Complementary use of conduction system pacing techniques for the “pace and ablate” strategy in permanent atrial fibrillation - a case report

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Abstract
Introduction: The feasibility of the conduction system pacing combined with atrioventricular node ablation was demonstrated in patients with atrial fibrillation in whom rate control can’t be achieved with medication and heart failure.
Clinical case: We present a case of an 82-year-old man with a personal history of permanent atrial fibrillation, admitted with symptoms of heart failure. The resting electrocardiogram showed a very fast ventricular response, and the echocardiography showed a depressed left ventricular function, raising the suspicion of a tachycardia-mediated cardiomyopathy. Since the patient was on maximum doses of atrioventricular nodal-blocking drugs, we opted for a physiological pacing and atrioventricular node ablation strategy. First, the His bundle capture was achieved at low pacing thresholds, and ablation of the atrioventricular node was attempted. Unfortunately, after several failed attempts, an acute increase in the His bundle capture threshold was noted, suggesting inadvertent tissue ablation beneath the pacing lead. In this scenario, we removed the lead from the His bundle area and achieved optimal left bundle branch area pacing. With the lead in this position, atrioventricular node ablation was performed during the first attempt. At the six-month follow-up, there was no recovery of atrioventricular node conduction. Device interrogation revealed stable pacing and sensing parameters, and there was a significant improvement in clinical status and left ventricular function.
Conclusions: Mastering both His bundle pacing and left bundle branch area pacing offers the potential to overcome intraprocedural challenges, giving alternative strategies to achieve physiological pacing. These approaches can be used interchangeably based on the evolving dynamics of the procedure and the patient’s specific needs.

Keywords
His bundle pacing, left bundle branch area pacing, atrioventricular node ablation, atrial fibrillation

Rezumat
Introducere: Fezabilitatea stimulării sistemului de conducere combinată cu ablația nodului atrioventricular a fost demonstrată pentru pacienții cu fibrilație atrială cu alura ventriculară necontrolată medicamentos și insuficiență cardiacă.
Caz clinic: Prezentăm cazul unui bărbat de 82 de ani, cunoscut cu fibrilație atrială permanentă, internat pentru simptome de insuficiență cardiacă. Electrocardiografic s-a decelat o alură ventriculară înaltă, iar ecocardiografic pacientul prezenta o funcție sistolică a ventriculului stâng sever depreciată, ridicând suspiciunea unei tahicardiomiopatii. Având în vedere că pacientul era în tratament cu doze maxime tolerate de betablocant, am optat pentru strategia de stimulare de sistem de conducere si ablație a nodului atrioventricular. După decelarea electrogramei hisiene cu obținerea unor praguri de stimulare acceptabile la acest nivel, s-a tentat ablația nodului atrioventricular. După câteva tentative nereușite, s-a observat o creștere acută a pragului de stimulare, sugerând ablația inadvertentă a țesutului adiacent sondei de stimulare. Astfel, am decis repoziționarea sondei la 1-1,5cm de fasciculului His, în direcția apexului ventriculului drept, transseptal, obținând o stimulare optimă a ramului stâng. În timpul doi, s-a realizat ablația nodului atrioventricular. La controlul de la șase luni nu s-a decelat reluarea conducerii de la nivelul nodului atrioventricular, cu parametri de sensing si pacing stabili la interogarea dispozitivului, alături de ameliorarea semnificativă a parametrilor clinici și electrocardiografici.
Concluzie: Stăpânirea deopotrivă a tehnicii de stimulare a fasciculului His, dar și a ramului stâng, oferă posibilitatea depășirii provocărilor intraprocedurale și aduce strategii alternative pentru obținerea stimulării fiziologice. Aceste abordări pot fi utilizate interschimbabil, în funcție de evoluția intraprocedurală și a nevoilor specifice ale pacientului.

Cuvinte cheie
stimulare de fasciul His, stimularea ariei ramului stâng, ablația nodului atrioventricular, fibrilație atrială

Introduction

Rate control is an essential goal in the treatment of permanent atrial fibrillation (AF) to reduce morbidity and improve quality of life. Atrioventricular node (AVN) blocking drugs can be inefficient, and their use can be limited by adverse effects. The feasibility of conduction system pacing (CSP) combined with AVN ablation was demonstrated

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in patients with AF and heart failure (HF), and this approach was linked to improved left ventricular ejection fraction, lower mortality, and reduction in HF hospitalizations.[1] In this case report, we described the complementary use of different CSP techniques and the concomitant AVN ablation, which allows electrophysiologists to adapt their strategy based on real-time intraprocedural changes.

Case report

An 82-year-old man was admitted to the Emergency Department of Brasov County Emergency Clinical Hospital for shortness of breath, light-headedness, and exercise intolerance. The patient's medical history included a diagnosis of type 2 diabetes mellitus treated with oral antidiabetic agents and permanent AF diagnosed approximately five years ago.

The presenting electrocardiogram (ECG) showed AF with an uncontrolled rapid ventricular response of 150 bpm (Figure 1A).

The echocardiography showed a non-dilated LV with a reduced ejection fraction of 35% and bi-atrial enlargement (a left atrial volume of 90 ml and a right atrial volume of 88 ml). There was moderate to severe mitral regurgitation and moderate tricuspid regurgitation, with an estimated pressure in the pulmonary artery of 45 mmHg.

Considering the presence of symptomatic permanent AF with uncontrolled ventricular rate and the echocardiographic findings, we primarily suspected the diagnosis of tachycardia-induced cardiomyopathy. Since the patient was on a maximal tolerated dose of beta-blocker (10 mg of bisoprolol), after a discussion with the patient and the family, we chose to control the heart rate with a physiological pacing and AVN ablation strategy.

Once a left axillary venous entrance site was obtained, a Medtronic C315 His (Medtronic, Minneapolis, MN, USA) delivery sheath and a Medtronic Select Secure 3830 (Medtronic, Minneapolis, MN, USA) pacing lead was advanced to the anteroseptal tricuspid annulus, where a clear His bundle (HB) signal was identified (Figure 1A). The lead was fixed at that site, where an HB current of injury (Figure 1B) and a selective HB pacing response were noted with a capture threshold of 0.75 V at 1 msec pulse duration (Figure 1C). The lead was connected to the programmer, and asynchronous pacing was started at 30 bpm to avoid oversensing during radiofrequency current applications and to constantly evaluate for HB capture.

During the same setting, in the second part of the procedure, a 4 mm non-irrigated ablation catheter was introduced through the right femoral vein at the expected radiological level of the AVN, and a radiofrequency current was repeatedly applied (Figure 1D). After several ineffective attempts at blocking the AVN close to the lead

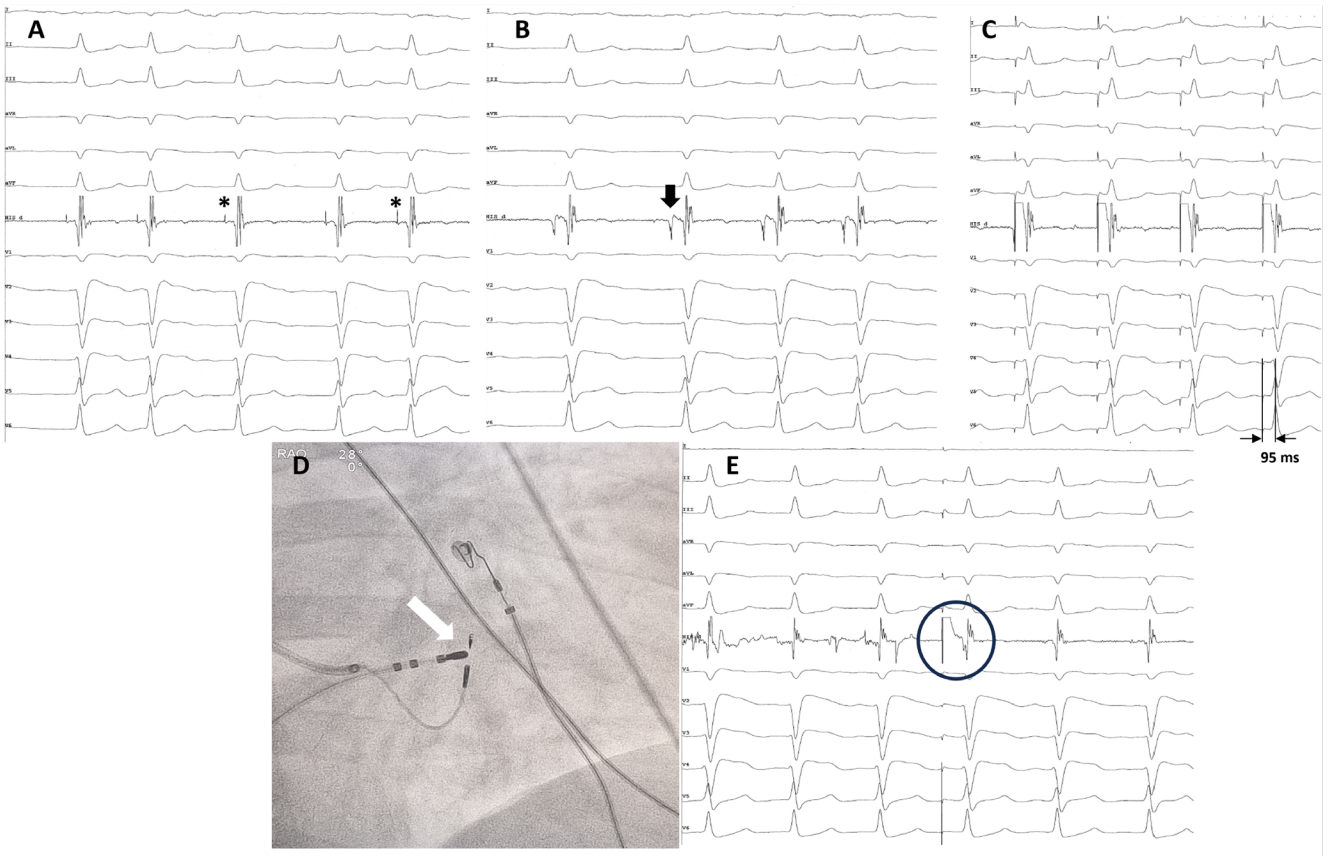


Figure 1 - A) Initial 12-lead ECG with rapid conducting AF. Intracardiac electrocardiogram from the lead tip showing a sharp HB signal (asterisk). B) After lead fixation in that area, an HB current of injury is noted with widening and polarity change of the electrogram (black arrow). C) Selective HB capture at high thresholds (3V) with an LVAT of 95 ms. D) RAO fluoroscopic image showing the proximity between the ablation catheter and the lead tip (white arrow). E) At that spot, during radiofrequency current application, a sudden loss of HB capture was noted (circle). ECG recording speed - 49mm/s. ECG, electrocardiogram; AF, atrial fibrillation; HB, His bundle; LVAT, left ventricular activation time; RAO, right anterior oblique.

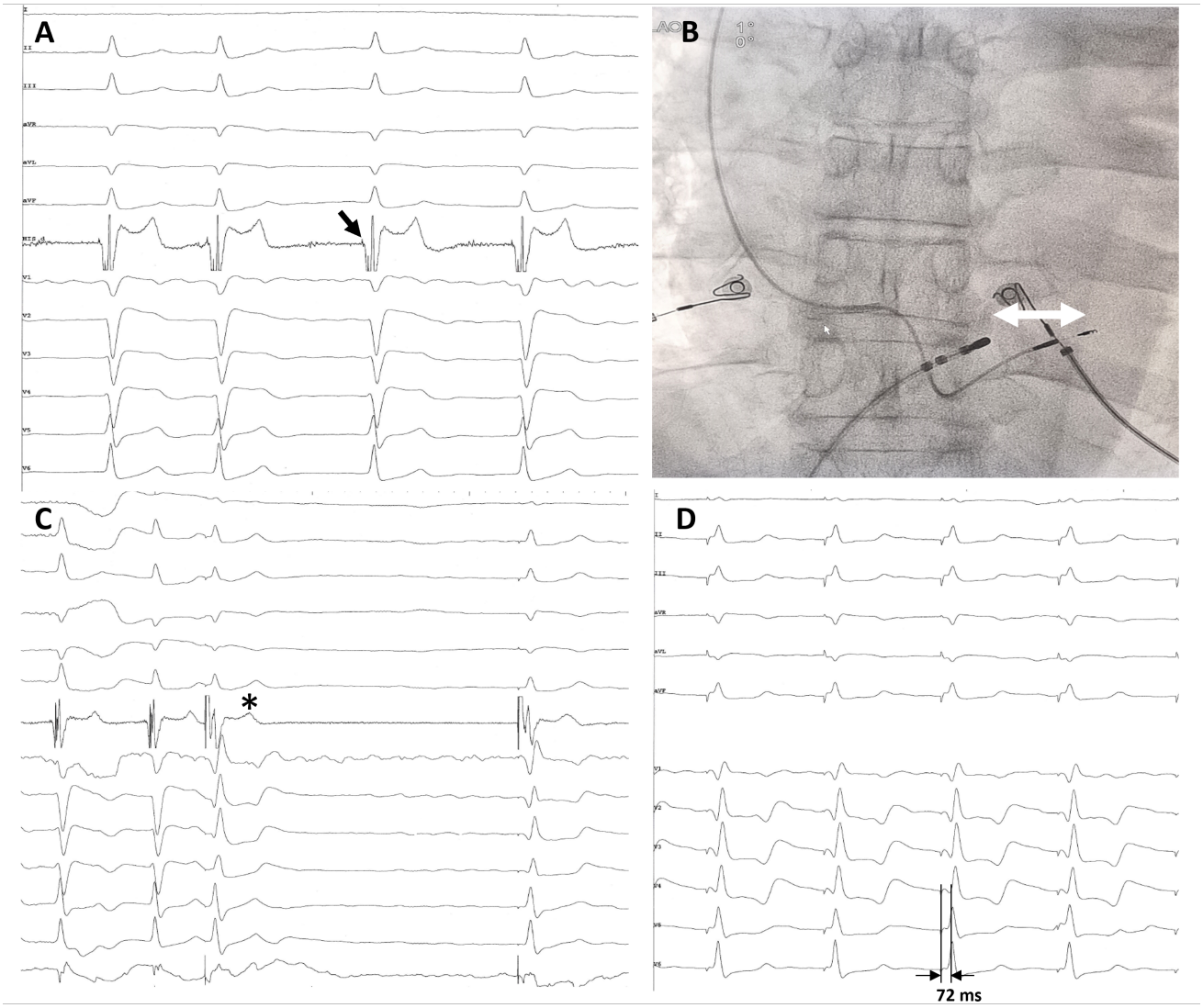


Figure 2 - A) After the lead penetrated the interventricular septum and reached the left endocardium, the intracardiac electrocardiogram recorded a fascicular potential (black arrow). B) PA fluoroscopic image showing the distance between the ablation catheter and the lead tip (double-headed white arrow). C) The moment when, during RF current application, AV block is achieved (asterisk). D) Final 12-lead ECG with a paced QRS of RBBB morphology and an LVAT of 72 ms. ECG recording speed - 49mm/s. PA, posteroanterior; RF, radiofrequency; ECG, electrocardiogram; RBBB, right bundle branch block; LVAT, left ventricular activation time.

tip, a sudden loss of capture of the HB was observed (Figure 1E). After retesting, a significant increase in the pacing threshold to 3 V was noted.

In this situation, we removed the lead from the HB position and advanced the assembly around 1-1.5 cm towards the apex of the right ventricle, followed by successful penetration of the interventricular septum to reach the left bundle branch (LBB) area where a fascicular potential was recorded (Figure 2A). Compared to HB pacing, a narrower LV activation time was obtained (72 mm vs. 95 mm), indicating that the lead was capturing the LBB distally from the HB level. The final position showed an excellent pacing threshold of 0.7 V at 0.4 msec pulse duration and sensing of 3.8 mV. Subsequently, with the lead out of the way (Figure 2B), AVN ablation was achieved after a single radiofrequency application (Figure 2C). The lead was connected to a VVIR pacemaker programmed at a rate of 80 bpm for the first month and at 70 bpm after that.

The post-procedural ECG showed a regular-paced rhythm with a narrow QRS complex of right bundle branch block morphology (Figure 2D).

The patient was discharged the next day, on optimal heart failure treatment (sacubitril/valsartan 24/26mg bid, spironolactone 25mg od, bisoprolol 10mg od, empagliflozin 10mg od, furosemide 40mg od). At the six-month follow-up, there was no recovery of AVN conduction. Device interrogation revealed stable pacing and sensing parameters, and there was a significant improvement in clinical status and echocardiographic parameters (LV function with EF of 50% and moderate mitral regurgitation).

Discussion

Two mechanisms are responsible for symptom development during permanent AF: high ventricular rate and total irregularity of the rhythm. Although not proven to reduce mortality in AF patients, drugs such as beta-blockers and digitalis are frequently used to control the resting and active heart rate.[2] Unfortunately, a significant proportion of patients remain symptomatic despite the combination of the two drugs.

Therefore, the recent guidelines for the diagnosis and management of AF gave a class IIa recommendation for AVN ablation and permanent pacing for heart rate control when pharmacological therapy is insufficient and rhythm control is unattainable. [3]

Two pacing strategies are currently recommended after AVN ablation. Biventricular pacing has the strongest evidence and has been shown to reduce mortality compared to medical treatment in patients with reduced ejection fraction and AF after junctional ablation.[4] Nevertheless, the procedure is not physiological and can induce dyssynchrony, especially in patients with narrow baseline QRS complexes. Although biventricular pacing is superior to right ventricular apical pacing for patients with AVN ablation, up to 30% of these patients do not respond favorably.[5] Moreover, there are instances when placing the LV lead in the coronary sinus for biventricular pacing is either unfeasible or unsuccessful due to difficult anatomies.

Physiological pacing mitigates the limitation of an altered ventricular activation in right ventricular or biventricular pacing, whether the final target is the HB or the LBB.

HB pacing is the most physiological pacing technique because it uses both bundle branches for fast and synchronous biventricular activation. The advantage of having a lead placed at the level of the HB is that it provides a very useful radiological landmark for AVN ablation. One of the first studies on the matter published by Vijayaraman et al. showed that most successful ablation sites were near the ring electrode.[6] However, as in our case, delivery in that area is sometimes unsuccessful, and sites closer to the lead tip are targeted. This may lead to acute increases in capture thresholds due to tissue injury directly under the lead tip. Although we continuously paced the HB during radiofrequency current application and stopped after the first non-captured electrical spike, we couldn`t avoid the significant increase in the pacing threshold. Another major disadvantage of HB pacing, even in successful cases, is the spontaneous increase in capture thresholds over time occurring in up to 25% of the patients, a potentially harmful situation since most patients will become pacemaker-dependent after AVN ablation.[7] This is why current guidelines recommend adding a right ventricular backup pacing lead in these patients.[8]

Before the introduction of LBBA pacing in clinical practice, we would have probably switched to biventricular pacing after the failure of HB pacing. Nowadays, the procedure can be saved, and the patient can still receive a physiological form of pacing by simply placing the lead through the interventricular septum approximately one to two centimeters downstream in the conduction system and pacing the LBBA. The major advantages of this approach are that there is no requirement for additional tools, the pacing and sensing thresholds are excellent, and there is a sufficient safety margin for AVN ablation without intercepting the paced area. In our case, after placing the LBBA pacing lead, AVN ablation was successful on the first attempt, probably because, without the fear of pacing failure, we ablated the distal part of the AVN or the initial part of the HB. Because the risk of threshold increase with LBBA pacing is minimal and the lead is very well fixed in the interventricular septum, there is no recommendation for placing a backup pacing lead.[8]

For the above reasons, many centers that took up physiological pacing perform mainly LBBA pacing. At our center, we still allow a few minutes of fluoroscopy to search for the HB electrogram. We accept this final position if it is successfully captured at very low thresholds (usually below 1 Volt) since we believe it is the best form of physiological pacing. Also, some physicians advocate a delay in AVN ablation, at least a month after the pacing procedure, to allow for stability assessment and maturation of the lead. Although we agree with these arguments for LBBA pacing, in the case of an HB pacing approach, the concern for tissue damage during ablation and loss of capture, as shown in our case report, determines us to conduct both cardiac pacing and AVN ablation in the same setting. Performing AVN ablation concomitantly with either pacing technique allows electrophysiologists to adapt their strategy based on real-time intraprocedural changes. Furthermore, this strategy has been proven feasible and safe in recently published studies.[9]

The patient showed significant improvement over follow-up in clinical and LV function evaluation. The explanation resides in the final result of the procedure, which addressed both harmful mechanisms of rapid conducting AF. The final rhythm provided by the pacemaker had a controlled rate, and most importantly, it was perfectly regular. Furthermore, physiological pacing resulted in a very narrow QRS complex, protecting the patient from iatrogenic dyssynchronous ventricular activation, which could have offset the benefits of rhythm regularization in time.

In a non-randomized on-treatment study comparing CSP and conventional pacing after AVN ablation, Vijayaraman et al. showed that, during a mean follow-up of 27 ± 19 months, the primary combined endpoint of time to death or HF hospitalizations was significantly reduced in CSP compared to conventional pacing (48% vs 62%, $p<0.01$).[10] Also, in a retrospective study, HB pacing was superior to biventricular pacing regarding post-implant QRS duration, implantation fluoroscopy times, reduction of indexed LV volumes, and improvement of LV ejection fraction.[11] Current ongoing randomized studies will probably determine the role of CSP and AVN ablation in patients with fast-conducting AF and HF.

Apart from general CIEDs implantation procedure-related complications, potential drawbacks of LBBA pacing would be concerns about lead dislodgements, late perforations to the LV cavity, and a significant increase in pacing threshold.

The key message of this paper is that the pace and ablate strategy is the most efficient in achieving rate control in patients with fast AF. CSP is the best approach to ensure LV synchronous activation and

contraction after AVN ablation. Mastering both HB and LBBA pacing techniques allows the physician to tailor the best physiological pacing option for each patient. When used in a complementary fashion, one procedure could provide for the limitations of the other. HB pacing could be the solution if the septum can't be penetrated or the LBBA is not reached. LBBA pacing is the solution if the HB is not identified during the fast AF rhythm or not captured at acceptable thresholds and if AVN ablation results in an acute increase in capture threshold due to damage of the HB beneath the lead tip.

Conclusion

Mastering both HB and LBBA pacing techniques offers the potential to overcome intraprocedural challenges and gives alternative strategies to achieve physiological pacing. These approaches can be used interchangeably based on the evolving dynamics of the procedure and the patient's specific needs.

Author Contributions

All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Written informed consent for the procedure and to publish this paper has been obtained from the patient.

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None.

Conflicts of Interest

The authors declare no conflict of interest.

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