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CLASSICAL CASE
Arrhythmias/electrophysiology

Diagnosis and treatment of atrioventricular nodal reentrant tachycardia: a case report illustrating clinical management and ablation strategy

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Background Atrioventricular nodal reentrant tachycardia (AVNRT) is a common supraventricular arrhythmia that is frequently encountered in an otherwise healthy patient population. Recent guidelines of the European Society of Cardiology underline the role of catheter ablation in the long-term management of these patients.

Case summary This case describes the clinical presentation and treatment options in a patient with typical slow/fast AVNRT, the most common subform of AVNRT, where antegrade conduction occurs over the slow pathway and retrograde conduction over the fast pathway. The ablation strategy in these patients is illustrated based on intracardiac recordings in combination with per-procedural three-dimensional imaging.

Discussion Atrioventricular nodal reentrant tachycardia is a common arrhythmia with good prognosis but significant impact on quality of life of affected patients. Catheter ablation should be considered early as it can be performed safely and with a very high success rate.

Keywords Atrioventricular nodal reentrant tachycardia • Electrocardiography • Electrophysiology study • Ablation • Case report

Learning points

- Atrioventricular nodal reentrant tachycardia (AVNRT) is an arrhythmia frequently encountered in an otherwise healthy patient population.
- Catheter ablation should be considered as an initial treatment choice in symptomatic patients with AVNRT, given the high success rate and low risk for complications.
- Ablation is typically performed in the slow pathway region corresponding to the rightward inferior extension of the atrioventricular (AV) node. If ablation is not successful in this region, a left-sided ablation approach should be considered rather than ablating near the His-bundle or compact AV node.

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Introduction

Treating patients with supraventricular tachycardia can be very rewarding, both in the acute setting in the emergency room, as in the long term with currently available ablation strategies. This case describes in detail the diagnosis, acute, and long-term treatment of a patient with atrioventricular nodal reentrant tachycardia (AVNRT), providing insights in typical electrocardiogram (ECG) characteristics and the basic principles of intracardiac recordings and ablation therapy.

Timeline

Case atrioventricular nodal reentrant tachycardia (AVNRT) timeline

Timeline ablation procedure

0 min	Start femoral vein puncture
15 min	Catheters positioned (fluoroscopic guidance)
21 min	Induction of slow/fast AVNRT
36 min	Three-dimensional reconstruction completed
48 min	Slow pathway elimination

Case presentation

A 36-year-old female patient presented in the emergency department with sudden-onset palpitations that had started 2 h before. She had been suffering from comparable self-limiting episodes since the age of 24 years and was found to have a structurally normal heart on an earlier cardiology examination including transthoracic echocardiography. As the episodes were generally self-terminating within 10 min, she never took any medication to prevent recurrences. She had no other relevant medical history. Physical examination showed no abnormalities other than a regular tachycardia at 190 b.p.m., and blood pressure was 137/78 mmHg. The ECG on presentation in the emergency ward is presented in *Figure 1*.

The ECG on presentation showed a regular narrow QRS tachycardia with a ventricular rate of 192 b.p.m. The presence of a retrograde p-wave in or at the end of the QRS-complex is the hallmark of typical slow/fast AVNRT. Other tachycardias that should be considered in the differential diagnosis are orthodromic atrioventricular reentrant tachycardia (AVRT) over an accessory pathway, focal atrial tachycardia, and atrial flutter. In orthodromic AVRT, the retrograde p-waves are typically identified later (80–120 ms) after the end of the QRS-complex as the atria are only activated retrogradely over the accessory pathway after the ventricular myocardium has been depolarized. In focal atrial tachycardia, the p-waves are not retrograde and typically present not after, but just before the QRS-complex, with a PR-interval depending on antegrade conduction properties. In atrial flutter, flutter waves with a typical sawtooth pattern can be regarded as the main hallmark of common clockwise isthmus-dependent atrial flutter.

When confronted with patients with haemodynamically stable narrow QRS tachycardia, vagal manoeuvres can be used as a first-line attempt to achieve reconversion to sinus rhythm. In patients with AVNRT and AVRT, carotid sinus massage and Valsalva manoeuvres are often used successfully to terminate the tachycardia by slowing conduction over the atrioventricular (AV) node, which is a critical part of the circuit.

In 2015, it was shown that the modified Valsalva manoeuvre, combining Valsalva with a postural modification (leg elevation and supine positioning at the end), was more efficient in terminating episodes of supraventricular tachycardia than the standard Valsalva manoeuvre (43% vs. 17% restoration of sinus rhythm, $P < 0.0001$).[1] Therefore, this method is currently recommended as a first-line over other vagal manoeuvres to achieve sinus rhythm in the acute phase.

When vagal manoeuvres fail to restore sinus rhythm, intravenous adenosine can be administered as second-line therapy. Although adenosine blocks AV nodal conduction and therefore is mainly used to terminate AVNRT and AVRT, it may also terminate some forms of focal atrial tachycardia that are based on triggered activity.[2] When adenosine fails to terminate AVNRT, or when there is rapid recurrence after cardioversion, intravenous administration of calcium channel blockers (verapamil/diltiazem) or beta-blockers may be used to restore sinus rhythm.

In patients with recurrent symptomatic episodes of AVNRT, there is a good and clear indication for catheter ablation, which can be performed with a high success rate (97%) and a very low risk of complications.[2] By avoiding ablation in the mid-septal area and the roof of the coronary sinus, targeting the inferior nodal extensions of the AV node for ablation, the risk of periprocedural AV block can be reduced to a minimum. Special consideration should be given to older patients with a baseline first-degree atrioventricular block, as the risk of iatrogenic AV block after ablation has been reported to be considerably higher in this group.[3]

Our patient consented to an ablation procedure which was performed under general anaesthesia with propofol and mechanical ventilation, as is the standard in our centre. After obtaining bilateral femoral venous access, three diagnostic catheters and one ablation catheter were positioned intracardially according to the positions shown in *Figure 2*. The procedure was performed under X-ray fluoroscopic guidance without the use of a three-dimensional (3D) mapping system, as is usually the case for such procedures.[4] With incremental atrial pacing, a clear jump from antegrade conduction over the fast pathway to the slow pathway was observed, with initiation of typical slow/fast AVNRT, as represented by the intracardiac recordings in *Figure 3*.

Ablation was then performed in the slow pathway region, corresponding to the rightward inferior extension of the AV node. Before ablation, a 3D reconstruction of right atrial anatomy was performed using 3D rotational angiography, as part of a study protocol on the anatomical evaluation of Koch's triangle in patients with AVNRT.[5] A oesophageal temperature probe was used as part of this study protocol to improve image integration accuracy; not to monitor temperature as there is no oesophageal temperature rise during ablation in the slow pathway region. Using dedicated software,[6] the position of

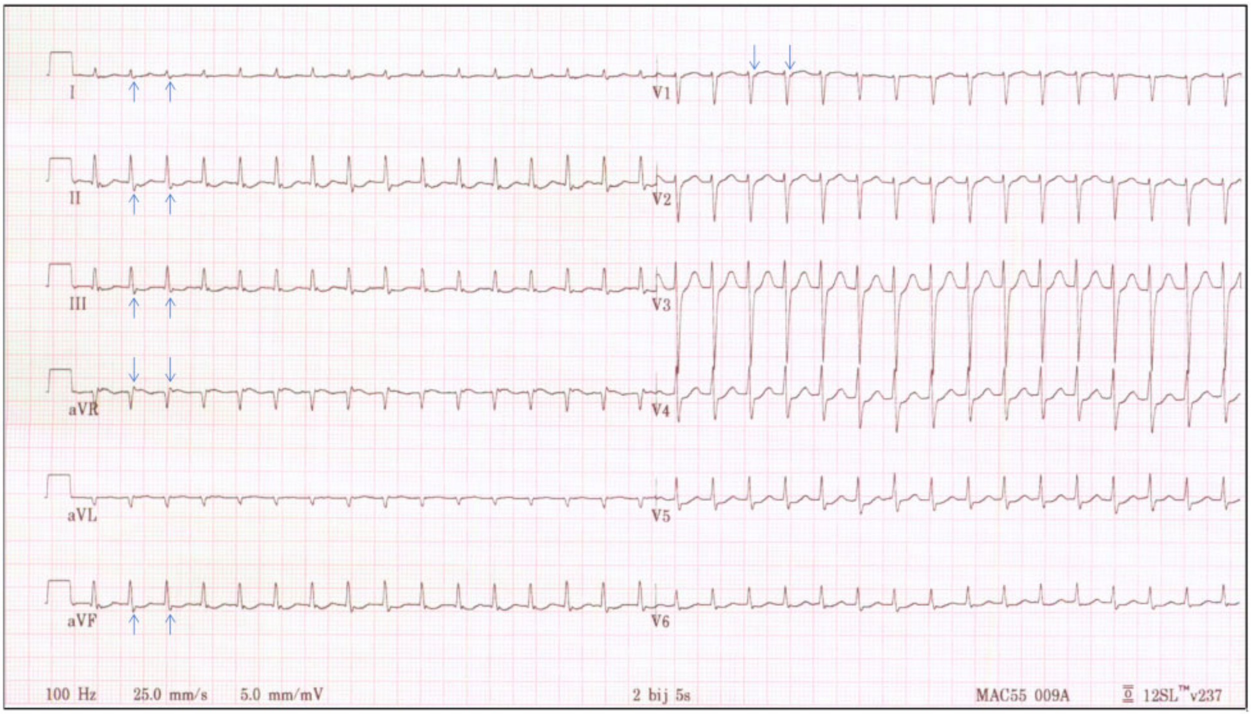

Figure 1 Regular narrow QRS tachycardia at a rate of 192 b.p.m. On close inspection of the electrocardiogram, a retrograde p-wave can be identified at the end of the QRS-complex, as a pseudo-S wave in lead I, and as notching at the end of the QRS in the inferior leads, aVR and V1 (marked with blue arrows). The presence of a retrograde p-wave in or at the end of the QRS-complex is the hallmark of typical slow/fast atrioventricular nodal reentrant tachycardia.

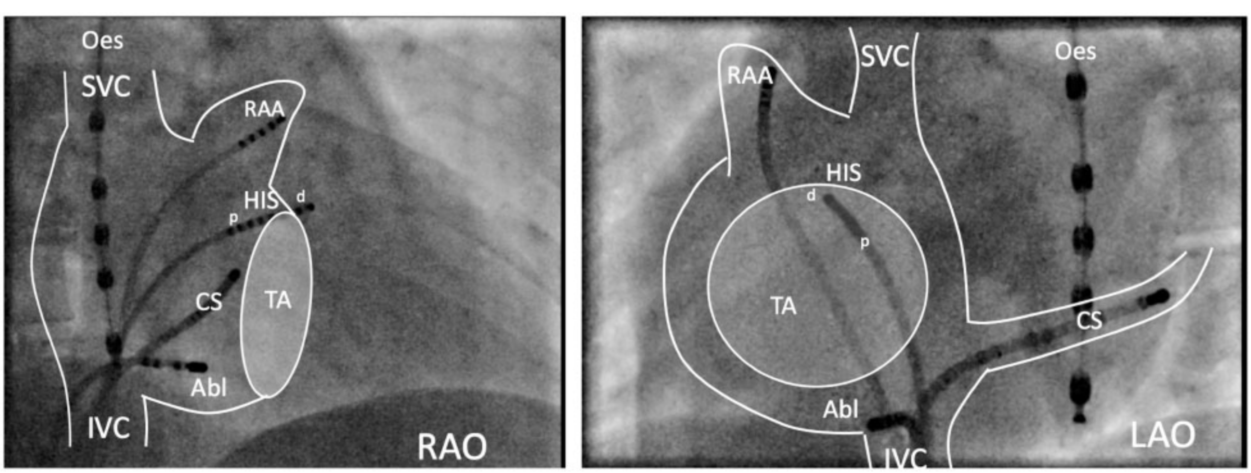

Figure 2 X-ray fluoroscopic images of catheter positions during induction of slow/fast atrioventricular nodal reentrant tachycardia, in right anterior oblique and left anterior oblique projections. A schematic representation of right atrial anatomy is projected on the fluoroscopic images. Corresponding intracardiac signals are represented in *Figure 3*. Abl, ablation catheter; CS, coronary sinus catheter; d, distal; HIS, His-bundle catheter; IVC, inferior vena cava; LAO, left anterior oblique; Oes, oesophageal temperature electrode; p, proximal; RAA, right atrial appendage; RAO, right anterior oblique; SVC, superior vena cava; TA, tricuspid annulus.

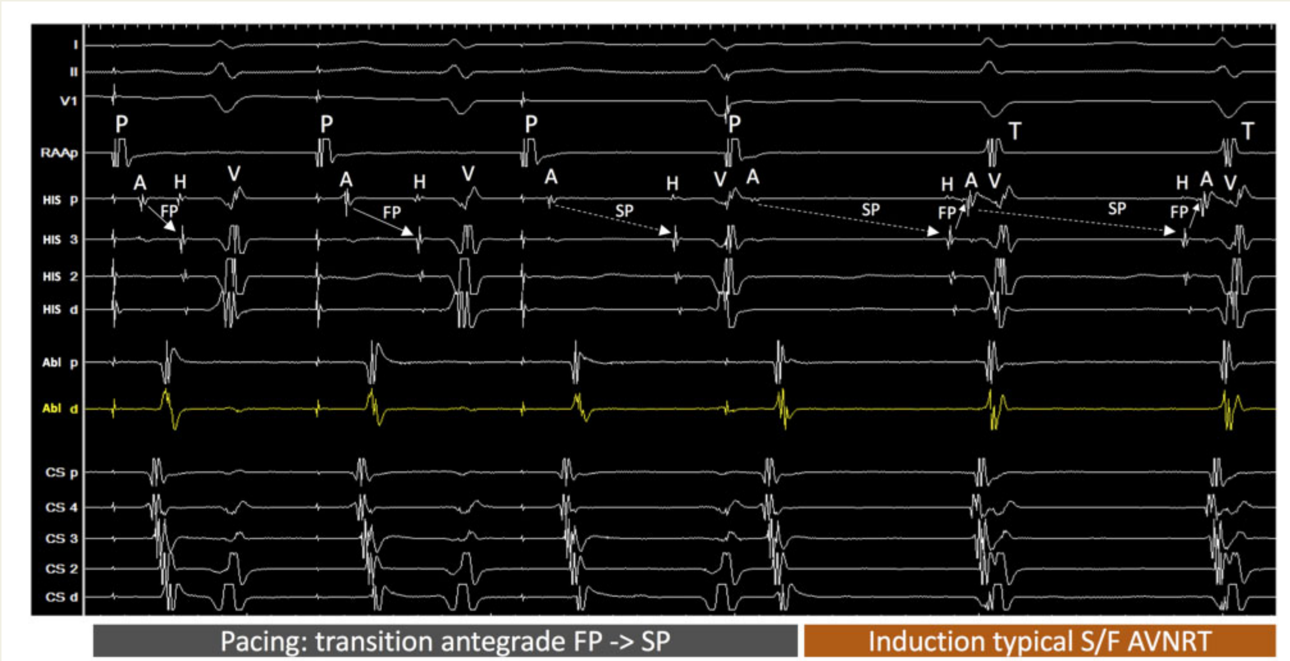

Figure 3 Induction of typical slow/fast atrioventricular nodal reentrant tachycardia during electrophysiology study (recording speed 100 mm/s). Catheters are positioned as shown in *Figure 4*. Signals shown from top to bottom: surface leads I, II, and V1; bipolar intracardiac electrograms from catheter in the right atrial appendage; four intracardiac electrograms from proximal to distal His-bundle catheter; bipolar electrograms on proximal and distal (yellow) ablation catheter; five bipolar electrograms from coronary sinus catheter arranged from proximal to distal. Pacing is performed from the right atrial appendage catheter, marked as 'P', with conduction from atrium to ventricle over the fast atrioventricular nodal pathway in the first two beats, and over the slow pathway in the third and fourth paced beats, with a clear jump in the atrial to His interval between FP and SP conduction. After the fourth paced beat, antegrade conduction over the slow pathway is followed by retrograde conduction over the fast pathway and typical slow/fast atrioventricular nodal reentrant tachycardia is initiated. Similarly, as on the surface electrocardiogram, the arrhythmia is characterized by quasi-simultaneous activation of atria and ventricles. A, atrium; Abl: ablation catheter; CS, coronary sinus; d, distal; FP, fast pathway; H, His; HIS: His-bundle catheter, p, proximal; RAA, right atrial appendage; S/F AVNRT: slow/fast atrioventricular nodal reentrant tachycardia; SP, slow pathway; V, ventricle.

the ablation catheter could be projected on the 3D model during ablation, demonstrating the site of successful slow pathway ablation (*Figure 4*).

During ablation in this region, accelerated nodal rhythm occurred indicating heating of the rightward inferior nodal extension, as is typically seen during successful radiofrequency applications in this region. The ablation power was increased from 25 to 40 W at the site of accelerated nodal rhythm and the application was continued for 90 s. After the first RF application, there was complete elimination of 1:1 antegrade slow pathway conduction, as can be seen in *Figure 5*, and tachycardia was non-inducible during a waiting period of 30 min. The different chronological steps of the procedure are illustrated in the *Figure 6*.

Discussion

This case describes the clinical presentation and treatment options in a patient with typical slow/fast AVNRT, an arrhythmia encountered commonly in an otherwise healthy patient population. As for other forms of supraventricular tachycardia, the recently published ESC guidelines[2] emphasize the role of catheter ablation as an initial treatment choice in symptomatic patients with AVNRT, given the high success rate and low risk for complications. The risk of periprocedural AV block can be minimized by avoiding ablation near the His-bundle and compact AV node. Rather than moving the ablation catheter higher up to the mid-septum if slow pathway conduction cannot be eliminated from the right posteroseptal area (region marked with red dots in *Figure 4*), a left-sided approach is recommended to eliminate slow pathway conduction by targeting the leftward inferior extension of the AV node.[7,8] This way, the procedure can be accomplished with almost no risk of AV block when performed in experienced centres.[2]

The current case illustrates the most common subform of AVNRT, where antegrade conduction occurs over the slow pathway and retrograde conduction over the fast pathway (slow/fast AVNRT or typical AVNRT).[7] This subform is characterized by the typical simultaneous activation of atria and ventricles as appreciated on the surface ECG and intracardiac recordings. This subform accounts for the large majority of AVNRT episodes, whereas other subforms (slow/slow and fast/slow AVNRT, also designated as the atypical forms of AVNRT) account for only 5–

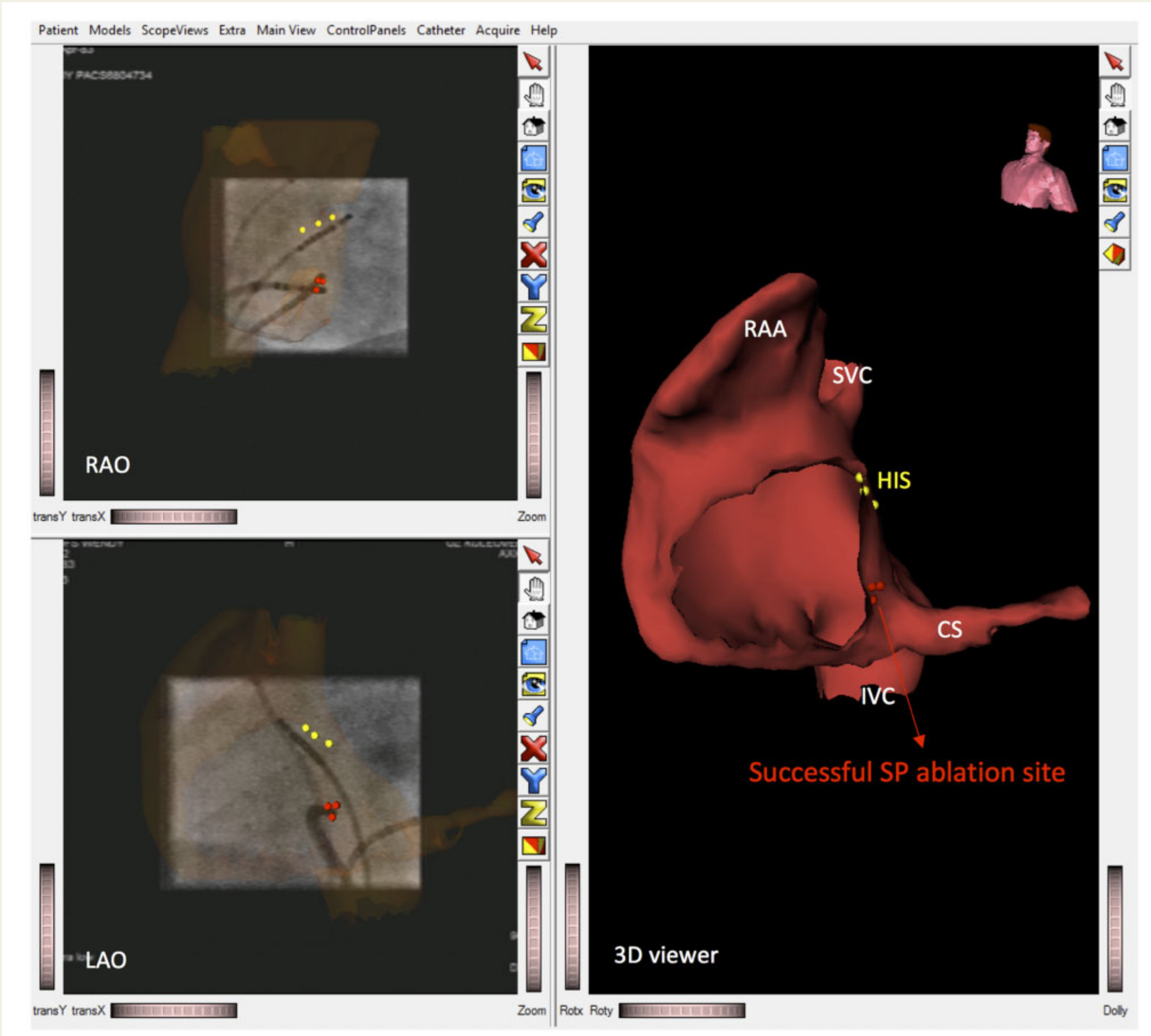

Figure 4 Position of the ablation catheter during successful slow pathway ablation, visualized using software for three-dimensional fluoroscopy integration. A three-dimensional reconstruction of the right atrium was generated during the procedure using three-dimensional rotational angiography and registered within the biplane fluoroscopic framework. Based on the position of the catheter in right and left anterior oblique projections (right anterior oblique and left anterior oblique, left upper and lower panes), the three-dimensional position can be visualized on the acquired three-dimensional model (right pane). Note the relatively long distance between successful ablation site, marked in red, and the region of the His-bundle recording. If ablation is not successful at this site, ablation from the left atrial side can be considered to eliminate slow pathway conduction, rather than ablating closer to the atrioventricular node at the right atrial mid-septum. 3D, three-dimensional; CS, coronary sinus; HIS, His-bundle recording; IVC: inferior vena cava; LAO, left anterior oblique; RAA: right atrial appendage, RAO: right anterior oblique; SP, slow pathway; SVC: superior vena cava.

10% of AVNRT episodes.[9] In atypical AVNRT, the retrograde conduction occurs over the slow pathway resulting in later retrograde atrial activation and a longer RP interval on the surface ECG.

While ablation of AVNRT is typically performed under fluoroscopic guidance, 3D mapping systems can also be used to facilitate ablation and reduce the radiation dose associated with these procedures, especially in the paediatric population.[10–12] While radiofrequency energy is used most commonly as energy source for ablation of AVNRT, cryoablation may carry a lower risk for AV block and therefore is sometimes preferred for ablation in children, although studies have demonstrated a higher risk of recurrence when compared with radiofrequency catheter ablation.[13,14] While we use general anaesthesia for most of our ablation procedures, ablation of AVNRT can also perfectly be performed under conscious sedation in the non-paediatric population.

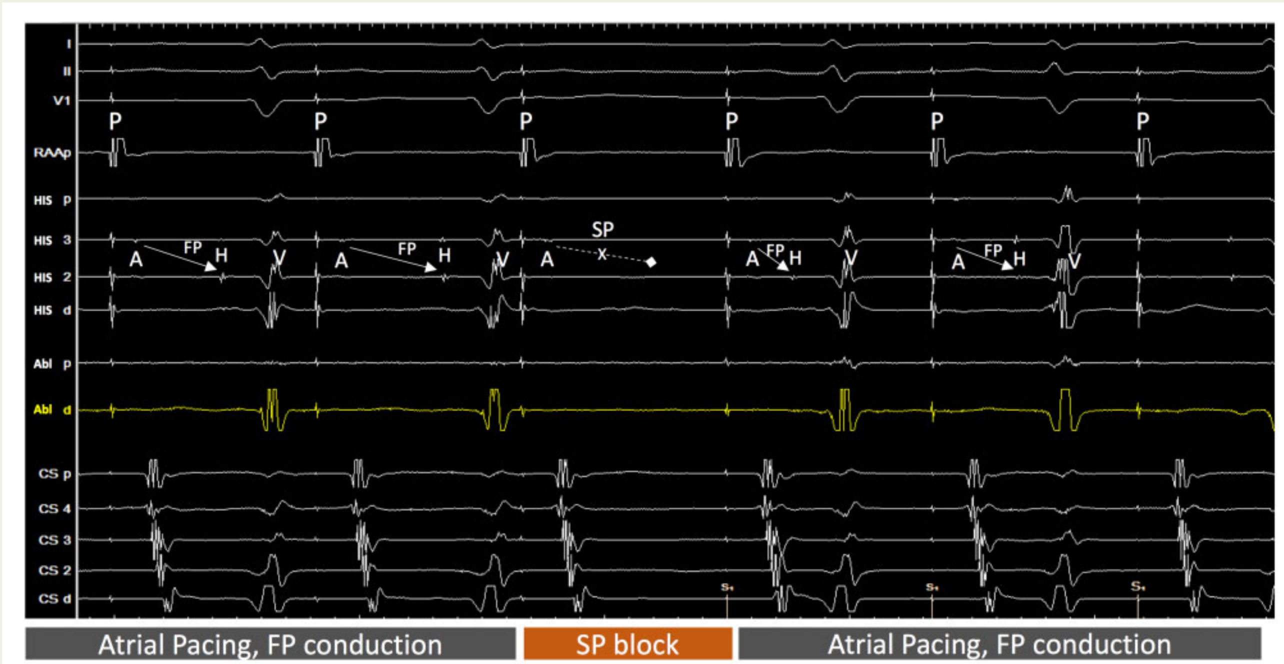

Figure 5 Elimination of 1:1 slow pathway conduction after successful ablation. In contrast to *Figure 4*, incremental atrial pacing does not lead to a jump in the atrial-His interval and conduction over the slow pathway. After the third paced beat, block in the slow pathway occurs and afterwards conduction over the fast pathway resumes. Besides tachycardia non-inducibility, such complete elimination of 1:1 slow pathway conduction is a solid endpoint for atrioventricular nodal reentrant tachycardia ablation. A, atrial; CS, coronary sinus; FP, fast pathway; H, His; P, pacing; RAA: right atrial appendage, SP, slow pathway

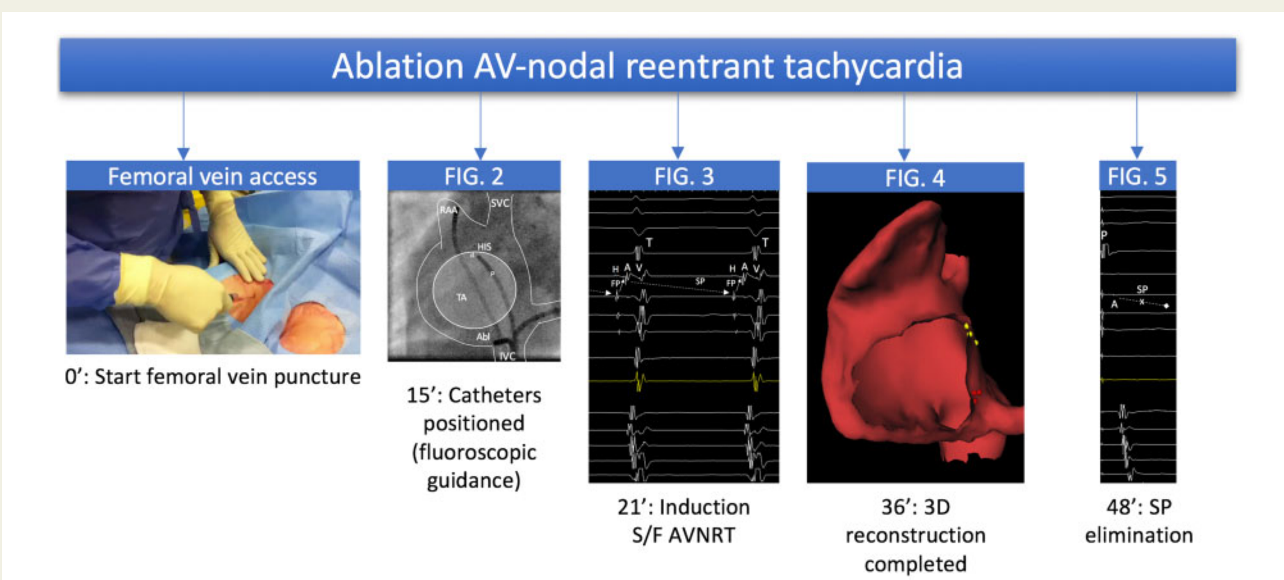

Figure 6 Figure representing different chronological steps during the ablation procedure, with corresponding figure numbers from the text. After slow pathway elimination, a waiting period of 30 minutes was applied after which the procedural endpoints of non-inducibility and slow pathway elimination were re-evaluated, before ending the procedure. S/F AVNRT: slow/fast atrioventricular nodal reentrant tachycardia, 3D, three-dimensional; RF, radiofrequency; SP, slow pathway.

Lead author biography

Joris Ector, MD, PhD, leads the cardiac ablation programme at the University Hospital Leuven, Belgium. He obtained a PhD in 2008 after working on new 3D fluoroscopic imaging applications to support cardiac ablation procedures. During this 4-year period, there was an intense collaboration with the Electrical Engineering Department resulting in software and clinical applications to support cardiac ablation procedures. Ongoing collaboration projects with the Electrical Engineering Department involve the development of augmented and virtual reality approaches to support complex cardiac ablation procedures.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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