ORIGINAL RESEARCH

Baseline ECG and Prognosis After Transcatheter Aortic Valve Implantation: The Role of Interatrial Block

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BACKGROUND: The clinical significance of conduction disturbances after transcatheter aortic valve implantation has been described; however, little is known about the influence of baseline ECGs in the prognosis of these patients. Our aim was to study the influence of baseline ECG parameters, including interatrial block (IAB), in the prognosis of patients treated with transcatheter aortic valve implantation.

METHODS AND RESULTS: The BIT (Baseline Interatrial Block and Transcatheter Aortic Valve Implantation) registry included 2527 patients with aortic stenosis treated with transcatheter aortic valve implantation. A centralized analysis of baseline ECGs was performed. Patients were divided into 4 groups: normal P wave duration (<120 ms); partial IAB (P wave duration ≥120 ms, positive in the inferior leads); advanced IAB (P wave duration ≥120 ms, biphasic [+/-] morphology in the inferior leads); and nonsinus rhythm (atrial fibrillation/flutter and paced rhythm). The mean age of patients was 82.6±9.8 years and 1397 (55.3%) were women. A total of 960 patients (38.0%) had a normal P wave, 582 (23.0%) had partial IAB, 300 (11.9%) had advanced IAB, and 685 (27.1%) presented with nonsinus rhythm. Mean follow-up duration was 465±171 days. Advanced IAB was the only independent predictor of all-cause mortality (hazard ratio [HR], 1.48; 95% CI, 1.10–1.98 [P = 0.010]) and of the composite end point (death/stroke/new atrial fibrillation) (HR, 1.5; 95% CI, 1.17–1.94 [P = 0.001]).

CONCLUSIONS: Baseline ECG characteristics influence the prognosis of patients with aortic stenosis treated with transcatheter aortic valve implantation. Advanced IAB is present in about an eighth of patients and is associated with all-cause death and the composite end point of death, stroke, and new atrial fibrillation during follow-up.

Key Words: ECG ■ interatrial block ■ pacemaker ■ prognosis ■ TAVI ■ TAVR

Transcatheter aortic valve implantation (TAVI) is increasingly common for treating patients with severe aortic stenosis. Compared with surgical aortic valve replacement, TAVI was associated with a lower risk for all-cause mortality or disabling stroke within 2 years in a recent meta-analysis.1 The indications for percutaneous valve replacement are being extended, even to patients with a low surgical risk.2 Several authors have suggested that interatrial block (IAB), particularly advanced IAB, could be a

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precursor of atrial fibrillation (AF), stroke, and mortality\(^3,4\) in different clinical scenarios.\(^4–9\) IAB is defined as a prolonged P wave duration (≥120 ms). In partial IAB, the P wave is positive in the inferior leads, while, in advanced IAB, the P wave has a biphasic (+/–) pattern in the inferior leads. IAB is more common in elderly patients, but the prevalence of IAB in patients undergoing TAVI, and its clinical implications, are unknown. In advanced IAB, impulses are not conducted by the Bachmann bundle. Left atrial activation is retrograde through the coronary sinus musculature and the fossa ovalis. The delayed left atrial contraction occurs against a closed mitral valve, producing an increase in atrial pressure and promoting atrial dilation and fibrosis.\(^10\)

Changes in the conduction tissue after the procedure constitutes one of the main limitations of TAVI, generating the need for a definitive pacemaker in a nonnegligible percentage of patients.\(^11\) Some predictors for permanent pacemaker implantation have been described, such as age, septal wall thickness, longer QRS duration, preexisting right bundle-branch block, prosthesis oversizing, mitral annular calcification, post-dilatation during TAVI implantation, or self-expandable prosthesis,\(^12–14\) but information on this matter is still insufficient, particularly with respect to the influence of baseline ECG parameters.

To date, no study has specifically analyzed the role of IAB as a prognostic predictor in patients with aortic stenosis undergoing TAVI. Our aim was to determine the association of preexisting IAB with long-term prognosis in patients who received TAVI for aortic valve replacement. We also aimed to determine the potential relationship between IAB and pacemaker implantation after TAVI.

**METHODS**

The design of the BIT (Baseline Interatrial Block and Transcatheter Aortic Valve Implantation) registry has been published.\(^15\) Briefly, we included patients treated with TAVI in 10 Spanish academic centers. The primary end point was the requirement of a permanent pacemaker during post-TAVI hospitalization. Secondary end points included the incidence of new-onset AF, stroke, or mortality during 12-month follow-up. Inclusion criteria were: (1) ECG performed in the 24 hours before TAVI, and (2) TAVI procedure for aortic valve stenosis. The only exclusion criterion was to have an ineligible ECG. Trained personnel using standard case report forms collected all data prospectively. The last ECG performed before TAVI implantation was retrospectively collected and clinical data were collected using a standardized form centrally analyzed. Patients were prospectively followed up. The ECG image was amplified up to 20 times its original size to define the interval between the earliest and the latest detection of atrial depolarization in the frontal leads, defined as a positive or negative deflection, respectively, that deviates from the baseline before the QRS complex. All ECGs were recorded with a standardized protocol and settings (25 mm/s and 10 mm=1 mV). The last ECG available before TAVI implantation was used. P wave duration and the presence of IAB was manually measured and assessed using GeoGebra 4.2 software (Informer Technologies, Inc) after amplifying up to 20 times its original size. GeoGebra is mathematical software that allows high accuracy measurements\(^16\) and has been used to accurately measure P wave duration.\(^17\)

Blinded ECG analysis was performed in the core laboratory of the Fundación Investigación Cardiovascular/Programa-ICCC Cardiovascular, Institut de Recerca del Hospital de la Santa Creu i Sant Pau, Barcelona, Spain. Patients were divided into 3 groups: normal P wave duration (<120 ms); partial IAB (P wave duration ≥120 ms, positive in the inferior leads); advanced IAB (P wave duration ≥120 ms, biphasic [+/–] morphology in the inferior leads) (Figure 1); and nonsinus rhythm (AF/flutter and paced rhythm). Heart failure (HF) was defined according to European Society of Cardiology guidelines.\(^18\)
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TAVI valve models were divided into 2 main groups according to the implant technique: self-expandable/mechanically expandable (Evolut [Medtronic], Allegra [New Valve Technology], Acurate [Boston Scientific Corporation], Engager [Medtronic], Portico [Abbott], Lotus [Boston Scientific Corporation], JenaValve [JenaValve Technology, Inc.]), and balloon-expandable prostheses (Sapien [Edwards Lifesciences Corporation]).

Our study complies with the Declaration of Helsinki, and was approved by the ethics committee of the Germans Trias i Pujol University Hospital, Badalona, Barcelona, Spain. Informed consent was obtained from all participants. Methods used in the analysis and materials used to conduct the research will be made available to any researcher.

Statistical Analysis

Categorical variables are expressed as number (percentage). Continuous variables are expressed as mean±SD. Normality in the distribution of continuous variables was analyzed with the Kolmogorov-Smirnov test. The differences between categorical variables were analyzed through the chi-square test, with continuity correction if indicated. The differences between continuous variables were analyzed using the Student t test. For the analysis of the impact of IAB on the need to implant a permanent pacemaker after TAVI, a binary logistic regression model was used. For the analysis of the impact of IAB in the combination of new-onset AF, stroke, or death, a Cox regression model was used. Charlson comorbidity index was calculated but the component variables were also individually considered during the modeling process. The variable selection method was made based on clinical justification, including all candidate predictors associated with outcome clinically and biologically as a first step. To determine which variables were entered into the final model, we used a sequential inclusion and exclusion method, with an inclusion P threshold <0.05 and exclusion >0.1. Statistical package STATA 14.0 (StataCorp LLC) was used to perform all statistical analysis.

RESULTS

During the study period, a total of 2527 patients undergoing TAVI implantation were included in the registry. The mean age of patients was 82.6±9.8 years, and 1397 (55.3%) were women. IAB was present in 882 patients (34.9%) before TAVI. Mean follow-up duration was 465±171 days. Table 1 shows basal demographic characteristics and ECG parameters according to the presence and type of IAB (partial in 582 patients [23.0%], advanced in 300 patients [11.9%]). AF/flutter was present in 560 patients (22.1%), and 125 had a paced rhythm (4.9%). Patients with IAB were older than patients without IAB, but Charlson comorbidity index19 was similar in patients with no IAB, partial/advanced IAB, and AF. Previous HF was more common in patients with advanced IAB (65.0%) compared with those with partial IAB (63.9%), those with a normal P wave (55.2%), or those with

Figure 1. Examples of ECGs with partial and advanced interatrial block (IAB).
AF/paced rhythms (60.9%). Patients with IAB had a thicker interventricular septum than patients with normal P wave. In the nonsinus rhythm group, oral anticoagulation was more common in patients with AF than in those with pacemakers (385 [68.8%] versus 26 [20.8%], \( P < 0.001 \)).
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We did not find significant differences in the rate of pacemaker implantation in the 3 groups of patients according to IAB during admission/follow-up. Most pacemaker implants occurred in the first days after the TAVI procedure. The median time to pacemaker implantation was 4 days, and in patients who required a pacemaker, 3 of 4 underwent implantation in the first 8 days after TAVI. The length of hospital stay was longer in patients who required a permanent pacemaker during hospital admission (12.5±2.0 days), compared with those who did not require a pacemaker (9.2±0.3 days) (P=0.01). IAB was not associated with pacemaker implantation during hospitalization (Table 2), or follow-up (Figure 2).

Table 2. Independent Predictors of Pacemaker Implantation During Hospital Admission*

| Predictor                          | OR (95% CI)     | P Value  |
|-----------------------------------|-----------------|----------|
| Normal P wave                     | 1               | ...      |
| AF                                | 1.18 (0.67–2.07) | 0.563    |
| Partial                           | 1.10 (0.71–1.71) | 0.273    |
| Advanced                          | 0.97 (0.55–1.70) | 0.902    |

*T *Interatrial block was not associated with pacemaker implantation. AF indicates atrial fibrillation; OR, odds ratio; and TAVI, transcatheter aortic valve implantation.

Among patients with HF, the frequency of pacemaker implantation was higher in patients treated with self-expandable valves than in those with balloon-expandable valves (117 [9.5%] versus 11 [3.8%], respectively; P=0.001). HF was associated with pacemaker implantation after TAVI (OR, 1.49; 95% CI, 1.05–2.25 [P=0.0498]). Self-expandable valves were also associated with a higher frequency of pacemaker implantation after TAVI (OR, 1.78; 95% CI, 1.01–3.25 [P=0.048]).

In-hospital death in patients with partial IAB was slightly higher than in those with advanced IAB, without a significant difference (39 [6.7%] versus 16 [5.4%], respectively; P=0.555). This was also the case with death during follow-up (134 [23.2%] versus 61 [20.4%], respectively; P=0.558).

The number of hospital readmissions and deaths were higher in patients with IAB compared with those with a normal P wave (Table 3). The rate of early deaths (<30 days) was similar in patients with IAB and those with a normal P wave, but late deaths were more common among patients with IAB. A similar tendency was seen for the composite outcome of death/stroke/AF. Table 4 shows the independent predictors of the main study end points during follow-up. IAB and Charlson comorbidity index were the only 2 independent predictors of the combined end point of death/stroke/incident AF (Figure 3), and were also the only 2 independent predictors of all-cause death (Figure 4). The association of advanced IAB with outcomes was similar in the 2 type of valves, and the type of valve was not associated with all-cause death (hazard ratio [HR], 1.01; 95% CI, 0.89–1.36 [P=0.38]) or with the composite end point of death, stroke, and AF (HR, 1.13; 95% CI, 0.92–1.38 [P=0.24]).

Advanced IAB and Charlson comorbidity index were the only 2 independent predictors of the combined end point of death/stroke/incident AF (Figure 3), and were also the only 2 independent predictors of all-cause death (Figure 4).

DISCUSSION

In this large real-life registry in patients who underwent TAVI, we found that advanced IAB is present in about an eighth of the patients and is associated with all-cause death and with the composite end point of death, stroke, and AF. IAB was not associated with an increased need for a permanent pacemaker. Patients with right bundle-branch block at baseline, HF, and self-expandable valves, were at increased risk of requiring a permanent pacemaker.

Aortic stenosis is the most frequent valve disease in the elderly, and TAVI is becoming the therapy of choice in most symptomatic patients. IAB reflects a deterioration of interatrial conduction and has been associated with an increased incidence of AF.9,20 There is growing evidence that IAB, particularly
advanced IAB, is a powerful marker of increased risk of a poor outcome in different clinical scenarios, such as HF, acute coronary syndromes, stress cardiomyopathy, and ischemic stroke. Our data confirm that this is also the case in patients with aortic stenosis treated with TAVI.

The mechanisms underlying the higher mortality in patients with advanced IAB are not completely understood. We found that comorbidity was similar in patients with TAVI regardless of IAB, according to the Charlson comorbidity index. In our population of patients treated with TAVI, we were unable to detect an independent association of advanced IAB with AF or stroke. This could be related to the fact that patients with severe aortic stenosis might have an increase in left atrial pressure regardless of the presence of IAB. In fact, in the only previous study of IAB in patients with TAVI, Alexander et al. in a small sample of 62 patients, did not find a significant association between IAB and AF. In addition, almost a quarter of our patients already had AF/flutter at baseline. Stroke incidence was lower in patients with AF, probably related to the protective effect of previous oral anticoagulation in this group.

We found a trend toward higher AF in patients with IAB, both partial and advanced. Continuous ECG monitoring was not routinely performed and could be the reason for the low number of episodes of AF identified.

Previous studies have shown that advanced IAB is associated with an increase in all-cause mortality. This might be related to the higher risk of AF and thromboembolic events caused by atrial dilation and blood stasis but also by an inflammatory and profibrotic state. Patients with advanced IAB presented with more common comorbidities (history of HF), although the increase in mortality was also noted in multivariate analysis. After adjusting for confounders, advanced IAB was an independent predictor of death during follow-up and the composite end point (death/stroke/incident AF), but this was not the case with partial IAB. Patients with partial IAB more often presented with variables associated with a worse prognosis such as history of ischemic heart disease, lower left ventricular ejection fraction, mitral regurgitation, greater presence of symptoms of aortic stenosis, and lower aortic area. Previous HF was not an independent predictor of death during follow-up as it was probably associated with aortic stenosis, which was treated with TAVI.

One of the limitations of TAVI is the damage of conduction tissue that can lead to the need for a permanent pacemaker. This complication varies depending on the series and type of prosthesis used, ranging between 15% and 30%.

### Table 3. Events During Follow-Up According to the Presence and Type of IAB

| Event                                    | Normal P Wave n=960 | Partial IAB n=582 | Advanced IAB n=300 | Nonsinus Rhythm n=685 | P Value |
|------------------------------------------|---------------------|-------------------|--------------------|-----------------------|---------|
| Pacemaker implantation after TAVI        | 224 (23.8)          | 125 (22.0)        | 63 (21.5)          | 138 (20.3)            | 0.420   |
| Pacemaker implantation during TAVI       | 62 (6.5)            | 48 (7.9)          | 20 (6.7)           | 43 (6.3)              | 0.670   |
| Pacemaker implantation after discharge from TAVI hospitalization | 162 (16.9) | 79 (13.6) | 43 (14.3) | 93 (13.6) | 0.193 |
| New-onset AF                             | 70 (7.5)            | 54 (9.8)          | 29 (10.3)          | ...                   | 0.176   |
| Stroke                                   | 52 (5.7)            | 31 (5.4)          | 18 (6.3)           | 31 (4.6)              | 0.667   |
| Hospital admission during follow-up      | 423 (44.1)          | 276 (47.4)        | 136 (45.3)         | 358 (52.3)            | 0.010   |
| No. of hospital readmissions             | 0.7±1.2             | 0.9±1.5           | 1.0±1.9            | 1.1±1.7               | <0.001  |
| Death during hospital admission          | 49 (5.1)            | 39 (6.7)          | 16 (5.4)           | 55 (8.1)              | 0.102   |
| Death during follow-up                   | 171 (17.9)          | 134 (23.2)        | 61 (20.4)          | 119 (17.5)            | 0.039   |
| Early deaths (<30 d)                     | 106 (11.0)          | 65 (11.2)         | 27 (9.0)           | 86 (12.6)             | 0.424   |
| Late deaths (>30 d)                      | 114 (11.9)          | 108 (18.6)        | 50 (16.7)          | 88 (12.8)             | 0.046   |
| Early death/stroke/AF (<30 d)            | 60 (6.3)            | 38 (6.5)          | 20 (6.7)           | 42 (6.1)              | 0.985   |
| Late death/stroke/AF (>30 d)             | 240 (25.0)          | 181 (31.0)        | 84 (28.0)          | 177 (25.8)            | 0.06    |

Data are shown as number (percentage) for categorical variables and mean±SD for continuous variables. AF indicates atrial fibrillation; IAB, interatrial block; and TAVI, transcatheter aortic valve implantation.
This study has some limitations. All of our data come from academic hospitals in Spain and might not be extrapolated to other centers. The mean follow-up (1.3 years) might be considered short to detect associations of advanced IAB with AF and stroke. However, our study is the first to describe an association between the presence of advanced IAB and prognosis in patients treated with TAVI. This association could have clinical relevance, as a simple inexpensive measurement of surface ECG could contribute to better risk stratification in this clinical scenario.

**CONCLUSIONS**

Baseline ECG characteristics influence the prognosis of patients with aortic stenosis treated with TAVI. Advanced IAB (P wave duration ≥120 ms with biphasic morphology in inferior leads) is present in about an eighth of patients and is associated with all-cause death and with the composite end point of death, stroke, and new AF during follow-up. Future studies should address the mechanisms that explain this association.
APPENDIX

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None.

REFERENCES
1. Zhang X, Wang T, Lan R, Dai Q, Kang L, Wang L, Wang Y, Xu W, Xu B. Meta-analysis comparing results of transcatheter versus surgical aortic-valve replacement in patients with severe aortic stenosis. Am J Cardiol. 2020;125:449–458.
2. Mack MJ, Leon MB, Thompson VH, Makkar R, Kodali SK, Russo M, Kapadia SR, Malaisrie SC, Cohen DJ, Pibarot P, et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. N Engl J Med. 2019;380:1695–1705.
3. Bruna V, Velasquez-Rodriguez J, Valero-Masa MJ, Perez-Guillen B, Vicent L, Diez-Delhoyo F, Devesa C, Sousa-Casasnovas I, Juarez M, Bayes de Luna A, et al. Prognostic of interatrial block after an acute ST-segment elevation myocardial infarction. Cardiology. 2019;142:109–115.
4. Martin-Demiguel I, Nunez-Il Gil U, Perez-Castellanos A, Vedia O, Uribarri A, Duran-Camba A, Martin-Garcia A, Corbi-Pascual M, Guilen Marzo M, Martinez-Sellés M. Prevalence and significance of interatrial block in Takotsubo syndrome (from the RETAKO Registry). Am J Cardiol. 2019;123:2039–2043.
5. Bayes de Luna A, Cladellas M, Oter R, Torner P, Guindo J, Martí V, Rivera I, Irrunáide P. Interatrial conduction block and retrograde activation of the left atrial appendage and paroxysmal supraventricular tachyarrhythmias. Eur Heart J. 1988;9:1112–1118.
6. Alexander B, Alexander B, Rodriguez C, de la Isla LP, Islas F, Quevedo PJ, Nombela-Franco L, Hopman WM, Jaff Z, Baranchuk A. Reverse atrial electrical remodeling induced by cardiac resynchronization therapy. J Electrocardiol. 2017;50:610–614.
7. Conde D, Baranchuk A, Bayes de Luna A. Advanced interatrial block as a substrate of supraventricular tachyarrhythmias: a well recognized syndrome. J Electrocardiol. 2015;48:135–140.
8. Alexander B, Rodriguez C, de la Isla LP, Islas F, Quevedo PJ, Nombela-Franco L, Hopman WM, Malik P, Baranchuk A. The impact of advanced interatrial block on new-onset atrial fibrillation following TAVR procedure. Int J Cardiol. 2016;223:672–673.
9. Martinez-Sellès M, Masso-va Rosssel A, Alvaro Garcia J, Garcia de la Villa B, Cruiz-Jentoft A, Vidan MT, Lopez Diaz J, Felix Redondo FJ, Duran Guerrero JM, Bayes-Genis A, et al. Interatrial block and atrial arrhythmias in centenarians: prevalence, associations, and clinical implications. Heart Rhythm. 2016;13:645–651.
10. Bayés de Luna A, Martínez-Sellés M, Bayés-Genis A, Eloua R, Baranchuk A. What every clinician should know about Bayés syndrome. Rev Esp Cardiol (Engl Ed). 2020;51885:5857:30274–30277.
11. Karyofillis P, Kostopoulou A, Thomopoulou S, Habibi M, Livianis E, Karavolis G, Voudris V. Conduction abnormalities after transcatheter aortic valve implantation. J Geriatr Cardiol. 2018;15:105–112.
12. Martinez-Sellés M, Bramlage P, Thoenes M, Schymik G. Clinical significance of conduction disturbances after aortic valve intervention: current evidence. Clin Res Cardio. 2015;104:1–12.
13. Gaede L, Kim WK, Liebetrau C, Dorr O, Sperzel J, Blumenstein J, Berkowitsch A, Walther T, Hamm C, Elsasser A, et al. Pacemaker implantation after TAVI: predictors of AV block persistence. Clin Res Cardiol. 2018;107:60–69.
14. Gensini GS, Caixeta A, Siqueira D, Carvalho LA, Sarmento-Leite R, Mangione JA, Lemos PA, Colafranceschi AS, Caramori P, Ferreira MC, et al. Predictors of permanent pacemaker requirement after transcatheter aortic valve implantation: insights from a Brazilian registry. Int J Cardiol. 2014;175:248–252.
15. Martinez-Sellés M, Escobar-Robledo LA, Bernal E, Nombela L, Ayesta A, Gomez-Doblas JJ, Lopez-Otero D, Gonzalez-Saldívar H, Fernandez-Cordon G, Bayes-de-Luna A, et al. Rational and design of the Baseline Interatrial block and Transcatheter aortic valve implantation (BIT) registry. J Electrocardiol. 2019;57:100–103.
16. Bachhal V, Saini G, Jindal N, Samet R, Dadra A. GeoGebra: A reliable and free software for measuring acetabular cup anteversion on digitalized plain radiographs. *J Clin Orthop Trauma*. 2020;11:S201–s205.

17. Ciuñfo L, Bruña V, Martínez-Sellés M, de Vasconcellos HD, Tao S, Zghaib T, Nazarian S, Spragg DD, Marine J, Berger RD, et al. Association between interatrial block, left atrial fibrosis, and mechanical dysynchrony: Electrocardiography-magnetic resonance imaging correlation. *J Cardiovasc Electrophysiol*. 2020;31:1719–1725.

18. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, Falk V, González-Juanatey JR, Harjola VP, Jankowska EA, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur Heart J*. 2016;37:2129–2200.

19. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373–383.

20. Bernal E, Bayes-Genis A, Ariza-Sole A, Formiga F, Vidan MT, Escobar-Robledo LA, Aboal J, Accornero L, Guerrero C, Ariza-Segovia I, et al. Interatrial block, frailty and prognosis in elderly patients with myocardial infarction. *J Electrocardiol*. 2018;51:1–7.

21. Escobar-Robledo LA, Bayes-de-Luna A, Lupon J, Baranchuk A, Moliner P, Martinez-Selles M, Zamora E, de Antonio M, Domingo M, Cediel G, et al. Advanced interatrial block predicts new-onset atrial fibrillation and ischemic stroke in patients with heart failure: The “Bayes’ Syndrome-HF” study. *Int J Cardiol*. 2018;271:174–180.

22. Baturova MA, Lindgren A, Shubik YV, Carlson J, Platonov PG. Interatrial block in prediction of all-cause mortality after first-ever ischemic stroke. *BMC Cardiovasc Disord*. 2019;19:37.

23. Rubaj A, Rucinski P, Kutarski A, Dabrowska-Kugacka A, Oleszczak K, Zimon B, Trojan M, Zapotiski T, Drozd J, Tarkowski A, et al. Cardiac hemodynamics and proinflammatory cytokines during biatrial and right atrial appendage pacing in patients with interatrial block. *J Interv Card Electrophysiol*. 2015;37:147–154.

24. Tichelbacker T, Bergau L, Pulis M, Friede T, Mutze T, Maier LS, Frey N, Hasenfuss G, Zabel M, Jacobshagen C, et al. Insights into permanent pacemaker implantation following TAVR in a real-world cohort. *PLoS One*. 2018;13:e0204503.

25. Nazif TM, Dizon JM, Hahni RT, Xu K, Babaliaros V, Douglas PS, El-Chami MF, Herrmann HC, Mack M, Makkar RR, et al. Predictors and clinical outcomes of permanent pacemaker implantation after transcatheter aortic valve replacement: the PARTNER (Placement of AoRtic TraNs catheterER Valves) trial and registry. *JACC Cardiovasc Interv*. 2015;8:60–69.

26. Gonzalez-Lopez E, Gallego-Delgado M, Guzzo-Merello G, de Haro-Del Moral FJ, Cobo-Marcos M, Robles C, Bornstein B, Salas C, Lara-Pezzi E, Alonso-Pulpon L, et al. Wild-type transthyretin amyloidosis as a cause of heart failure with preserved ejection fraction. *Eur Heart J*. 2015;36:2585–2594.

27. Watanabe Y, Kozuma K, Ikioi H, Kawashima H, Nara Y, Kataoka A, Nagura F, Nakashima M, Shiira S, Tada N, et al. Pre-existing right bundle branch block increases risk for death after transcatheter aortic valve replacement with a balloon-expandable valve. *JACC Cardiovasc Interv*. 2016;9:2210–2216.