Atrioventricular nodal ablation and left bundle branch pacing for treatment of refractory atrial fibrillation post alcohol septal ablation for hypertrophic obstructive cardiomyopathy

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Introduction
Alcohol septal ablation (ASA) is a minimally invasive therapeutic option for patients with symptomatic hypertrophic obstructive cardiomyopathy (HOCM) whereby nonsurgical reduction of the hypertrophied septum is induced via injection of ethanol into the first septal perforator. This improves symptoms through reduction of left ventricular (LV) outflow tract obstruction. Electrophysiological complications of this procedure include bradycardia and tachyarrhythmia, such as atrial fibrillation (AF).1 Refractory AF can be treated with ativoventricular (AV) nodal ablation and permanent pacemaker implantation.2 Newer pacing modalities have been developed that may improve patient outcomes, such as left bundle branch pacing (LBBP).3 This strategy has not previously been described in a patient who has undergone ASA. LBBP has been considered challenging in these patients, as ASA can cause fibrosis in the septal region of interest, which could theoretically lead to difficulties with lead implantation and subsequent successful capture.

Case report
An 83-year-old female patient was referred to the electrophysiology outpatient clinic complaining of exertional dyspnea and palpitations. Background history was significant for permanent AF with suboptimal rate control on medical therapy and HOCM, for which she had previously undergone ASA. Physical examination did not reveal signs of heart failure and symptoms correlated with poor rate control.

Baseline 12-lead electrocardiogram showed AF and left bundle branch block (LBBB) (Figure 1). Transthoracic echocardiogram showed hyperdynamic LV systolic function, mild-to-moderate mitral regurgitation, and no significant residual LV outflow tract gradient (value = 11 mm Hg). There was an implantable loop recorder in situ, which revealed 100% of time spent in AF. Symptoms were felt to be due to AF refractory to various combinations of rate/rhythm control pharmacotherapy. Catheter ablation was deemed unsuitable owing to a longstanding history of persistent AF and relatively advanced age. The decided therapeutic option was AV nodal ablation with permanent cardiac pacemaker implantation. In light of the baseline LBBB, and to reduce

KEY TEACHING POINTS
- Cardiac pacing is frequently indicated in patients with hypertrophic obstructive cardiomyopathy following alcohol septal ablation.
- Left bundle branch pacing offers a more physiologic pacing mechanism than classical right ventricular pacing and may improve outcomes in select patients.
- Our case report shows that left bundle branch pacing may be safe and feasible in patients who have undergone alcohol septal ablation, despite concerns over potential difficulties with lead implantation and capture.
the impact of ventricular dyssynchrony secondary to right ventricular (RV) pacing, LBBP was the preferred strategy. His bundle pacing (HBP) was another potential option for this patient. Late threshold rises and poor R-wave sensing have been noted with HBP, and as this patient would become

![Baseline electrocardiogram showing atrial fibrillation and left bundle branch block.](image1)

![Transesophageal echocardiography–guided lead implantation into interventricular septum for left bundle branch pacing (LBBP) location.](image2)
pacer-dependent following AV nodal ablation, LBBP was preferred. AV nodal ablation can also be challenging during HBP owing to the proximity of the ablation catheter to the implant site, which is another reason that LBBP was selected.

Implantation of a single-chamber Medtronic Azure (Minneapolis, MN) permanent pacemaker was performed under general anesthesia. Two C315 His sheaths were inserted via left axillary transvenous access with 3830 leads advanced under fluoroscopic guidance; the first to the AV node for His location, the second to left bundle pacing position with transesophageal echocardiography guidance (Figure 2). The His bundle was marked via unipolar pacing, and the lead was then advanced approximately 2 cm to the insertion point. Unipolar pacing showed right bundle branch block (RBBB) morphology in V1, and the other lead was then advanced while watching for movement of the mid-QRS notch in RBBB morphology to an R prime position in V1. Lead impedance was monitored closely to detect potential perforation into the LV cavity.

Pace mapping was used to confirm location with nonselective left bundle branch pacing (Supplemental Figure A). Our criteria for selective pacing are initial RBBB morphology in V1 with movement of mid-QRS notch to R prime (as above). Nonselective pacing showed a QR morphology in V1. Lead impedance was monitored closely to detect potential perforation into the LV cavity.

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Follow-up device check at 8 weeks postimplant was satisfactory with threshold 0.75 V @ 0.4 ms, impedance 627 Ω, and sensing 20 mV. The patient therefore underwent successful AV nodal ablation approximately 8 weeks post-LBBP implantation without complication. Subsequent device check at 6 months postprocedure showed stable threshold (0.75 V), impedance (628 Ω), and sensing (20 mV) values with 99.9% ventricular pacing and no intrinsic ventricular sensing, indicating a successful AV node ablation procedure without any compromise of LBBP. Her 12-lead electrocardiogram at this point is displayed in Figure 3.

Discussion

Patients with HOCM have a 4–6 times increased risk of AF. It may also develop post-ASA, with 1 study showing an incidence of 7%–8% in patients who did not have documented preprocedural AF. This leads to increased morbidity and mortality in HOCM patients. In cases of AF where pharmacological rate and/or rhythm control is ineffective or intolerable, AV nodal ablation and permanent pacemaker implantation can be considered, as supported by the recently updated ESC guidelines on the management of AF. This strategy has been shown to be effective in prior studies such as the Ablate and Pace and AIRCRAFT trials.
Classical RV apical pacing can worsen patient outcomes over time by causing dyssynchronous ventricular activation and pacing-induced cardiomyopathy, leading to an increased risk of heart failure and arrhythmia. Cardiac resynchronization therapy (CRT) uses biventricular pacing to avoid this problem and has been shown in multiple trials to improve outcomes for certain patients with heart failure. The Post-AV Nodal Evaluation (PAVE) study provided improved functional outcomes over RV pacing when used after AV nodal ablation for treatment of refractory AF. Drawbacks of CRT include procedural difficulty and complications, the inherent nonphysiological mechanism, and the incidence of “nonresponders.” This has led to the development of more physiological pacing strategies such as HBP.

Studies have shown the benefit of HBP over RV and biventricular pacing, as well as its feasibility and efficacy post-AV nodal ablation. Results of other studies, however, such as the His-SYNC Trial, have been less convincing. Approximately one-half of patients with LBBB could not normalize their QRS duration, and this recurring issue may be better targeted by LBBP. A recent study directly compared HBP and LBBP in 251 patients and found that the latter modality showed similar paced QRS durations and success rates to HBP but with shorter procedural and fluoroscopy times and better pacing parameters, including lower capture thresholds.

A recent multicenter prospective study showed LBBP to be a safe, feasible, and effective alternative to HBP across a range of indications, of which refractory AF accounted for 10%. The procedure for LBBP has been well described, consisting of standard transvenous access with subsequent transseptal lead implantation into the LV subendocardium in the left bundle branch region. Upon screw advancement and lead deployment under fluoroscopic guidance, the electrocardiography pattern will be observed to change to RBBB morphology.

Our literature review did not find any prior cases where LBBP has been attempted following ASA. ASA can lead to fibrosis in the septal region of interest in LBBP implantation, which could theoretically make lead deployment difficult and increase the chance of failure and/or complications. In our case, despite this potential difficulty, successful LBBP implantation was achieved. Limitations include that, owing to this being a relatively novel procedure, the long-term effects have not yet been fully elucidated in large randomized trials, and our capacity for long-term follow-up was also limited as a result.

Conclusion
This case shows that LBBP may be a safe and feasible option with AV nodal ablation for treatment of refractory AF in HOCM patients who have undergone ASA.

Appendix
Supplementary data
Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.08.005.

References
1. Moss TJ, Zipse MM, Krantz MJ, Sauer WH, Salcedo EE, Schuller JL. Incidence of atrial fibrillation following alcohol septal ablation for hypertrophic cardiomyopathy. Ann Noninvasive Electrocardiol 2016;21:443–449.
2. Hirshikas G, Potpara T, Dages N, et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association of Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC). Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J 2021;42:373–498.
3. Zhang S, Zhou X, Gold MR. Left bundle branch pacing. J Am Coll Cardiol 2019;74:3039.
4. Kay GN, Ellenbogen KA, Giudici M, et al. The Ablate and Pace Trial: a prospective study of catheter ablation of the AV conduction system and permanent pacemaker implantation for treatment of atrial fibrillation. APT Investigators. J Interv Card Electrophysiol 1998;2:121–135.
5. Lim KT, Davis MJ, Powell A, et al. Ablate and pace strategy for atrial fibrillation: long-term outcome of AIRCRAFT trial. Europace 2007;9:498–505.
6. Moss AJ, Hall WI, Cannon DS, et al. Cardiac-resynchronization therapy for the prevention of heart-failure events. N Engl J Med 2009;361:1329–1338.
7. Curtis AB, Worley SJ, Adamson PB, et al. Biventricular pacing for atroventricular block and systolic dysfunction. N Engl J Med 2013;368:1585–1593.
8. Doshi RN, Daoed EG, Fellows C, et al. Left ventricular-based cardiac stimulation post AV nodal ablation evaluation (the PAVE study). J Cardiovasc Electrophysiol 2005;16:1160–1165.
9. Abdulrahman M, Subzposh FA, Beer D, et al. Clinical outcomes of His bundle pacing compared to right ventricular pacing. J Am Coll Cardiol 2018;71:2319–2330.
10. Arnold AD, Shun-Shin MJ, Keene D, et al. His resynchronization versus biventricular pacing in patients with heart failure and left bundle branch block. J Am Coll Cardiol 2018;72:3112–3122.
11. Wang S, Wu S, Xu L, et al. Feasibility and efficacy of His bundle pacing or left bundle pacing combined with atrioventricular node ablation in patients with persistent atrial fibrillation and implantable cardioverter-defibrillator therapy. J Am Heart Assoc 2019;8:e014253.
12. Upadhyay GA, Vijayaraman P, Nayak HM, et al. His corrective pacing or biventricular pacing for cardiac resynchronization in heart failure. J Am Coll Cardiol 2019;74:157.
13. Hua W, Fan X, Li X, et al. Comparison of left bundle branch and His bundle pacing in bradycardia patients. JACC Clin Electrophysiol 2020;1175.
14. Pudala SK, Master VM, Terricabras M, et al. Initial experience, safety, and feasibility of left bundle branch area pacing. JACC Clin Electrophysiol 2020;1241.
15. Huang W, Chen X, Su L, Wu S, Xia X, Vijayaraman P. A beginner’s guide to permanent left bundle branch pacing. Heart Rhythm 2019;16:1791–1796.