.

**Methods:** We prospectively followed up all patients less than 18 years old (n = 41, mean age of 12.8 years old) who were referred to our center for radiofrequency (RF) catheter ablation of WPW between January 2010 and July 2011. Catheter ablation was performed in all patients using an open irrigated-tip catheter (Celsius Thermocool 3.5 mm, 7F, B-type, Biosense Webster, Diamond Bar, CA, USA). Power was started from 15 W up to 30 W in right-sided AP; RF pulses in left-sided APs were delivered at 40 W while 20 W was delivered inside the coronary sinus.

**Results:** Mean procedure time was 26.4 minutes and mean fluoroscopy time was 12.2 minutes. Overall procedural success was obtained in 39/41 (95.1%) patients after the first procedure. No complications were observed after the procedure. All patients attended their scheduled follow-up visit at 3, 6, and 12 months and no recurrences were observed based on 12-lead electrocardiogram and 24-hour Holter monitoring.

**Conclusions:** RF ablation of APs using open irrigated-tip catheters can be performed in children and adolescents with a high acute and long-term success rate, very short procedure times, and acceptable fluoroscopy times. (PACE 2013; 36:486–490)
Permanent Pacemaker Implantation for Late Atrioventricular Block in Patients Receiving Catheter Ablation for Atrioventricular Nodal Reentrant Tachycardia

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(Am J Cardiol 2013;111:569-573)
Atrial wall thickness

- Right atrium wall thickness
  - In children less than 1 mm between the pectinated muscles
  - The free wall 2mm and the crista terminalis up to 6mm

- Septum
  - Limbus 4-8mm depending on age

- Left atrium
  - 1-3mm thickness
Ventricular wall thickness

- **RV**
  - 3-5 mm free wall
  - 1-2 mm RVOT

- **Septum**
  - 8-15mm

- **LV**
  - 9-15mm
Coronary Arteries

Effect in pediatric patients irrigated vs. non irrigated

Table 5  Serum CK, CK-MB, and cTnT levels after atrial and ventricular wall ablation using non-irrigated-tip or irrigated-tip catheters

<table>
<thead>
<tr>
<th>Ablation target</th>
<th>Atrial wall</th>
<th>Ventricular wall</th>
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<tbody>
<tr>
<td></td>
<td>Non-irrigated-tip</td>
<td>Irrigated-tip</td>
</tr>
<tr>
<td>CK (IU/l)</td>
<td>453.1 ± 652.0</td>
<td>298.8 ± 336.9</td>
</tr>
<tr>
<td>CK-MB (IU/l)</td>
<td>24.8 ± 19.7</td>
<td>22.6 ± 5.0†</td>
</tr>
<tr>
<td>cTnT(μg/l)</td>
<td>0.36 ± 0.34*</td>
<td>0.38 ± 0.30**</td>
</tr>
<tr>
<td>p value</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
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CK creatine kinase, CK-MB CK–myocardial band, cTnT cardiac troponin T
*p = 0.004, **p = 0.031, †p = 0.006

Joachim Will et al, PediatricCardiology 2012, 33, 1348-1354
Examples of RA wall thickness
A) control patient: mean RA wall thickness = 1.6 mm;
B) patient with tricuspid atresia: Fontan operation at age 9 years and death 3 months after surgery, mean RA thickness = 7.0 mm; (bar scale = 10 mm in both panels)
Prospective trial of electroanatomically guided, irrigated catheter ablation of atrial tachycardia in patients with congenital heart disease


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Irrigated-tip catheter ablation of intraatrial reentrant tachycardia in patients late after surgery of congenital heart disease


Hildegard Tanner, MD,a Peter Lukac, MD,b Nicola Schwick, MD,a Juerg Fuhrer, MD,a Anders Kirstein Pedersen, MD,b Peter Steen Hansen, MD,b Etienne Delacretaz, MDa
Irrigated Catheter in CHD

- Studies:
  - Tanner: Comparison with historical group

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of power and temperature during irrigated-tip catheter versus conventional catheter radiofrequency ablation (historical control group)</th>
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<tbody>
<tr>
<td></td>
<td>Irrigated-tip catheter ablation (624 lesions)</td>
</tr>
<tr>
<td>No. of lesions per tachycardia isthmus</td>
<td>13 ± 11</td>
</tr>
<tr>
<td>Maximal power (W)</td>
<td>42 ± 8</td>
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<tr>
<td>Mean power (W)</td>
<td>36 ± 8</td>
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<tr>
<td>Percentage of sites with mean power</td>
<td></td>
</tr>
<tr>
<td>≤10 W</td>
<td>0</td>
</tr>
<tr>
<td>≤15 W</td>
<td>0</td>
</tr>
<tr>
<td>≤20 W</td>
<td>1</td>
</tr>
<tr>
<td>Mean temperature (°C)</td>
<td>41 ± 5</td>
</tr>
</tbody>
</table>
CoolFlex Smart tip

Conventional 6 holes irrigated tip

More uniform cooling
More stable anatomical conformability?

The Smart tip might absorb movement and might improve tissue wall contact better in the beating heart.
All patients treated with an average CF of 10 g (5 of 5 patients) experienced recurrences, whereas 80% of the patients treated with an average CF of 20 g (8 of 10 patients) were free from AF recurrence at 12 months.

The analysis of the average force-time integral showed that 75% of the patients treated with 500 gs were recurrent whereas only 31% of the patients treated with 1000 gs had recurrences at 12 months.

**Figure 1** Two different concepts of RF ablation catheters with integrated US imaging. A: Catheter with platinum ring ablation electrode; B: catheter with US transparent ablation electrode, which is made of TPX.
Figure 2  Real-time lesion formation on US for epicardial right atrial ablation (A) and epicardial left ventricle ablation (B) with ring catheter (7 W) and the small TPX catheter (4.5 W), respectively. The red line indicates the change in US tissue contrast upon energy delivery. The back wall of the left ventricular tissue is not visible on the US image.

Figure 5  A: Real-time visualization of lesion formation on US for epicardial ablation of the right atrium with the ring catheter. The red line indicates the change in US tissue contrast upon energy delivery. The ablation was stopped after incidence of a tissue pop, which is indicated on the image. Corresponding pathology and histology showed a lesion that was partially transmural. B: Real-time visualization of catheter slippage on US for epicardial ablation of the RV with the big TPX catheter. The red lines indicate the change in US tissue contrast upon energy delivery, and slippage is indicated by the arrow. Tissue back wall is not visible on the US image. Two distinct lesions were visible at the tissue surface and pathology cross section.
Correlation of measurements

Potential Disadvantages

- Fluid overload
- Price
- Thicker, less flexible catheter
- Higher risk of air embolism
Potential damage

• Coronary artery rupture or stenosis
• Pulmonary vein stenosis
• Esophageal damage
• Mitral valve/papillary muscle
• Phrenic nerve damage
Potential advantages

- Energy delivered more effectively and independent of blood flow
- Higher energy delivery without the risk of steam pops (comparing same size electrodes)
- Deeper lesion (transmural)
Conclusion

• Irrigated tip ablation has it’s role in congenital heart disease

• It might be very useful in pediatric patients if one is able to control the lesion size

• Need for more studies