Catheter ablation of macroreentrant atrial tachycardia in patients following atriotomy

See doi:10.1053/euhj.2002.3168 for the article to which this Editorial refers

Macoreentrant right atrial tachycardia is a common late complication of surgical correction or palliation of congenital heart disease, and its prevalence increases as the time following surgery increases[1–9]. These arrhythmias are often refractory to pharmacological therapy.

Macoreentrant atrial tachycardia following surgical repair of congenital heart disease (‘incisional tachycardia’ or ‘atypical atrial flutter’) has been thought to be due to reentry around the atriotomy scar or around a septal patch following atrial septal defect closure[5,6]. Catheter ablation has been useful in selected patients[2,4–8], but these procedures have been limited in many patients due to the presence of multiple or unstable (unmappable) atrial tachycardias, especially in patients with more complicated surgeries (i.e. Fontan procedure). Two approaches were initially explored for catheter ablation of macroreentrant atrial tachycardias following atriotomy. In one approach, mapping focuses on identifying an isolated diastolic atrial potential, presumably originating from an isolated zone of slow conduction[4,7]. Entrainment pacing is used to confirm participation of that site in the reentrant circuit. In one series, this approach successfully ablated at least one tachycardia in 73% of the patients[5]. However, atrial tachycardia recurred in 53% of the patients with acute ablation success (mean time to recurrence 4-1 months)[7].

The second approach is based on the concept that atrial tachycardia in patients following atriotomy results from reentry around the atriotomy scar[5,6].
Catheter ablation is used to create a linear transmural lesion between the atriotomy scar and an anatomical barrier (such as the tricuspid annulus or inferior vena cava) to interrupt the reentrant circuit. The atriotomy scar is identified as an area without an atrial potential or with double atrial potentials separated by an isoelectric baseline, indicating a line of conduction block. The direction of reentry around the scar is determined by identifying the timing of atrial activation at several sites around the scar, or sweeping Halo technique as used by Anne et al. In two earlier studies using this approach, ablation acutely eliminated at least one atrial tachycardia in 83% and 93% of patients, with recurrence of atrial tachycardia in 33% and 46% of the patients with acute ablation success, respectively. Anne et al. studied 45 patients following atriotomy with typical atrial flutter and macroreentrant atrial tachycardia. For macroreentrant atrial tachycardia, they used the sweeping Halo technique to identify the atriotomy scar and created a linear lesion between the scar and anatomical boundary (such as the inferior vena cava). A total of 116 atrial tachycardias (macroreentrant atrial tachycardia and atrial flutter) were induced. A total of 86 tachycardias (58 macroreentrant atrial tachycardia and 28 atrial flutter) were targeted for ablation and 81 were successfully ablated. In 10 of the 45 patients, typical atrial flutter (reentry around the tricuspid annulus) was the only arrhythmia. With a mean follow-up of 24 months, 13 patients had a recurrence of atrial tachycardia, two (20%) of the 10 patients with only atrial flutter and 11 (31%) of the 35 patients with macroreentrant atrial tachycardia. Importantly, they found a significant relationship between the number of atrial arrhythmias identified during the procedure and the recurrence of tachycardia.

Reconstruction of the reentrant circuit with conventional catheter mapping techniques (including biplane fluoroscopy and sweeping Halo technique) is challenging, especially in patients with multiple surgical scars and multiple macroreentrant atrial tachycardias (i.e. post Fontan procedure). Without the ability to store and display the timing of activation at each of the mapped sites, only an approximate estimation of the reentrant circuit is achieved. The less than optimal long-term success of ablation may relate to the inability to localize multiple scars and multiple (including unmappable) reentrant circuits.

**Substrate for macroreentrant atrial tachycardia**

The recently developed catheter electroanatomical mapping system (CARTo), which combines anatomical recreation of the cardiac chamber with local activation times, is uniquely suited for identifying the reentrant circuit in macroreentrant right atrial tachycardia. High-density (250–400 mapped points) electroanatomical maps have demonstrated that the substrate for macroreentrant atrial tachycardia is a very large area of low voltage (involving almost all of the right atrial free-wall) containing two or more adjacent scars. Narrow channels (usually <3 cm in width) between the scars are the critical component of the reentrant circuit. The reentrant impulse propagates around one of the scars and through the channel between the scars.

Patients with macroreentrant right atrial tachycardia who have had repair of atrial septal defect or correction of tetralogy of Fallot typically have two right atrial free-wall scars. The lower scar is usually continuous with the inferior vena cava. The reentrant impulse propagates around the upper scar and through the narrow (0.7–1.6 cm) channel between the two scars. Ablation across the narrow channel connects the two scars with the inferior vena cava, and consistently eliminates the tachycardia with a small number of radiofrequency applications and a low rate of recurrence. Anne et al. identified the upper scar using the sweeping Halo technique and created a linear lesion from the upper scar to the inferior vena cava. This approach is as effective as ablating across the channel if a continuous transmural lesion is obtained. However, this may be more difficult.

Macroreentrant atrial tachycardias are much more complex in patients who have had a Fontan procedure. These patients have even larger areas of low voltage with 3–8 dense scars in variable locations, producing 2–7 isolated channels between scars and a larger number (3–8, median 5-5) of inducible atrial tachycardias. Some of these tachycardias are non-sustained. Others frequently shift atrial activation sequence, suggesting multiple simultaneous reentrant circuits. Identification of all of the scars, channels and reentrant circuits would be difficult using conventional mapping techniques. This probably accounts for the higher recurrence rates found by Anne et al. in patients with multiple tachycardias.

The areas of scars and lines of double potentials identified during tachycardia are also present during sinus rhythm or atrial pacing, indicating these scars are fixed anatomical structures and are not functional blocks related to the rapid rate of the tachycardia. Therefore, unmappable macroreentrant atrial tachycardias (non-sustained or varying atrial activation sequence) can be effectively ablated by targeting all of the channels between scars identified from a high...
density electroanatomical map obtained during one stable tachycardia or during atrial pacing[12].

**Limitations of entrainment pacing**

In the absence of a complete activation map during tachycardia, entrainment pacing is a powerful tool to determine whether a particular site is located within the circuit of a macroreentrant atrial or ventricular tachycardia[13,14]. Entrainment pacing is utilized most often at sites of isolated diastolic potentials thought to potentially represent activation within a ‘protected isthmus’ of the reentrant circuit. The presence of an isolated diastolic potential combined with entrainment pacing producing concealed fusion and a post-pacing interval equal to the tachycardia cycle length (confirming a location within the reentrant circuit) has been considered the optimal criteria for selecting an ablation site[2,4–8,13,14]. However, in macroreentrant atrial tachycardia, focal ablation at these sites is often unsuccessful. The reasons for failed ablation at a site with perfect entrainment mapping criteria are the following. In macroreentrant atrial tachycardia, the entire circuit is located within a large area of low voltage. The majority of the reentrant circuit is located outside an isolated channel (outer loop sites), yet still exhibits an isolated diastolic potential with ideal entrainment criteria. A single point ablation at these sites will not eliminate the tachycardia. Successful ablation would require creating an ablation line on each side of this site to a fixed anatomical obstacle (such as the atriotomy scar and the tricuspid annulus)[5,6].

Another major limitation is that entrainment pacing during macroreentrant atrial tachycardia (in patients with and without previous surgery[15]) occasionally during macroreentrant atrial tachycardia (in patients with previous surgery[15]).

In the presence of a complete electroanatomical map, entrainment pacing is just confirmatory. The map does not exhibit a clear, single macroreentrant circuit[12,15].

**H. NAKAGAWA**  
**W. M. JACKMAN**  
*Cardiac Arrhythmia Research Institute, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, U.S.A.*

**References**


