CASE REPORT

Late atypical atrial flutter after ablation of atrial fibrillation

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Abstract Cardiac surgery for structural heart disease (often involving the left atrium) and radiofrequency catheter ablation of atrial fibrillation have led to an increased incidence of regular atrial tachycardias, often presenting as atypical flutters. This type of flutter is particularly common after pulmonary vein isolation, especially after extensive atrial ablation including linear lesions and/or defragmentation.

The authors describe the case of a 51-year-old man, with no relevant medical history, referred for a cardiology consultation in 2009 for paroxysmal atrial fibrillation. After failure of antiarrhythmic therapy, he underwent catheter ablation, with criteria of acute success. Three years later he again suffered palpitations and atypical atrial flutter was documented. The electrophysiology study confirmed the diagnosis of atypical left flutter and reappearance of electrical activity in the right inferior pulmonary vein. This vein was again ablated successfully and there has been no arrhythmia recurrence to date.

In an era of frequent catheter ablation it is essential to understand the mechanism of this arrhythmia and to recognize such atypical flutters.

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Case report

The authors describe the case of a 51-year-old man, referred for a cardiology consultation in 2009 for paroxysmal atrial fibrillation (AF), the first episode of which was documented in December 2008, lasting 18 hours and terminating spontaneously; he had no other relevant medical history. Further investigation by transthoracic echocardiography revealed no structural heart disease, normal cardiac chamber dimensions, and preserved biventricular systolic function with no evidence of diastolic or valve dysfunction; laboratory tests, including renal, thyroid and liver function, showed no significant alterations. Exercise testing (Bruce protocol lasting 8 min 30 s, rate-limited, asymptomatic) revealed no significant electrocardiographic alterations or evidence of cardiac rhythm disturbances during exertion or recovery. In 2010 he reported several episodes of palpitations (European Heart Rhythm Association [EHRA] classification III), and AF was documented. Since AFl was not inducible and could therefore not be mapped in detail, the right inferior pulmonary vein was isolated, advanced to the left atrium. As the Lasso catheter was being manipulated near the inferior pulmonary vein, to map the anatomy of the left atrium during the EPS, although the images were not integrated.

A quadripolar catheter was introduced into the right atrium or His position and a decapolar catheter was advanced to the coronary sinus, both by femoral vein catheterization. Based on the previous pulmonary vein isolation and the algorithms for locating the circuit according to the morphology of flutter (F) waves on the surface electrocardiogram (ECG), a double transseptal approach was immediately performed, introducing a decapolar circular catheter (Lasso, Biosense) and an irrigated-tip ablation catheter with pressure sensor (SmartTouch), which were advanced to the left atrium. As the Lasso catheter was being manipulated near the inferior pulmonary vein, to map the anatomy of the left atrium, the AFL ceased due to mechanical block (Figure 2).

Mapping of the left atrium only showed electrical activity in the right inferior pulmonary vein (Figure 3). Programmed electrical stimulation of the atrium was performed with three base cycles and three coupled extrastimuli until the refractory period without AFL or AF being induced. Since AFL was not inducible and could therefore not be mapped in detail, the right inferior pulmonary vein was isolated, with criteria of acute success and no periprocedural complications (Figure 4).

At six-month follow-up the patient reported clear symptomatic improvement, with only sporadic palpitations.
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Figure 1 12-lead electrocardiogram showing atypical atrial flutter at 101 bpm with positive flutter waves in the inferior leads and V1.

Figure 2 Electrophysiology study demonstrating conversion of left atrial flutter to sinus rhythm by simply manipulating the Lasso catheter in the left atrium next to or inside the left inferior pulmonary vein, and showing a pulmonary vein signal in the first sinus beat. CS1-CS5: decapolar catheter in the coronary sinus; (L2-L3) to (L9-L10) decapolar circular Lasso catheter; RDFd-RDFp: ablation catheter. Arrow: pulmonary vein signals.

Repeat 24-hour electrocardiographic monitoring revealed sinus rhythm and nine supraventricular extrasystoles.

Discussion

AF is a major cardiovascular challenge in modern society. Its prevalence is estimated at 1.5-2% of the general population and it is associated with increased risk for stroke and congestive heart failure and thus high mortality.1,2

According to the European Society of Cardiology guidelines, catheter ablation of symptomatic paroxysmal AF is recommended in patients who have symptomatic recurrence of AF on antiarrhythmic drug therapy (class I recommendation, level of evidence A).1 Pulmonary vein isolation is considered the reference treatment in catheter ablation.1-3

There have been significant technical advances in catheter ablation of AF in recent years, and it has become one of the most widely used treatments for this arrhythmia. However, success rates vary considerably, which may be due to differences in population characteristics, techniques, and assessment criteria.4

Ablation is more effective in maintaining sinus rhythm than antiarrhythmic drugs in AF, but long-term recurrence rates are significant. Previous studies report success rates of 85% at one year and 52% at five years for radiofrequency ablation. Early recurrence appears to be the main negative
predictor, but age, left atrial dimensions, structural heart disease, and type and duration of AF are also factors in recurrence.\textsuperscript{1,2,4}

Wei et al. studied 267 patients treated by pulmonary vein isolation and found that in a mean follow-up of 300 days, 44 patients (16.5\%) showed recurrence, of which 21 had AFI, 18 AF, and five atrial tachycardia. Multivariate analysis revealed that AF type, AF duration, left atrial diameter and left pulmonary vein diameter were risk factors for recurrence (hazard ratios of 3.416, 2.148, 4.619 and 2.811, respectively, \( p<0.05 \)).\textsuperscript{4}

Cryoablation has gained increasing acceptance for pulmonary vein isolation. Although first-generation cryoablation balloons showed only moderate long-term efficacy and an acceptable safety profile (the main adverse effects being phrenic nerve paralysis), second-generation devices (28 mm balloon incorporating a modified refrigerant injection system providing homogeneous cooling of the complete

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**Figure 3** Electrophysiology study demonstrating electrical activity in the right inferior pulmonary vein (left) and no electrical activity following re-isolation of the vein (right). CS1-CS5: decapolar catheter in the coronary sinus; (L2-L3) to (L9-L10) decapolar circular Lasso catheter; RDFd-RDFp: ablation catheter. Arrow: pulmonary vein signals.

**Figure 4** CARTO three-dimensional electroanatomical mapping system showing points of circumferential ablation leading to isolation of the right inferior pulmonary vein. The ablation points in the upper part of the left superior pulmonary vein correspond to fragmented potentials.
distal balloon hemisphere) demonstrated 80% success in a one-year follow-up (81% in paroxysmal AF and 77% in short-term persistent AF). The incidence of esophageal injury ranges between 12% and 19%, and the incidence of phrenic nerve palsy varies considerably between centers (3.5-19.5%).

AFI can occur after catheter AF ablation. The term “flutter” was first used in 1887 by John McWilliam, who described the visual phenomena resulting from atrial stimulation as “a rapid flutter”. A macroreentrant mechanism was finally proven by detailed mapping in the electrophysiology laboratory.

AFI is less common than AF, but its prevalence also increases with age. The incidence of AFI in those younger than 50 years is 5/100 000 and 587/100 000 in those >80 years old.

AFI can coexist with or precede AF, and the relation between the two is complex. Some authors have shown that patients with coexistent AF and AFI benefit from catheter ablation of AF, possibly associated with AFI ablation instead of AFI ablation only.

In 1970 Puech and Grolleau proposed a classification of AFI according to 12-lead electrocardiographic morphology. The most frequent form of flutter, termed “common”, was characterized by predominantly negative biphasic F waves in the inferior leads with a sawtooth pattern, and predominantly positive F waves in V1; AFI was termed “atypical” if the electrocardiographic morphology was different from the common type.

AFI is currently defined as a regular atrial tachycardia with a rate of ≥240 bpm lacking an isoelectric baseline between deflections. It is termed typical (cavotricuspid isthmus-dependent) if the inferior pivot point is the area bounded anteriorly by the inferior part of the tricuspid orifice, and posteriorly by the inferior part of the vena cava orifice.

Cardiac surgery for structural heart disease (often involving the left atrium) and radiofrequency catheter ablation of atrial fibrillation have led to an increased incidence of regular atrial tachycardias, often presenting as atypical flutters. This type of flutter is particularly common after pulmonary vein isolation, especially after extensive atrial ablation including linear lesions and/or defragmentation. Gaps in prior ablation lines may also play a role in reentrant circuits. The most common mechanisms are perimital, roof-dependent and septal circuits; recently, bilateral circuits have also been reported.

The most useful method for determining the origin (left or right) of AFI from the surface ECG is assessment of F-wave morphology in V1. F waves in this lead with a broad positive base and aVL. Clockwise mitral flutter demonstrated a significant negative F-wave in the inferior leads and positive F-wave in leads I and aVL. An electrophysiologic diagnosis of perimital flutter is obtained by pacing techniques using a single multipolar catheter in the coronary sinus when the post-pacing interval is <30 ms in the proximal as well as the distal coronary sinus.

The European and American guidelines recommend catheter ablation of symptomatic non-cavotricuspid isthmus-dependent AFI refractory to antiarrhythmic drug therapy (class Ib recommendation).

Successful ablation of atypical AFI depends on identifying the critical part of the reentrant circuit that can be interrupted by radiofrequency application. Mapping systems enable three-dimensional reconstruction of the sequence of atrial activation during tachycardia and localization of areas of scarring or conduction block. In patients who have undergone previous cardiac surgery, the surgical report is useful in identifying the possible location of reentrant circuits near surgical incisions in the atrium.

Perimital AFI is particularly difficult to treat, since bidirectional mitral isthmus block has a limited effect on recurrence and can be a challenge to achieve in the acute phase, requiring potentially dangerous epicardial ablation in the coronary sinus, and significant late conduction recovery is seen in up to 60% of cases despite complete acute block. Ablation of a modified anterior mitral line has recently been shown to be safe and effective compared to the lateral line, improving the success rate of mitral isthmus block.

With this case, the authors highlight the importance of catheter ablation of AFI nowadays and the forms in which arrhythmias may recur during follow-up. In our patient there was recurrence three years after pulmonary vein isolation in the form of atypical left AFI of unknown location. The case also demonstrates that in AFI following pulmonary vein isolation when ablation lines are not created, the circuits responsible are usually related to recovery of electrical activity in one or more pulmonary veins, with the microreentrant circuit located close to one of them, and with centrifugal activation of both atria. Effective treatment consists simply of re-isolation of the pulmonary veins involved.

To conclude, the case presented is a good example of the above approach, since our patient is symptom-free, in sinus rhythm and not taking antiarrhythmic medication, six months after a simple re-ablation of the right inferior pulmonary vein, the only one to show recovery of conduction,
even though the reentrant circuit involved in the genesis of
this atypical AFL could not be mapped in detail.

Ethical disclosures

Protection of human and animal subjects. The authors
declare that no experiments were performed on humans or
animals for this study.

Confidentiality of data. The authors declare that no patient
data appear in this article.

Right to privacy and informed consent. The authors have
obtained the written informed consent of the patients or
subjects mentioned in the article. The corresponding author
is in possession of this document.

Conflicts of interest

The authors have no conflicts of interest to declare.

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