Advances in the Catheter Ablation of Isthmus-Dependent Atrial Flutter

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Summary

The critical zone of slow conduction in isthmus-dependent atrial flutter, including typical atrial flutter, is the cavotricuspid isthmus in the right atrium. Since conduction across the isthmus is essential for the maintenance of this type of flutter, a simple anatomic approach of isthmus ablation may provide a cure. For therapy success a correct diagnosis with proof of slow conduction at the isthmus, as well as achieving bidirectional isthmus block, are essential. This brief review covers the current challenges in isthmus-dependent flutter ablation, including classification of atrial flutters, new approaches to achieving a complete line of transmural lesion, and assessment of bidirectional block.

Key Words

Atrial flutter, radiofrequency ablation, cavotricuspid isthmus

Introduction

Typical atrial flutter, the most common form of isthmus-dependent flutters, is arguably the closest clinical tachycardia to the classic ring model of reentry with a critical zone of slow conduction. The reentrant circuit is confined to the right atrium in which the activation front travels up the atrial septum and then down the right atrial free wall to re-enter the atrial septum through an isthmus bounded by the inferior vena cava and eustachian ridge; the coronary sinus os being on one and the tricuspid valve annulus on the other side. This cavotricuspid isthmus has been shown to be the slow conduction zone of the reentrant circuit of isthmus-dependent flutters [1]; thus, prevention of conduction over the isthmus by linear ablation would treat ongoing and recurrent isthmus-dependent flutter. Since the isthmus can be trabeculated and the myocardium might be up to 8 mm thick, the challenge is to fully achieve and reliably assess a complete, bidirectional conduction block at this site. This review will focus on the following three issues:

- classification of atrial flutter;
- newer techniques to achieve isthmus block; and
- methods to assess bidirectional block.

Definition and Classification of Atrial Flutter

Classic, typical atrial flutter is documented by a surface ECG from the inferior leads II, III, and aVF containing negative sawtooth waves of continuous atrial activity at a rate of 240 – 350 beats/min. This type of flutter is also termed as common, counterclockwise, or type I flutter. Recently, an expert group of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology attempted to classify atrial tachyarrhythmias based on their electrophysiologic mechanisms [2]. Atrial flutter was defined as a type of macro-reentrant tachycardia and is situated around an anatomically defined obstacle (eustachian ridge and a functional line of block at either the posteromedial – sinus venosus –

I.	**Isthmus-dependent flutter**	• Typical flutter (common, counter-clockwise, type I) • Atypical flutter (uncommon, clockwise) • Lower loop flutter (if isthmus is part of the circuit) • Drug-organized atrial fibrillation (if isthmus is part of the circuit; most notably seen with amiodarone)
II.	**Isthmus-independent flutter**	• Incisional flutter • Left atrial flutter • Miscellaneous

Table 1. A proposed practical classification of atrial flutter for ablation purposes.

right atrium in cases of typical flutter [3], a surgical incision in cases of incisional flutter, and the pulmonary vein os in cases of left atrial tachycardia), with a continuous electrical activity on the surface ECG. From a practical, ablation-oriented standpoint, atrial flutter may be classified as isthmus-dependent (which includes the typical and reverse route of atrial flutter, as well as many of the atrial fibrillations, that become organized by antiarrhythmic drugs – most frequently seen with amiodarone) or non-isthmus-dependent. The former would be curable by isthmus ablation, while the latter would require complex mapping to define the reentrant circuit and critical zone of slow conduction. A classification of atrial flutter for ablation purposes is proposed in Table 1.

Methods of Isthmus Ablation

Diagnosis of Isthmus-Dependent Atrial Flutter

Characteristic, negative sawtooth waves in leads II, III, and aVF on the surface ECG and a typical activation sequence along the crista terminalis picked up by a 20-pole catheter is highly suggestive of typical, and hence isthmus-dependent, flutter. The prudent way to prove the diagnosis is to demonstrate concealed entrainment from the isthmus. The entrainment characteristics of atrial flutter have been described [4]. Among the pitfalls are the selection of the stimulation site, since the chosen site on the isthmus – given its considerable width – might not be situated near the reentrant circuit; thus, entrainment from that site would result in a longer return cycle length than the tachycardia cycle length. This would erroneously indicate that the tachycardia is not isthmus-dependent; and assessment of the flutter wave morphology to determine whether the entrainment was concealed or not may be challenging, particularly in cases of 2:1 or higher conduction rates. Extra effort should be made, however, to demonstrate isthmus dependency, in case the flutter does not appear to be typical, or the flutter is still not terminated after a considerable effort is made to achieve isthmus block.

Ablation of the Isthmus

Various approaches have been developed to ablate the isthmus. Usually, a 20-pole catheter is placed along the crista terminalis, with the distal tip in the coronary sinus. The electrodes may be distributed evenly, or more densely in the isthmus region. An additional coronary sinus catheter may provide more information about left atrial activity. The ablation catheter can be a standard 4 mm tip, an 8 mm tip, a cooled tip radiofrequency ablation catheter, or a cryoablation catheter. Specially-designed long sheaths may be used to achieve better contact and stability with the isthmus. The right anterior oblique and left anterior oblique view of a typical catheter setup for isthmus ablation is shown in Figure 1. Ablation lines can be created laterally to the septum, between the tricuspid ring and the inferior vena cava, or more medially, from the tricuspid ring to the coronary sinus os, and from the coronary sinus os to the inferior vena cava [5]. The advantage of a more septally positioned line is that the isthmus tends to be less trabeculated towards the septum; the disadvantage is the sometimes narrow Koch's triangle, with the potential danger of damaging the AV node. Ablation lines can be created by dragging the ablation catheter along the isthmus during continuous radiofrequency application (for 2 min), or sequentially, spot by spot, by applying RF for 30 – 45 s at each site. Target temperature is usually set at 60° C, but may be increased up to 80° C.

The variety of methods underlines the fact that in some cases there is no easy way to achieve complete isthmus block ("resistant flutter"). It is thought to be due to the anatomical structure of the isthmus (which can be trabeculated rather than smooth), with an atrial wall thickness up to 8 mm. It can be challenging to achieve a transmural lesion in the case of a thick isthmus.

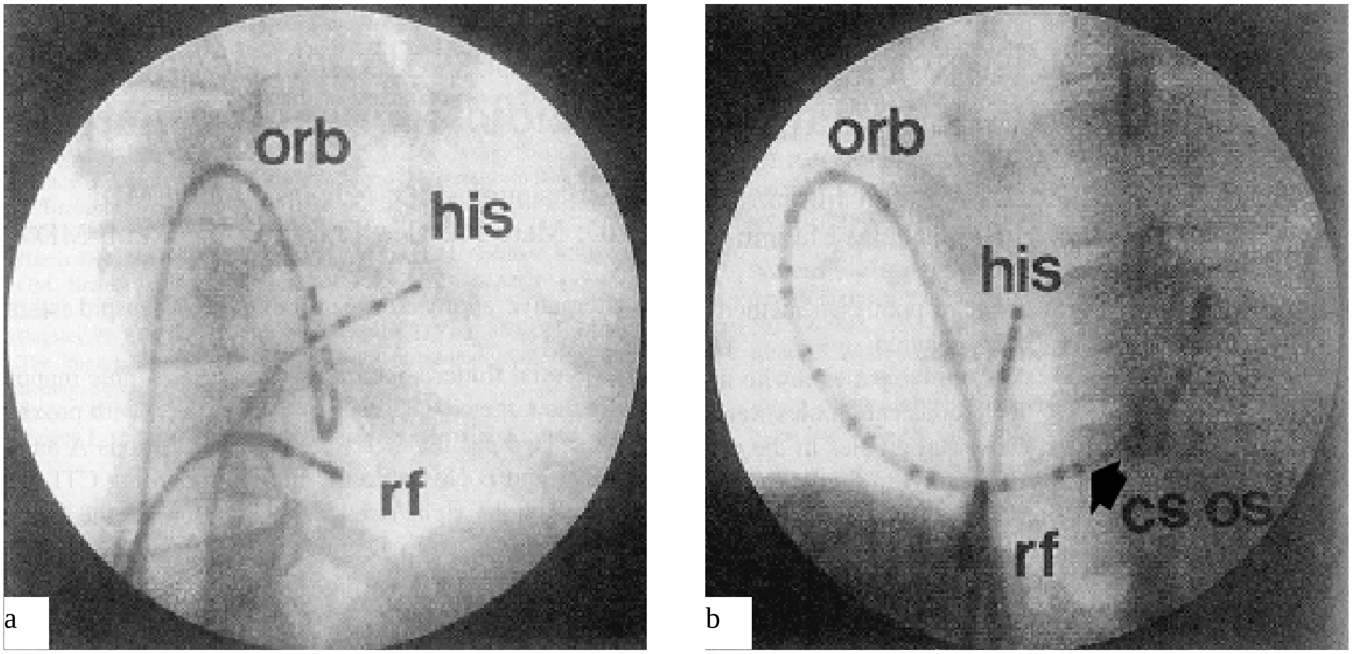

Figure 1. Right anterior oblique (a) and left anterior oblique (b) fluoroscopic views of catheter positions during isthmus ablation. A 20-pole catheter is placed along the crista terminalis in the right atrium (orb), while the distal part of the catheter is advanced into the coronary sinus ostium (CS OS). A quadripolar catheter is in the His position (his), and the ablation catheter (rf) is on the isthmus.

Therefore, most of the novel methods are aimed at achieving bigger or deeper lesions. These methods include the above mentioned use of an 8 mm ablation catheter tip, cooled tip catheter, higher target temperature, use of special sheaths using lateral or septal ablation lines, or novel energy sources. An interesting approach is to use the voltage mapping feature of electroanatomical mapping to design an ablation line that goes across a low voltage area only, which indicates thinner myocardium, and hence a higher chance to achieve isthmus block. Since comparative studies of these methods are just under way and success and complication rates depend heavily on the operator's experience, currently the best approach to isthmus ablation is probably the one the operator is most familiar with.

The acute procedural success rate (the procedural endpoint being a bidirectional isthmus block) has been reported to be above 90 – 95 % in most experienced centers, with a complication rate comparable to that of ablation of accessory or slow pathways [6-8]. Recurrence of isthmus-dependent tachycardia depends on the presence or absence of a bidirectional block across the isthmus. In one study, the 1-year recurrence rate was 9 % among patients with isthmus block, in contrast to 68 % among patients without isthmus block [9]. When bidirectional block is achieved, the recurrence of isthmus-dependent flutter is less than 10 %; however, other atrial tachyarrhythmias, most notably atrial fibrillation, can occur.

Assessment of Bidirectional Isthmus Block

When isthmus conduction is blocked, the global activation sequence of the right atrium dramatically changes. If the ablation was performed during flutter, the flutter will terminate. However, change in the activation sequence or termination of the flutter does not prove the presence of bidirectional block, which should be the procedural endpoint [6,7,9]. Gaps along the ablation line may still be present, with very slow conduction.

Isthmus block may be assessed by one of the following methods:

- activation sequence and timing following stimulations at different sites in the atria;
- mapping double potentials along the presumed line of block;
- reversal of the polarity of bipolar electrograms;
- activation map by electroanatomical mapping.

Prolongation of the trans-isthmus conduction interval by more than 50 % in both clockwise and counter-clockwise directions has a 100 % sensitivity, but only 80 % specificity for isthmus block [10]. A definitive assessment can be achieved by a simple pacing technique that uses two close pacing sites on both sides of the isthmus block line [11]. Another simple indicator of complete block is the reversal of bipolar electrogram polarity recorded just anterior to the line of block during coronary sinus pacing [12]. The line of block can also be identified by double potentials in the isthmus region using a conventional mapping and pacing technique [13]. Wide separation of the double potentials indicates a complete line of block, whereas narrow separation indicates gap(s) in the line of block. This method, unlike the others, can guide attempts to complete the line of block.

Conclusion

Recognition of the importance of achieving bidirectional isthmus block, along with the continuously improving techniques of lesion creation and isthmus block assessment led to a marked improvement in both acute and long-term success rate of flutter ablation. However, at this time there is not enough evidence to recommend a single best approach. Appropriate patient selection is still an evolving issue.

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References

[1] Olshansky B, Okumura K, Hess PG, et al. Demonstration of an area of slow conduction in human atrial flutter. J Am Coll Cardiol. 1990; 16: 1639-1648.

[2] Saoudi N, Cosio F, Waldo A, et al. Classification of atrial flutter and regular atrial tachycardia according to electrophysiologic mechanism and anatomic bases. J Cardiovasc Electrophysiol. 2001; 12: 852-866.

[3] Friedman PA, Luria D, Fenton AM, et al. Global right atrial mapping of human right atrial flutter: The presence of posteromedial (sinus venosa region) functional block and double potentials. Circulation. 2000; 101: 1568-1577.

[4] Waldo AL. Atrial flutter: Entrainment characteristics. J Cardiovasc Electrophysiol. 1997; 8: 337-352.

[5] Nakagawa H, Lazzara R, Khastgir T, et al. Role of the tricuspid annulus and the Eustachian valve/ridge on atrial flutter. Circulation. 1996; 94: 407-424.

[6] Poty H, Saoudi N, Aziz AA, et al. Radiofrequency ablation of type I atrial flutter. Circulation. 1995; 92: 1389-1392.

[7] Fisher B, Jais P, Shah D, et al. Radiofrequency cathter ablation of common atrial flutter in 200 patients. J Cardiovasc Electrophysiol. 1996; 7: 1225-1233.

[8] Schwartzman D, Callans DJ, Gottlieb CD, et al. Conduction block in the inferior vena caval-tricuspid valve isthmus: Association with outcome of radiofrequency catheter ablation of type I atrial flutter. J Am Coll Cardiol. 1996; 28: 1519-1531.

[9] Schumacher B, Pfeiffer D, Tebbenjohanns J, et al. Acute and long-term effects of consecutive radiofrequency applications on conduction properties of the subeustachian isthmus in type I atrial flutter. J Cardiovasc Electrophysiol. 1998; 9: 152-163.

[10] Oral H, Sticherling C, Tada H, et al. Role of transisthmus conduction intervals in predicting bi-directional block after ablation of typical atrial flutter. J Cardiovasc Electrophysiol. 2001; 12: 169-174.

[11] Chen J, de Chillou C, Basiouny T, et al. Cavotricuspid isthmus mapping to assess bidirectional block during common atrial flutter radiofrequency ablation. Circulation. 1999; 100: 2507-2513.

[12] Tada H, Oral H, Sticherling C, et al. Electrogram polarity and cavotricuspid isthmus block during ablation of typical atrial flutter. J Cardiovasc Electrophysiol. 2001; 12: 393-399.

[13] Shah DC, Haissaguerre M, Jais P, et al. Atrial fluter: Contemporary electrophysiology and catheter ablation. PACE. 1999; 22: 344-359.

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