CASE REPORT

Role of cardiac event monitor in the detection of delayed high-grade atrioventricular block after negative electrophysiological study in patients with post–transcatheter aortic valve replacement

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Introduction

The first transcatheter aortic valve replacement (TAVR) device was approved in 2011. According to a report from the Society of Thoracic Surgeons/American College of Cardiology TVT registry, more than 276,000 TAVR procedures were performed since approval of the device.[1] One of the most common complications of TAVR is the development of conduction abnormalities after valve deployment. Despite technological advances in the procedure and improvement in operators' experience, conduction disturbances including high-grade atrioventricular block (HG AVB) are considered the most common complication.[2] Approximately, 15% of TAVR patients require a permanent pacemaker (PPM) because of HG AVB after the procedure.[3] The deployed TAVR valve can cause conduction abnormalities through damage to the atrioventricular (AV) node, His bundle, or infrahisian system.

Delayed HG AVB is defined as HG AVB that occurs more than 2 days after TAVR or after hospital discharge.[3] The percentage of patients requiring a PPM after TAVR has remained consistent since the start of its commercial use. The notable change lies in the demographic requiring the pacemaker—inpatient vs outpatient—because of the trend toward early discharge after TAVR.[4] A 30-day event monitor is recommended to detect patients in need of a PPM. Identifying those at higher risk for developing HG AVB after discharging post-TAVR is crucial for patient safety. Electrophysiological study (EPS), the day after post-TAVR, has emerged as a potential risk assessment method for earlier detection of HG AVB before hospital discharge.[5,6] The role of EPS after TAVR to guide PPM has not been studied in a randomized prospective clinical trial. The 2020 American College of Cardiology expert consensus document on the management of conduction disturbances in patients undergoing TAVR suggests a potential role for EPS in patients with new left bundle branch block (LBBB), new right bundle branch block (RBBB), old or new LBBB with an increase in PR duration >20 ms, an isolated increase in PR duration ≥40 ms, an increase in QRS duration ≥22 ms in sinus rhythm, and atrial fibrillation with a ventricular response <100 bpm in the presence of old or new LBBB.[3]

Ambulatory electrocardiographic (ECG) monitoring has been recommended to detect delayed HG AVB post-TAVR. The European Society of Cardiology 2021 guidelines recommend ambulatory ECG monitoring or EPS for patients who develop persistent new LBBB with QRS >125 ms or PR >240 ms with no further prolongation during >48 hours after TAVR procedure as a Class IIa recommendation. In addition, they recommend ambulatory ECG monitoring or EPS as a Class IIb recommendation for patients with pre-existing conduction abnormality and prolongation of QRS (>20 ms) or PR (>20 ms).[7]

We present 3 cases of HG AVB after TAVR procedures and negative EPS. The patients developed HG AVB on ambulatory ECG monitoring and required PPM implantation.

Case reports

Patient 1

A 94-year-old woman with a history of severe aortic valve stenosis, severe mitral valve stenosis, hypertension, and hyperlipidemia underwent a TAVR procedure with a 23-mm SAPIEN Ultra valve (Edwards Lifesciences Corporation, Irvine, CA). She developed transient complete heart block (<1 minute) during the procedure. Furthermore, the patient had a new-onset LBBB (QRS 142 ms) after the procedure. She was observed for 24 hours on inpatient telemetry with no significant abnormalities. EPS performed the next day showed normal AH (90 ms), His-ventricular (HV)

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KEY FINDINGS

- The development of high-grade atrioventricular block (HG AVB) remains a significant complication post–transcatheter aortic valve replacement (TAVR), with an incidence of 10%–15% in patients monitored after the procedure.
- Most post-TAVR conduction disturbances, including HG AVB, occur within the first 30 days of the procedure, although delayed-onset cases have been reported.
- Patients with new-onset left bundle branch block or pre-existing right bundle branch block would benefit from long-term ambulatory event monitoring despite negative electrophysiological study (EPS) results because some cases of HG AVB are detected months after the procedure
- EPS has limited diagnostic accuracy, especially in older patients, and may not reliably predict HG AVB risk post-TAVR, thus highlighting the need for additional monitoring, such as ambulatory event monitoring or implantable loop recorder, to detect late-onset conduction disturbances in high-risk patients.

(39 ms) intervals, normal AV nodal Wenckebach cycle length (370 ms), and no infrahisian block. She was discharged home with a 30-day cardiac event monitor. After discharge, the patient experienced intermittent episodes of HG AVB, including 4:1 block, on day 8 post-TAVR. The patient and her family were immediately contacted, and she was taken to the local hospital for placement of a PPM.

Patient 2

An 87-year-old woman with a history of severe aortic valve stenosis, heart failure with preserved left ventricular ejection fraction (55%), type 2 diabetes mellitus, hypertension, and end-stage renal disease on hemodialysis underwent a TAVR procedure with a 23-mm SAPIEN 3 Ultra valve. A few months before the TAVR, she had undergone AV valvuloplasty and developed first-degree AV block (220 ms) and LBBB (QRS 152 ms). Follow-up 30-day cardiac event monitor did not show any episodes of HG AVB. The TAVR procedure was uneventful, with no change of her baseline LBBB and first-degree AV block. She was observed on telemetry for 24 hours after the procedure, with no significant events noted. EPS performed 48 hours after the TAVR showed upper normal AH (131 ms) and HV (61 ms) intervals, normal AV nodal Wenckebach cycle length (450 ms) (Figures 1A and 1B), and no infrahisian block. The patient was discharged home with a 30-day cardiac event monitor 24 hours after her EPS. Inpatient cardiac telemetry did not show any abnormalities after the EPS. Two weeks later, she was admitted to the intensive care unit with hypoxic respiratory failure. During her hospital stay (day 24 post-TAVR), she developed sustained complete AV block requiring emergent transvenous pacemaker (Figure 1C). The patient received a leadless pacemaker the following day. She was discharged in stable condition.

Patient 3

A 93-year-old man with a history of severe aortic stenosis, abdominal aortic aneurysm status post–endovascular aneurysm repair (EVAR), hypertension, hyperlipidemia, and chronic kidney disease stage 3b underwent a TAVR procedure with a 26-mm SAPIEN 3 valve. ECG performed before the procedure showed normal sinus rhythm with complete RBBB pattern. During the procedure, he developed transient complete heart block for 5 minutes immediately after valve deployment. A temporary lead was placed. The patient was back in sinus rhythm with his baseline RBBB. He was observed on telemetry for 24 hours, with no significant events. Subsequent EPS demonstrated normal AH (95 ms) and HV (46 ms) intervals, normal AV nodal Wenckebach (513 ms) (Figures 2B and 2C), and no infrahisian block. The patient was discharged home with a 30-day event monitor. Five days later (day 7 post-TAVR), he developed several back-to-back episodes of HG AVB (4:1 and 5:1 AVB) (Figure 2C). He was admitted for a leadless pacemaker insertion. The patient was discharged home in stable condition.

Discussion

The development of HG AVB after TAVR remains one of the most significant complications of TAVR procedures. We present the cases of 3 patients at our hospital who developed HG AVB within 30 days of the TAVR procedure. Our patients had different conduction system abnormalities, such as intraprocedural transient complete heart block, pre-existing RBBB, pre-existing LBBB, and new-onset LBBB.

In a study that evaluated the utility of ambulatory event monitoring in identifying delayed HG AVB, Ream et al[8] reported a 10% (12/118 patients with monitoring data) incidence of delayed HG AVB among patients who underwent TAVR. Moreover, they found that patients with RBBB, either at baseline or after TAVR, had a 26-fold increased odds of developing HG AVB.[8] One of our reported patients (patient 3) had complete RBBB before the TAVR procedure. Despite a negative EPS, the patient had intermittent HG AVB on a 30-day monitor. Our case series presents a high-risk group of patients with pre-existing (RBBB), intraprocedural (transient complete heart block), or postprocedural (persistent LBBB) conduction abnormalities. These patients would benefit from ambulatory event monitoring despite a negative EPS.

The majority of post-TAVR conduction disturbances occur within 30 days of valve implantation. However, cases of delayed post-TAVR HG AVB occurring several months after the procedure have been reported.[9,10] Despite being relatively rare, very delayed post-TAVR HG AVB can have grave consequences. A study evaluating the role of intracardiac monitoring in detecting HG AVB in patients

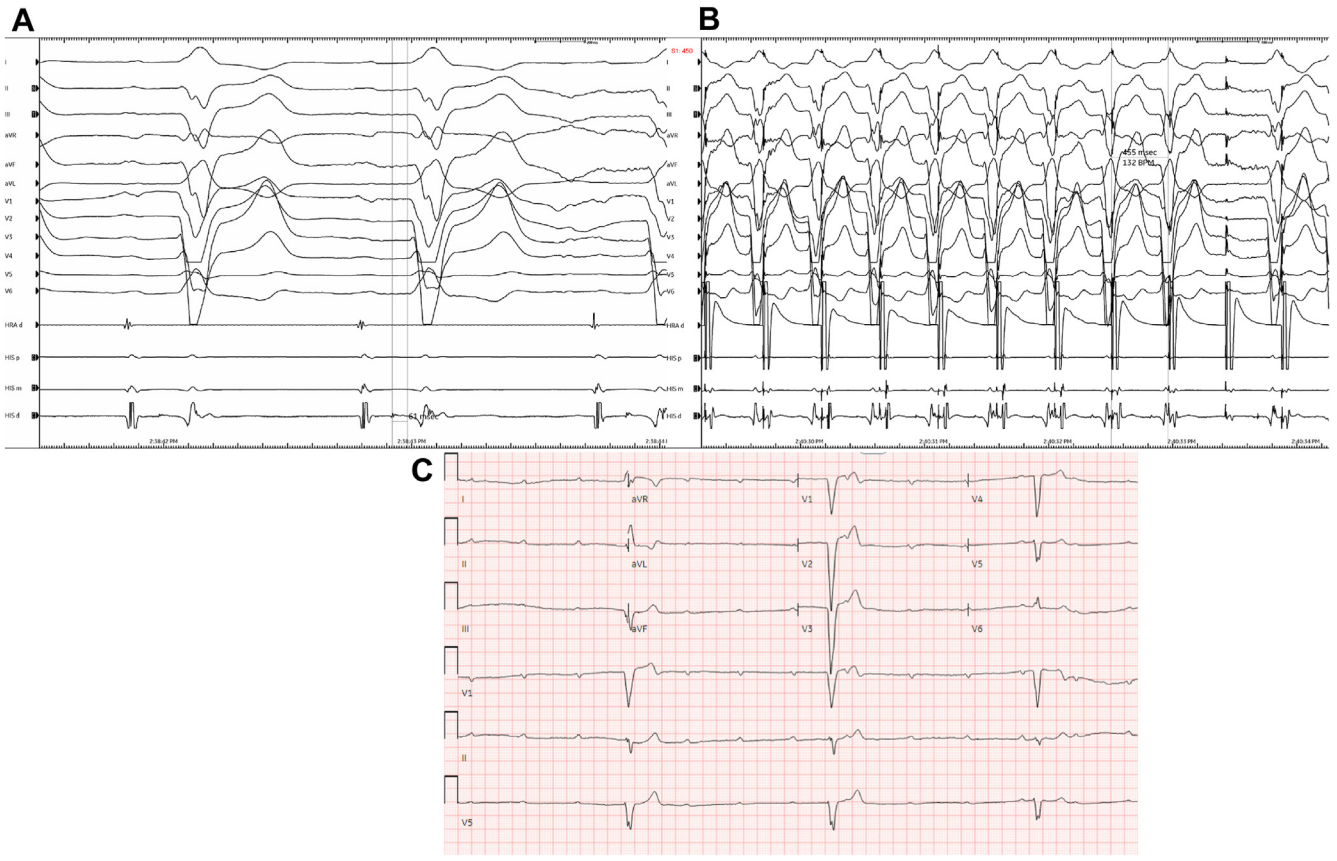

Figure 1 Baseline electrophysiological study **(A),** atrioventricular nodal Wenckebach **(B),** and 12-lead electrocardiogram showing high-grade atrioventricular block **(C)** in patient 2.

with new-onset persistent LBBB found that most HG AVB cases occurred in the early post-TAVR phase (50% within the first month and 80% within 4 months) with only 1 event after 12 months.[11] There might be a subset of patients with periprocedural conduction abnormalities (such as post-TAVR LBBB or pre-existing RBBB) who would benefit from long-term intracardiac monitoring despite a negative EPS and negative 30-day monitoring.

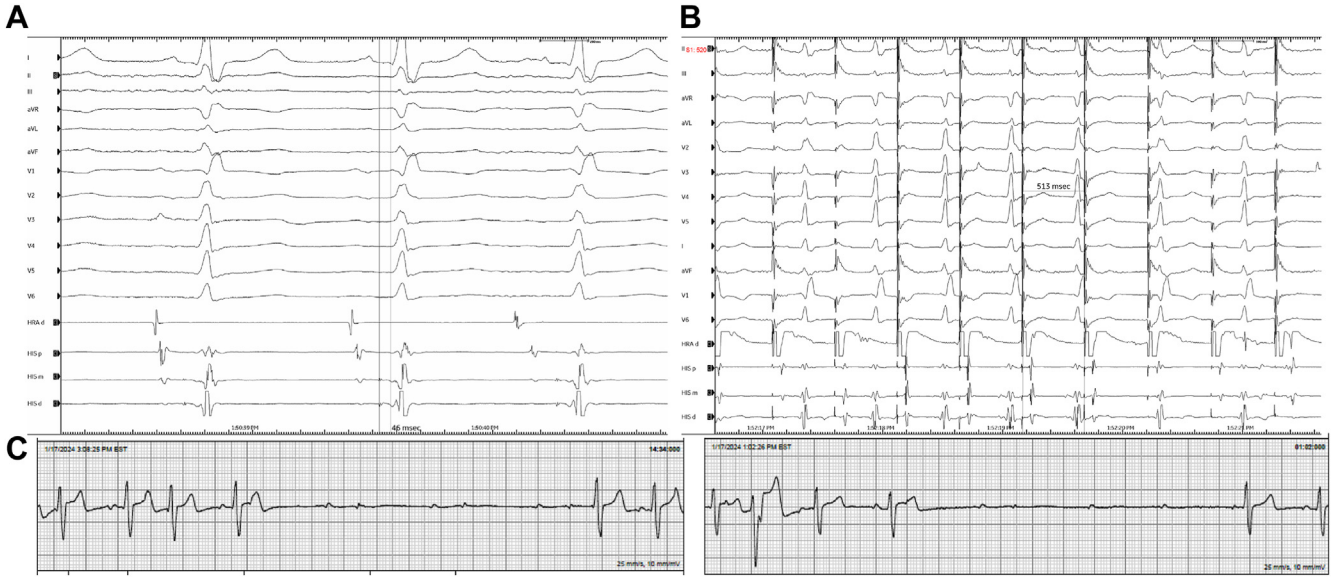

Figure 2 Baseline electrophysiological study **(A),** atrioventricular nodal Wenckebach **(B),** and high-grade atrioventricular block on ambulatory electrocardiographic tracings **(C)** in patient 3.

There has been a shifting trend in the timing of PPM implantation in patients undergoing TAVR. A study evaluated the trends in PPM implantation during index TAVR hospitalization and during a subsequent hospitalization after TAVR.[4] Mazzella et al[4] found a trend of decreased length of stay for the index TAVR hospitalization from 2012 to 2017. Moreover, they observed an increase in the proportion of PPM implants during a subsequent hospitalization after discharge from TAVR. This trend is suggestive of a growing cohort of patients at high risk for adverse complications as outpatients. These data shed light on the importance of outpatient rhythm monitoring after discharge from TAVR hospitalization.

Two of our reported patients had intraprocedural temporary complete heart block. Patient 1 had a short episode that lasted <1 minute, and patient 2 had an episode that lasted for 5 minutes. Both patients recovered their AV conduction and had no more episodes of HG AVB on 24-hour telemetry monitoring. There is an increased association between the development of intraprocedural transient HG AVB and the incidence of later sustained HG AVB requiring PPM implantation. El-Sabawi et al[12] examined the temporal incidence and predictors of HG AVB after TAVR. They evaluated 953 patients who underwent TAVR between February 2012 and June 2019. Of those patients, 10.5% (100 patients) had intraprocedural HG AVB. Of the 100 patients, 40 developed transient HG AVB. Six of these patients had a PPM placed prophylactically because of concern of HG AVB recurrence. Among the remaining patients, 16 of 34 (47.1%) had HG AVB within 30 days. Of those patients, 68.8% (11 patients) had RBBB on their pre-TAVR ECG ($P = .04$).[12] These data show that patients who develop transient intraprocedural HG AVB are at higher risk for delayed HG AVB. Our data demonstrate that patients with pre-existing RBBB, new-onset LBBB, or transient intraprocedural AV block are at higher risk for HG AVB despite a negative EPS closer to discharge. It could be that EPS, within 24 hours of discharge, is too early to detect delayed intervals associated with HG AVB.

Multiple studies have evaluated the role of EPS in patients with post-TAVR conduction abnormalities. A study by Badertscher et al[13] assessed 107 patients undergoing TAVR who had new-onset LBBB via HV interval measurement pre- and post-valve deployment the day after TAVR. Of the 107 patients, 50% (53 patients) developed new-onset LBBB post–valve deployment, and infranodal conduction delay was found in 45% (24 patients) during the procedure. In patients with new-onset LBBB and no infrahisian conduction delay, the HV interval did not prolong in the EPS performed the following day. During 30-day follow-up, 1 patient with new LBBB and a normal HV interval after TAVR developed new HG AVB.[13] These data represent a single-center experience with the utility of EPS in patients who developed post-TAVR LBBB. Our presented patients demonstrate the heterogeneity of periprocedural TAVR conduction abnormalities, which can challenge the utility of standard periprocedural invasive electrophysiological testing.

In a prospective study that aimed to determine the utility of pre- and post-TAVR HV interval in risk stratification of post-TAVR HG AVB, Raad et al[5] included 121 patients undergoing EPS before and after TAVR. The incidence of HG AVB was 10% (12 patients). Baseline RBBB, new persistent LBBB, implant depth >4 mm, and post-TAVR HV interval ≥65 ms were associated with high risk of post-TAVR HG AVB. Additionally, there was no association between pre-TAVR HV interval and the development of HG AVB after TAVR.[5]

In another study that evaluated the safety and efficacy of EPS (24 hours after TAVR) in patients with LBBB after TAVR or a pre-existing LBBB, Knecht et al[14] used an HV interval (>55 ms) as a cutoff for PPM implantation. They divided the cohort into 2 groups: patients with prolonged HV interval requiring PPM implantation after TAVR; and patients without a prolonged HV interval who were discharged on an implantable loop recorder. HG AVB occurred in 4 of the 41 patients in the implantable loop recorder group (10%) compared to 8 of the 15 patients in the pacemaker group (53%). Two of the cases of delayed HG AVB occurred in TAVR patients with SAPIEN 3 valves (the first patient developed HG AVB 3 days after TAVR and the second patient 158 days after TAVR).[14] This study suggests that a significant number of patients with underlying conduction system disease develop HG AVB despite a normal HV interval on EPS. Similar to our presented patients, there is a need for further risk stratification of patients who develop periprocedural TAVR conduction abnormalities.

Multiple studies and meta-analyses have shown an increased association of HG AVB with self-expanding valves compared to balloon-expandable valves.[15] All of our patients received balloon-expandable valves, which are the valves most commonly used at our institution.

EPS has limited diagnostic accuracy in the assessment of syncope, especially in older patients.[16] We report a cohort of older patients with a mean age of 91 years. It is possible that EPS has a reduced negative predictive value when performed in older patients post-TAVR. Additionally, EPS was not performed with pharmacologic testing using flecainide or procainamide, which could have unmasked underlying conduction disturbances.[17]

Conclusion

Our cases highlight the importance of post-discharge rhythm monitoring to detect late-onset HG AVB post-TAVR after negative EPS and 24–48 hours of telemetry monitoring. Negative EPS might not eliminate the need for ambulatory event monitors to detect late-onset HG AVB post-TAVR that requires emergent PPM. Currently, there is lack of prospective randomized data evaluating the role of monitoring after negative EPS in the management of patients with conduction system abnormalities after a TAVR procedure. Our cases demonstrate the heterogeneity in the presentations of patients with post-TAVR abnormalities, which speaks to the potential of individualizing the management of those patients. An invasive EPS might not be a "one size fits all" for all TAVR-related conduction abnormalities.

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Patient Consent: Consent was obtained from patients involved in this study.

Ethics Statement: The research reported in this article adhered to CARE case report guidelines.

References

1. Glenn K. Report finds TAVR is dominant form of aortic valve replacement, outcomes steadily improving in the United States. Data from the STS/ACC TVT Registry Provides Insights on 'State of TAVR in the United States November 16, 2020. Available at: https://www.acc.org/about-acc/press-releases/2020/11/16/18/53/report-finds-tavr-is-dominant-form-of-aortic-valve-replacement-outcomes-steadily-improving-in-the-us. Accessed April 24, 2024.
2. Grover FL, Vemulapalli S, Carroll JD, et al. 2016 annual report of the Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy Registry. J Am Coll Cardiol 2017;69:1215–1230.
3. Lilly SM, Deshmukh AJ, Epstein AE, et al. 2020 ACC expert consensus decision pathway on management of conduction disturbances in patients undergoing transcatheter aortic valve replacement: a report of the American College of Cardiology Solution Set Oversight Committee. J Am Coll Cardiol 2020; 76:2391–2411.
4. Mazzella AJ, Hendrickson MJ, Arora S, et al. Shifting trends in timing of pacemaker implantation after transcatheter aortic valve replacement. JACC Cardiovasc Interv 2021;14:232–234.
5. Raad M, Greenberg J, Altawil M, et al. The transcatheter aortic valve replacement-conduction study: the value of the his-ventricular interval in risk stratification for post-TAVR atrioventricular-block. Structural Heart 2024;100296.
6. Reiter C, Lambert T, Kellermair J, et al. Delayed total atrioventricular block after transcatheter aortic valve replacement assessed by implantable loop recorders. JACC Cardiovasc Interv 2021;14:2723–2732.
7. Iliodromitis K, Deftereos SG, Bogossian H. 2021 ESC guidelines on cardiac pacing and cardiac resynchronization: what is the correct level of evidence for the superiority of cephalic vein cutdown? C, B or maybe A? Europace 2022;24:697.
8. Ream K, Sandhu A, Valle J, et al. Ambulatory rhythm monitoring to detect late high-grade atrioventricular block following transcatheter aortic valve replacement. J Am Coll Cardiol 2019;73:2538–2547.
9. Patel S, Jamoor K, Khan A, et al. Late onset complete heart block after transcatheter aortic valve replacement treated with permanent his-bundle pacing. Pacing Clin Electrophysiol 2021;44:194–198.
10. Chopra N, Tong MS, Yakubov SJ. Very late occurrence of complete heart block without preexisting atrioventricular conduction abnormalities: a rare complication after transaortic valvular replacement. HeartRhythm Case Rep 2017;4:77–81.
11. Rodés-Cabau J, Urena M, Nombela-Franco L, et al. Arrhythmic burden as determined by ambulatory continuous cardiac monitoring in patients with new-onset persistent left bundle branch block following transcatheter aortic valve replacement: the MARE study. JACC Cardiovasc Interv 2018;11:1495–1505.
12. El-Sabawi B, Welle GA, Cha YM, et al. Temporal incidence and predictors of high-grade atrioventricular block after transcatheter aortic valve replacement. J Am Heart Assoc 2021;10:e020033.
13. Badertscher P, Knecht S, Spies F, et al. Value of periprocedural electrophysiology testing during transcatheter aortic valve replacement for risk stratification of patients with new-onset left bundle-branch block. J Am Heart Assoc 2022;11:e026239.
14. Knecht S, Schaer B, Reichlin T, et al. Electrophysiology testing to stratify patients with left bundle branch block after transcatheter aortic valve implantation. J Am Heart Assoc 2020;9:e014446.
15. Siddiqui SA, Kazemian S, Gupta T, et al. Outcomes of transcatheter aortic valve replacement using third-generation balloon-expandable versus self-expanding valves: a meta-analysis. J Soc Cardiovasc Angiography Interv 2024;:102146.
16. Sheldon RS, Lei LY, Solbiati M, et al. Electrophysiology studies for predicting atrioventricular block in patients with syncope: a systematic review and meta-analysis. Heart Rhythm 2021;18:1310–1317.
17. Roca-Luque I, Francisco-Pasqual J, Oristrell G, et al. Flecainide versus procainamide in electrophysiological study in patients with syncope and wide QRS duration. JACC Clin Electrophysiol 2019;5:212–219.