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Recovery of atrioventricular conduction after transcatheter aortic valve replacement: A single center experience

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ABSTRACT

Introduction: Limited data are available on long-term changes in the conduction system following transcatheter aortic valve implantation (TAVI).
Objective: To assess atrioventricular (AV) conduction changes after TAVI and examine the relationship between pacemaker (PM)-derived parameters and surface ECG findings.
Methods: We retrospectively analyzed patients who underwent PM implantation after TAVI between July 2014 and June 2023. Demographic, imaging, procedural, and ECG data were collected. A dedicated follow-up (FU) visit, including device interrogation and a 12-lead ECG recorded during temporary VVI pacing at 30 bpm, was performed on average 1.7 ± 1.3 years post-implant. Based on FU ECGs, patients were classified as having persistent (persAVB) or regressive AV block (regrAVB).
Results: Among 377 TAVI procedures, 33 PM implantations (8.7%) were performed at a mean of 5.7 days after the procedure. Indications included third-degree AV block in 27 (81%), second-degree AV block in 3 (9%), and significant bradycardia in 3 (9%). FU ECGs were available for 14 patients; 7 (50%) showed conduction recovery. Baseline QRS duration was significantly wider in persAVB than in regrAVB (107.1 ± 27.3 ms vs. 80.7 ± 1.6 ms; $p = 0.038$). Median right ventricular pacing (RVp) burden was substantially higher in persAVB (100% [IQR 98.8–100%]) compared with regrAVB (0% [IQR 0–2.5%]; $p < 0.001$). Pacemaker dependency was present in 28% of persAVB patients and in none of the regrAVB group.
Conclusions: A substantial proportion of patients showed recovery of AV- conduction over time, particularly those without pre-existing conduction disturbances. The degree of RVp closely reflected conduction recovery status during follow-up.

1. Introduction

Transcatheter aortic valve replacement (TAVI) was initially developed for high-risk patients with severe aortic stenosis. However, due to the expansion of practical and theoretical knowledge accumulated since its introduction, it has become increasingly used in lower risk populations as well [1,2]. Despite advances in device design and procedural techniques, conduction disturbances requiring pacemaker (PM) implantation remain among the most frequent complications, especially for self-expanding valve deployment (17-25%) [3]. The long-term reversibility of these changes is still not fully understood [4–6]. This article explores long-term changes in the conduction system post-TAVI, focusing on correlating pacemaker parameters with surface ECG changes.

2. Methods

2.1. Study population

We retrospectively collected baseline demographic, clinical, and follow-up (FU) data of patients who underwent PM implantation after TAVI at University of Szeged between 01.07.2014 and 20.06.2023, with special attention to long-term pacing requirements and changes in the 12-lead surface ECG. Patients with pre-existing PM or ICD devices, and those who developed PM indication more than 30 days after TAVI, were excluded from the study population. Late-onset conduction disturbances occurring beyond 30 days post-procedure are generally considered less likely to be directly related to TAVI, as most device-related conduction abnormalities emerge during the peri-procedural or early post-

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procedural phase and may instead reflect progression of underlying conduction system disease [7].

2.2. TAVI procedure

All TAVI procedures were performed according to current European Society of Cardiology/European Association of Cardio-Thoracic Society recommendations for severe symptomatic aortic stenosis. The transfemoral approach served as the standard access, while alternative routes (transaxillary or transapical) used when necessary. Pre-procedural multislice CT was routinely performed to evaluate annular dimensions and vascular anatomy.

Predominantly self-expanding valves (Medtronic CoreValve, Evolut R/PRO, Medtronic, Minneapolis, MN, USA) were implanted, while balloon-expandable devices (Edwards Sapien XT/S3, Edwards Lifesciences, Irvine, CA, USA) were used in selected anatomies. Valve positioning was guided by fluoroscopy and transoesophageal/transthoracic echocardiography, with rapid ventricular pacing applied during balloon valvuloplasty or valve deployment when required. Postprocedurally, continuous ECG and hemodynamic monitoring were performed for ≥72 h.

2.3. Indication for PM implantation and programming

The indication for permanent PM implantation and device selection followed current European Society of Cardiology guidelines [8]. Pacing requirement was assessed by continuous telemetry and daily ECG recordings after TAVI. Implantation was indicated in patients with persistent or intermittent complete or Mobitz II. second-degree atrioventricular (AV) block not resolving within 48–72 h post-procedure. Prolonged PR interval or new-onset left bundle branch block (LBBB) alone did not constitute an indication. In selected cases, invasive electrophysiological evaluation was performed, and pacing was considered when a markedly prolonged HV interval (>70 ms) or infra-His block was documented in association with symptoms.

Device type was determined according to underlying rhythm and left ventricular function. Single-chamber VVI systems were implanted in patients with permanent atrial fibrillation, and dual-chamber DDD systems in those with sinus rhythm and AV conduction disorders. In patients with reduced left ventricular ejection fraction (≤35%), biventricular devices (CRT-P or CRT-D) were implanted as indicated. Conduction system pacing (left bundle branch area pacing) was performed in selected cases as an alternative to conventional right ventricular pacing.

Devices from Medtronic (Medtronic plc, Minneapolis, MN, USA), Abbott (Abbott Laboratories, Abbott Park, IL, USA), and Biotronik (BIOTRONIK SE & Co. KG, Berlin, Germany) were used. In all VVI and DDD systems, manufacturer-specific algorithms minimizing unnecessary right ventricular pacing (e.g., Managed Ventricular Pacing™, Search AV+™, or IRSplus) were routinely activated.

2.4. Follow-up

After hospital discharge, pacemaker follow-up was scheduled at 6 weeks, 6 months, and annually thereafter. PM dependency and right ventricular pacing (RVp) percentage were routinely assessed during each visit. PM dependency was defined as the absence of intrinsic ventricular activity during temporary VVI pacing at 30 beats per minute.

As part of our protocol, a follow-up 12-lead ECG was recorded during temporary VVI 30/min pacing to assess conduction abnormalities and intrinsic QRS morphology.

Based on the findings of these FU ECGs, patients were categorized into two groups according to the persistence or recovery of AV conduction:

- Persistent AV block (persAVB): sustained third-degree AV block at FU, requiring continuous ventricular pacing.
- Regressive AV block (regrAVB): complete or partial recovery of AV conduction, defined by either the absence of AV block or the presence of only first-degree AV block on the FU ECG.

Clinical follow-up data, including re-hospitalizations and mortality, were obtained from the institutional electronic medical records and supplemented by structured telephone interviews with patients.

2.5. Study outcomes

The primary outcome of the study was the persistency or regression of atrioventricular block (AVB) following pacemaker implantation after TAVI, as determined by follow-up 12-lead ECGs and device interrogations. In addition, the study aimed to identify clinical, procedural, and electrophysiological predictors associated with AV conduction recovery by comparing patients with persistent AV block and regressive AV block. The secondary outcome was the correlation between long-term surface ECG findings and pacing parameters, particularly the right ventricular pacing (RVp) burden and pacemaker dependency, as these parameters are routinely assessed during clinical follow-up visits.

2.6. Statistical methods

Categorical variables were expressed as percentages and compared using the Chi-squared test or Fisher's exact test when appropriate. Continuous variables were presented as mean ± standard deviation (SD). The normality of distribution was assessed using the Shapiro–Wilk test. For normally distributed variables, one-sample or independent-samples t-tests were applied as appropriate. For non-normally distributed data, the Wilcoxon signed-rank test or Mann–Whitney U testwas used. For repeated measures, a one-way within-subjects ANOVA was performed. Statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). A two-tailed p value < 0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

After 377 TAVI implantations, a total of 37 (9,8%) patients underwent permanent pacemaker implantation. 4 patients were excluded from the further analysis because the PM was implanted more than 30 days after TAVI (on average 1.9 ± 0.6 years). Accordingly, the final study population consisted of 33 patients (8.7%), who underwent permanent PM implantation 5.8 ± 6.2 days after TAVI during the index hospitalization, following a period of continuous in-hospital monitoring. Fig. 1. Baseline clinical parameters and comorbidities are summarized in Supplementary Table 1. The mean age of patients was 79.6 ± 6.3 years, and 57% were male. The baseline ejection fraction was 49.0 ± 17.6%, the mean transaortic peak gradient above the aortic valve was 83.3 ± 26.6 mmHg, the mean gradient was 49.6 ± 17.6 mmHg. During the mean FU period of 1.55 ± 1.7 years, the overall all-cause mortality was 27% (9 patients). These data reflect a high-risk population with a significant burden of comorbidities.

3.2. TAVI procedural characteristics

Most patients (32 cases, 97%) received self-expanding valves, and balloon-expandable valve was used in one case (3%). Based on intraoperative echocardiographic assessment, the mean implantation depth of the prosthetic valve — measured from the aortic annular plane to the ventricular edge of the stent frame at the non-coronary and right coronary cusps — was 7.7 ± 4.7 mm. Further details of procedural

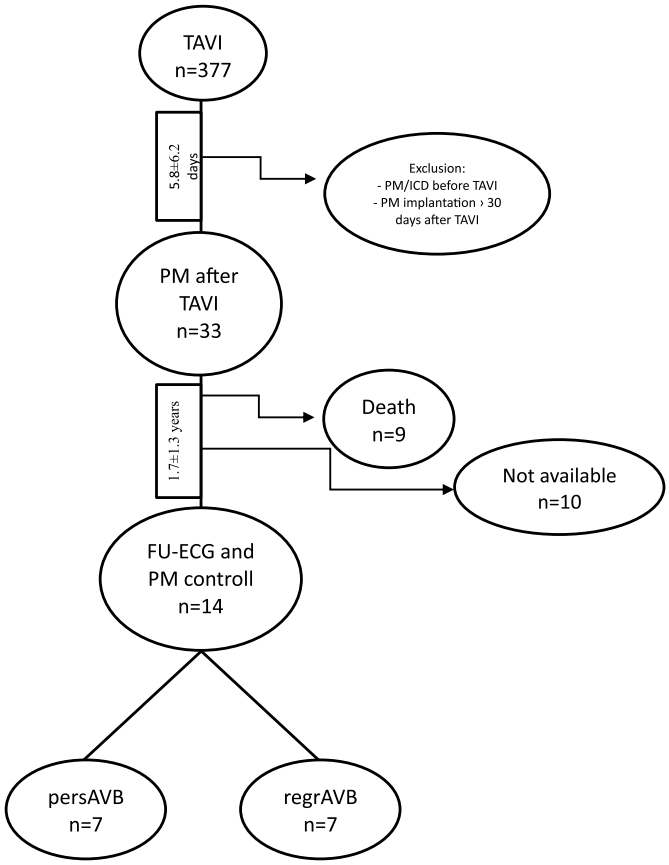

Fig. 1. Flowchart of study population. TAVI – transcathter aortic valve replacement, PM – pacemaker, FU-follow up, persAVB – persisting III. degree AV block, regrAVB – no/I. degree AV block.

characteristics are included in Supplementary Table 2.

3.3. Indications for pacemaker implantation and follow-up of pacing parameters

The indication for PM implantation was complete AV block in 28 cases (84.8%), second-degree AV block in 3 cases (9.1%), and significant bradycardia (i.e. atrial fibrillation with slow ventricular conduction, asystole + syncope) in 2 patients (6%). VVI or VDD pacemakers were implanted in 10 patients (33.3%), DDD devices in 19 patients (57.6%), and cardiac resynchronization therapy (CRT) was applied in 4 patients (12.1%) (Supplementary Fig. 1).

At the 6 weeks follow-up, 93% of patients were not pacemaker-dependent. The number of pacemaker-dependent patients remained low and stable over time, with 2 cases at both 6 weeks and 6 months, and 3 cases at 1- and 2-year follow-ups.Supplementary Table 3.

3.4. Long-term evolution of AV conduction after pacemaker implantation

After a follow-up period of 1.7 ± 1.3 years, 12-lead surface ECG recordings were available for 14 patients. Of the remaining patients, 9 patiens had died and 10 were not available for follow-up ECG due to technical issues.

Among the 14 patients, 7 (50%) showed persistent third-degree AV block (persAVB), while the remaining 7 (50%) demonstrated complete or partial regression of the initial conduction disorder (regrAVB). All patients in the persAVB group had received pacemaker implantation for complete AV block. In the regrAVB group, the original indication was complete AV block in 5 cases (71%), second-degree AVB in 1 case (14%), and significant bradycardia in 1 case (14%) (p = 0.12) Fig. 2.

3.5. Predictors of persistent AV-block

Baseline demographic, echocardiographic and procedural characteristics did not differ significantly between the persAVB and regrAVB groups. Among the examined variables, pre-procedural QRS duration was the only parameter significantly associated with persistent AV-block at follow-up. Patients in the persAVB group had a markedly wider baseline QRS compared with those demonstrating conduction recovery (107.1 ± 27.3 ms vs 80.7 ± 1.6 ms, p = 0.038). Contrary to expectations, the pre-procedural PQ interval did not differ between the 2 groups (persAVB: 180.0 ± 39.9 ms vs. regrAVB: 145.0 ± 39.4 ms, p = 0.179). Baseline ECG revealed RBBB in 2 patients, LBBB in 1 patient and LAHB in 2 patients the persAVB group, whereas none of these conduction abnormalities were observed in the regrAVB group (Table 1).

Post-procedurally, both groups showed significant increase in QRS width (persAVB from 107.1 ± 27.3 ms to 156.8 ± 39.4 ms, p = 0.04; regrAVB from 80.7 ± 1.6 ms to 130.6 ± 32.3 ms, p⟨0.01), however, the magnitude of QRS widening did not differ significantly between the groups (p = 0.862). At the end of the FU, QRS duration remained stable on surface ECG in both groups (persAVB: 146.0 ± 24.2 ms, p = 0.21; regrAVB: 151.0 ± 20.5, p = 0.14) Fig. 3. Notably, in some cases, the recorded QRS represented escape rhythm.

3.6. Correlation with right ventricular pacing

The median right ventricular pacing burden at follow-up was significantly higher in patients with persistent AV block compared with those showing conduction recovery [100% (IQR: 98.8–100%) vs 0% (IQR: 0–2.5%), $p < 0.001$], after excluding patients with cardiac resynchronization therapy devices (Fig. 4). At the final FU, pacemaker dependency was observed in 2 patients (28%) within the persAVB group, whereas none of the regrAVB patients were pacemaker-dependent ($p = 0.121$). Importantly, the inverse relationship between RVp burden and AV conduction recovery was already apparent at the first post-implant device interrogation (6 weeks after implantation) and remained consistent throughout all subsequent FU visits, suggesting that conduction system recovery after TAVI begins early and persists during long-term observation. Fig. 4.

4. Discussion

The population in our study mirrors the classical high-risk TAVI cohort characterized by advanced age, frequent NYHA II–IV status, and high prevalence of cardiomyopathy necessitating CRT in ~12% of cases. During a mean follow-up of 1.55 ± 1.7 years, all-cause mortality was 27%, exceeding the typical post-TAVI mortality (~9%) in broader cohorts, thereby underscoring the fragility of the pacemaker subpopulation in our series [9].

Although contemporary TAVI practice has expanded into younger and lower-risk populations, conduction disturbances remain a persistent challenge, particularly with self-expanding devices [3]. Factors including baseline conduction disease, prosthesis type, and procedural depth have been implicated as factors. [6-8] Autopsy studies have demonstrated local trauma to the His-Purkinje system due to radial force, septal edema, ischemia, and inflammatory changes [10]. Recent data also show that shorter membranous septum length increases susceptibility to conduction injury across valve platforms, reinforcing the anatomical vulnerability of the atrioventricular conduction axis and providing a biologic rationale for subsequent conduction recovery once transient compression or edema resolves [11]. Importantly, emerging clinical data suggest that TAVI-related conduction injury may be reversible in a substantial proportion of patients, with recovery observed in 60–77% of cases, even among those initially presenting with complete AV block [12–15].

The experiences we have learned from our own material are consistent with these observations, at six week follow ups the majority of

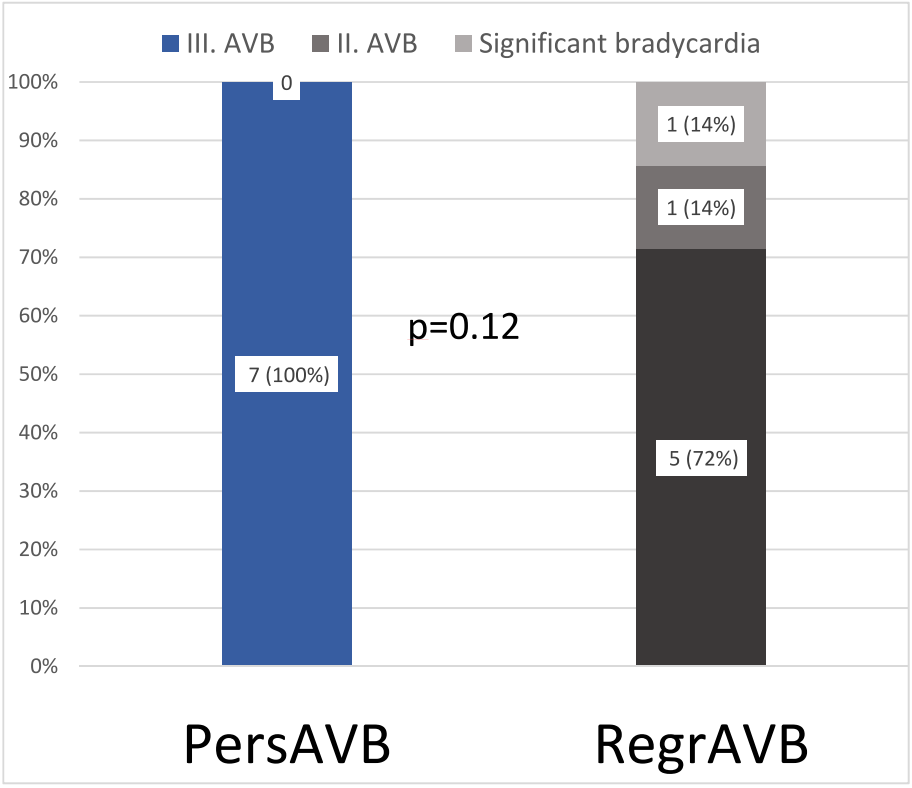

Fig. 2. Initial indication for PM implantation by AV block outcome at follow-up. persAVB – persisting III. degree AV block, regrAVB – no/I. degree AV block.

Table 1
Baseline demographic, echocardiographic and procedural characteristics of persistent and regressive AV-block groups.

	PersAVB (n = 7)	RegrAVB (n = 7)	p-value
Age (years)	78.9 ± 5.4	79.8 ± 2.7	0.708
Male (n/%)	4 (57%)	3 (43%)	0.593
Hypertension (n/%)	7 (100%)	7 (100%)	1.0
Hyperlipidemia (n/%)	6 (85%)	4 (57%)	0.237
Diabetes mellitus (n/%)	2 (28%)	1 (14%)	0.515
Chronic kidney disease (n/%)	1 (14%)	3 (42%)	0.237
Chronic obstructive pulmonary disease (n/%)	1 (14%)	1 (14%)	1.0
Stroke/Transient ischaemic attack (n/%)	2 (28%)	0 (0%)	0.127
Ejection fraction (%)	45.8 ± 17.4	51.2 ± 21.2	0.610
Transaortic peak gradient (mmHg)	78.1 ± 38.6	67.3 ± 27.5	0.634
Implantation depth (mm)	6.4 ± 1.8	6.6 ± 3.5	0.892
Self-expanding valve (n/%)	0 (0%)	1 (14%)	0.337
Pre-procedural PQ (msec)	180.0 ± 39.9	145.0 ± 39.4	0,130
Pre-procedural QRS (msec)	107.1 ± 27.3	80.7 ± 1.6	**0,038**
Pre-procedural RBBB (n/%)	2 (28%)	0 (0%)	0,155
Pre-procedural LBBB (n/%)	1 (14%)	0 (0%)	0,335

our patients were not pacemaker dependent (93 %) and this did not change during follow-up.

Pacemaker implantation usually takes place within a few days following TAVI, based on current indications, which means significantly less time than is commonly used in cases following surgical valve implantations where 7 days is generally accepted [16]. In our cohort, the mean time from TAVI to pacemaker implantation was 5.8 ± 6.2 days. Importantly, this interval did not necessarily reflect delayed onset of AV block, but rather a deliberate period of in-hospital observation aimed at evaluating the potential reversibility of conduction disturbances. The overall pacemaker implantation rate was relatively low (8.7%), particularly given the predominant use of self-expanding valves. Contemporary TAVI programs increasingly support early discharge strategies; however, conduction disturbances may evolve beyond the immediate post-procedural phase. Short in-hospital observation could therefore carry the risk that clinically significant AV block develops after discharge, potentially resulting in delayed recognition and serious adverse outcomes. At the same time long-term ECG monitoring revealed that up to 50% of patients exhibited complete or partial recovery of conduction abnormalities, highlighting the complexity of timing decisions and supporting careful rhythm surveillance and individualized pacing strategies.

Prior studies have associated pre-procedural conduction abnormalities (RBBB, bifascicular block), intraprocedural AV block, and wider baseline QRS (⟩120 msec) with long-term pacing dependence [17,18]. Our results similarly showed wider baseline QRS in patients with persistent AV block, with trends toward longer PR interval and greater prevalence of pre-existing conduction abnormalities.

Several groups have investigated CT-based predictors of post-TAVI conduction outcomes, including detailed annular and septal anatomy assessment, but these methods currently lack sufficient accuracy to guide pacing decisions [19]. Likewise, machine-learning models that successfully predicted other TAVI-related events, such as paravalvular leak, failed to reliably identify patients who ultimately required pacemakers, underscoring the multifactorial nature of conduction disturbances after TAVI [20].

In most of the studies mentioned above, conduction system qualities were calculated on the basis of PM dependence or right ventricular pace ratio observed during pacemaker controls and the appearance of escape rhythm during transient pacemaker suspension. However, we know that these methods can be misleading in assessing the real need for a pacemaker, because a lot depends on the actual pacemaker programming. Therefore, in a somewhat unique way, we tried to analyze the real conduction system changes in our own patient material in the light of real 12-lead surface ECG recordings made during pacemaker controls. Although, unfortunately, due to data loss, the results should only be

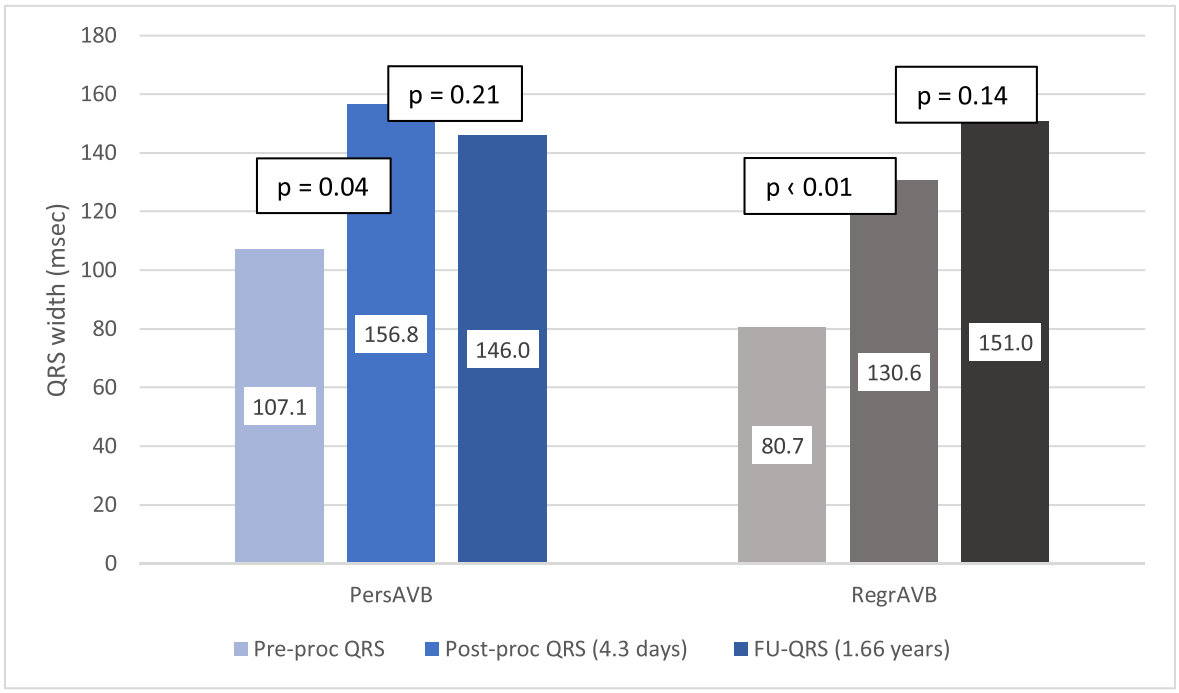

Fig. 3. Temporal changes in QRS duration in persistent and regressive AV block groups. persAVB – persisting III. degree AV block, regrAVB – no/I. degree AV block.

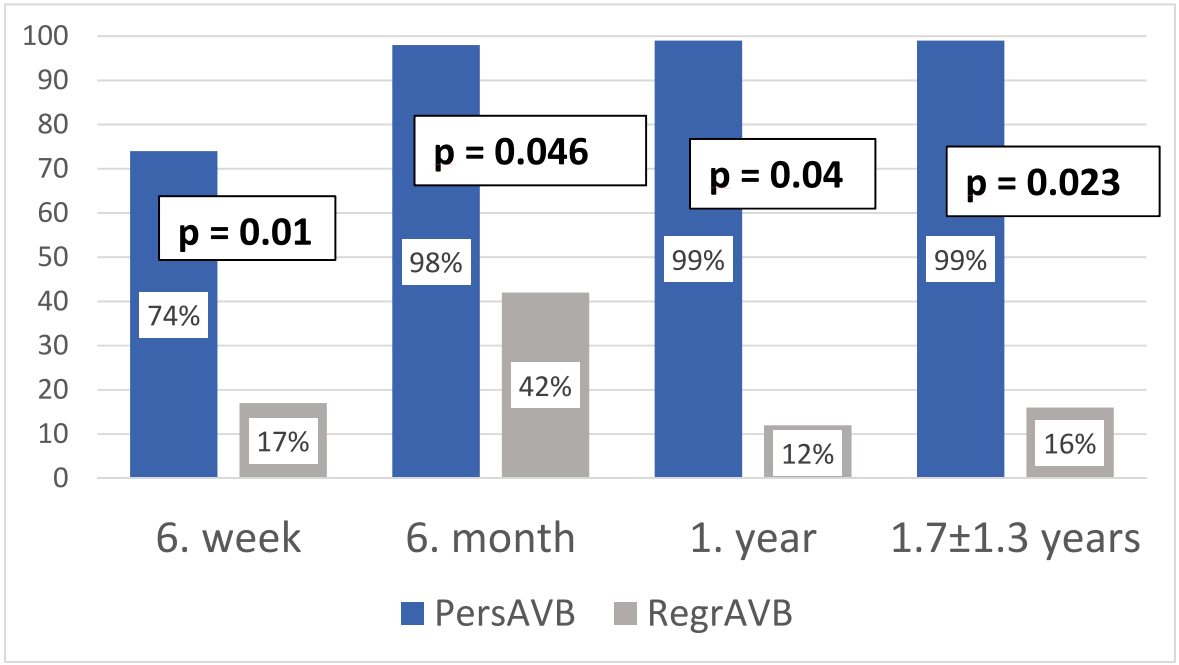

Fig. 4. Temporal changes in right ventricular pacing percentages in patients with persistent vs. regressive AV block
persAVB – persisting III. degree AV block, regrAVB – no/I. degree AV block.

interpreted with caution (see limitations of study), it was found that pacemaker dependence was present in only 28% of patients with otherwise persistent grade III AV block, while in the regressive AV block group it was not present at all. Right ventricular pacing percentage correlated with the findings on the 12-lead ECG, since patients in the regressive AV block group already on the first PM controll at 6 weeks had a significantly lower right ventricular pacing percentage, that persisted during the FU-period. This early divergence seen in pacing burden suggests that conduction recovery trajectories are established soon after TAVI and remain stable over time.

Unlike many reports limited to 1-year follow-up, our study extends beyond 12 months and suggests that conduction recovery may persist into the longer term in a sizable fraction of patients.

The limitation of our study is that due to the difficulties of retrospective data collection, we focused only on the follow-up of pacemaker patients, therefore there is no comparison with a control group available. Due to the patients high mean age, fragility, and significant mortality rate, more than 50% of patients could not attend prospective ECG data collection beyond pacemaker controls. The limited sample size constrained multivariable modeling and renders results hypothesis-

generating. In addition, the predominance of self-expanding valve systems in our cohort may limit generalizability across different TAVI platforms. This device distribution reflects institutional practice patterns and reimbursement conditions during the study period. Nevertheless, the consistency between device interrogation and ECG-verified conduction status strengthens the reliability of our observations.

5. Conclusion

In our single-center retrospective cohort of TAVI patients requiring permanent pacemaker implantation, a substantial proportion (50%) demonstrated partial or complete recovery of atrioventricular conduction during follow-up. This recovery was particularly evident in patients without pre-procedural conduction abnormalities and those with narrower baseline QRS complexes, the latter showing a statistically significant association with conduction persistence. These findings underscore the potential benefit of extending the observation period after TAVI before proceeding with permanent pacemaker implantation, especially in cases with transient or uncertain indications. An individualized pacing strategy, supported by systematic ECG-based follow-up, may help optimize long-term device management and reduce unnecessary lifelong pacing in this growing patient population.

Declaration of compliance with ethics

The study was approved by the institutional review board (222/2019-SZTE).

Authors contributions

Conceptualization: D.K., S.L.
Methodology: D.K., F.D.G.
Investigation: D.K., F.D.G., G.S.
Procedures: Z.R., T.Sz.
Formal analysis: F.D.G., D.K.
Writing – original draft: D.K.
Writing – review & editing: S.L., D.K., F.D.G., Z.R., V.M., T.Sz.T.
Supervision: S.L.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the author(s) used ChatGPT (OpenAI) for language editing and proofreading of the English manuscript. After using this tool, the author(s) thoroughly reviewed and revised the content as needed and take full responsibility for the content of the published article.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ipej.2026.05.001.

Data availability

The datasets generated and analyzed during the current study are not publicly available due to institutional and national data protection regulations but are available from the corresponding author on reasonable request. All data were handled in accordance with the European Union General Data Protection Regulation (GDPR) and institutional ethical standards.

References

[1] Kalogeropoulos AS, Redwood SR, Allen CJ, Hurrell H, Chehab O, Rajani R, et al. A 20-year journey in transcatheter aortic valve implantation: evolution to current eminence. Front Cardiovasc Med 2022;9:971762.
[2] Gulyás Zalán KG, Emese Tóth-Zsámboki, Horváth Zsófia KRG, Zoltán Duray Gábor. Expanding indications of transcatheter aortic valve implantation and cornerstones of the lifetime management of patients with severe aortic stenosis. Cardiologia Hungarica 2024;54:369–77.
[3] Postolache A, Sperlongano S, Lancellotti P. TAVI after more than 20 years. J Clin Med 2023;12(17).
[4] Sinhal Ajay, Altwegg Lukas, Pasupati Sanjeevan, Humphries Karin H, Allard Michael, Martin Paul, Cheung Anson, Ye Jian, Kerr Charles, Lichtenstein Sam V, Webb John G. Atrioventricular block after transcatheter balloon expandable aortic valve implantation. JACC Cardiovasc Interv 2008;1(3):305–9.
[5] Khawaja MZ, Cook A, Khavandi A, Moynagh A, Chowdhary S, Brown S, Khan SQ, Walker N, Trivedi U, Hutchinson N, De Belder AJ, Moat N, Blackman DJ, Manoharan G, Roberts D, Khogali SS, Crean P, Baumbach A, Mullen M, Laborde J-C, Hildick-Smith D. Permanent pacemaker insertion after CoreValve transcatheter aortic valve implantation incidence and contributing factors (the UK CoreValve collaborative). Circulation 2011:951–60.
[6] Moreno Raul, de Sá Esteban López, Prieto Mario, Morales Carmen, Orbe Luis Calvo, Moreno-Gomez Isidro, Filgueiras David, Galeote Guillermo, Jiménez-Valero Santiago, Lopez-Sendon José-Luis. Cause of complete atrioventricular block after percutaneous aortic valve implantation. Circulation 2009;120:e29–30.
[7] Houthuizen Patrick, van der Boon MA, Urena M, Van Mieghem N, Brueren Guus BR, Poels Thomas T, Van Garsse AFM, Rodés-Cabau Josep, de Jaegere Peter. Occurrence, fate and consequences of ventricular conduction abnormalities after transcatheter aortic valve implantation. EuroIntervention 2014;9:1142–50.
[8] Glikson M, Nielsen JC, Kronborg MB, Michowitz Y, Auricchio A, Barbash IM, et al. 2021 ESC guidelines on cardiac pacing and cardiac resynchronization therapy: developed by the task force on cardiac pacing and cardiac resynchronization therapy of the European Society of Cardiology (ESC) with the special contribution of the European Heart Rhythm Association (EHRA). Rev Esp Cardiol 2022;75(5):430.
[9] Ravaux JM, Di Mauro M, Vernooy K, Van't Hof AW, Veenstra L, Kats S, et al. One-year pacing dependency after pacemaker implantation in patients undergoing transcatheter aortic valve implantation: systematic review and meta-analysis. JTCVS Open 2021;6:41–55.e15.
[10] Saji M, Murai T, Tobaru T, Tabata M, Takanashi S, Takayama M. Autopsy finding of the Sapien XT valve from a patient who died suddenly after transcatheter aortic valve replacement. Cardiovasc Interv Ther 2013;28(3):267–71.
[11] Hokken TW, van Wiechen MP, Ooms JF, El Azzouzi I, de Ronde M, Kardys I, et al. Impact of Interventricular membranous septum length on pacemaker need with different Transcatheter aortic valve implantation systems. Int J Cardiol 2021;333:152–8.
[12] Marzahn C, Koban C, Seifert M, Isotani A, Neuß M, Hölschermann F, et al. Conduction recovery and avoidance of permanent pacing after transcatheter aortic valve implantation. J Cardiol 2018;71(1):101–8.
[13] Kaplan RM, Yadlapati A, Cantey EP, Passman RS, Gajjar M, Knight BP, et al. Conduction recovery following pacemaker implantation after transcatheter aortic valve replacement. Pacing Clin Electrophysiol 2019;42(2):146–52.
[14] Pinnacchio G, Ruscio E, Rocco E, Trani C, Burzotta F, Aurigemma C, et al. Short-term atrioventricular dysfunction recovery after Post-TAVI pacemaker implantation. J Cardiovasc Dev Dis 2022;9(10).
[15] Gaede L, Kim WK, Liebetrau C, Dörr O, Sperzel J, Blumenstein J, et al. Pacemaker implantation after TAVI: predictors of AV block persistence. Clin Res Cardiol 2018;107(1):60–9.
[16] Lilly SM, Deshmukh AJ, Epstein AE, Ricciardi MJ, Shreenivas S, Velagapudi P, 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(20):2391–411.
[17] Baldi E, Compagnone M, Errigo D, Ferlini M, Ziacchi M, Castagno D, et al. Long-term percentage of ventricular pacing in patients requiring pacemaker implantation after transcatheter aortic valve replacement: a multicenter 10-year experience. Heart Rhythm 2020;17(11):1897–903.

[18] Sharma E, Chu AF. Predictors of right ventricular pacing and pacemaker dependence in transcatheter aortic valve replacement patients. J Intervent Card Electrophysiol 2018;51(1):77–86.
[19] Nuis RJ, van den Dorpel M, Adrichem R, Daemen J, Van Mieghem N. Conduction abnormalities after transcatheter aortic valve implantation: incidence, impact and management using CT data interpretation. Intervent Cardiol 2024;19:e12.
[20] Hokken TW, Nuyens P, Ruffo C, Nuis RJ, Daemen J, Kardys I, et al. CT-derived simulations to predict outcomes in patients undergoing transcatheter aortic valve implantation with an ACURATE Neo2 valve the PRECISE-TAVI cohort B trial. Cathet Cardiovasc Interv 2024;104(5):1044–51.