# Very late occurrence of complete heart block without preexisting atrioventricular conduction abnormalities: A rare complication after transaortic valvular replacement

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## Introduction

Transaortic valve replacement (TAVR) has revolutionized the treatment of severe aortic stenosis. Complications such as atrioventricular (AV) conduction abnormalities including new left bundle branch block (LBBB) and various grades of intranodal AV block including complete heart block after TAVR are well described.[1] Although AV conduction abnormalities most commonly occur intraoperatively or during the immediate postoperative period, their very late occurrence post-TAVR in the *absence of preexisting AV conduction abnormalities* is rare and underrecognized. Since post-TAVR occurrence of very late heart block is considered one of the putative mechanisms underlying sudden cardiac death in this cohort of patients, its recognition and thorough understanding remains desirable.

We review 2 patients with normal preprocedure electrocardiograms (ECGs) undergoing TAVR without any post-procedural complications, who developed complete AV block several months postprocedure requiring permanent pacemakers.

## Case reports

### Case 1

A 74-year-old woman with a history of hypertension, severe chronic obstructive pulmonary disease with known aortic stenosis, and American Heart Association/American College of Cardiology stage D1 (Symptomatic, high gradient aortic stenosis with normal LV ejection fraction) was deemed a prohibitive risk for surgical aortic valve replacement (SAVR), but qualified for TAVR, because of patient's age, frailty, and comorbidities. Her echocardiogram showed a left ventricular (LV) ejection fraction of 70%, severe calcific aortic stenosis, and an LV outflow tract diameter of 2 cm. She had no significant obstructive coronary disease or pulmonary hypertension on left and right heart catheterization. Multiple pre-TAVR ECGs showed normal sinus rhythm (NSR) with a normal PR interval (130–138 ms). The QRS duration was also normal (68–76 ms), but an rSR pattern in lead $V_1$ was noted, which was likely a normal variant in light of normal QRS duration. No overt infranodal conduction abnormalities were noted. The QRS axis was also normal at +20°–30° (Figure 1A).

She underwent TAVR with a 29-mm CoreValve (Medtronic, Minneapolis, MN) via a transfemoral approach. Aortic insufficiency was noted after deployment, requiring balloon valvuloplasty with a 25-mm balloon. The post-TAVR mean aortic valve gradient was 8 mm Hg. The patient had a benign postoperative course and was monitored by telemetry without evidence of AV block or QRS widening. She was discharged on aspirin 81 mg/d and clopidogrel 75 mg/d 3 days after the procedure.

The ECG recorded ~20 hours after TAVR prosthesis deployment showed loss of an rSR pattern in leads $V_1$ and $V_2$, which was replaced with a QS pattern in lead $V_1$ with a small r wave in lead $V_2$ with a predominantly QS pattern. These changes coupled with modest QRS prolongation from 68 to 90 ms suggested preferential conduction over the right bundle, likely owing to sluggish conduction through the left bundle without overt LBBB (Figure 1B). Nonetheless, in 1 month these changes resolved with the resurgence of an r wave in leads $V_1$ through $V_3$ and normalization of QRS duration to baseline 78 ms, consistent with left to right septal depolarization via the left bundle without any significant infranodal conduction delay or block. No shift in the QRS axis was noted post-TAVR, precluding left anterior or

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**KEY TEACHING POINTS**

- After transaortic valve replacement (TAVR), complete atrioventricular (AV) block usually occurs during or immediately after the primary procedure and its very late occurrence is rare and may represent a putative mechanism of sudden death in this cohort of patients.
- The current dictum is that very late occurrence of complete AV block after TAVR occurs in patients with preexisting AV conduction abnormalities, most notably left bundle branch block; however, exception to this rule occur as described by our case reports and should be recognized as a clinical entity.
- Indications and length of cardiac monitoring after TAVR for the detection of AV block should be reevaluated.

posterior fascicular block. At follow-up, she had marked symptomatic improvement.

Approximately 1-year post-TAVR, the patient developed symptomatic complete AV heart block, requiring dual-chamber pacemaker implantation. Her echocardiogram revealed no significant changes from her previous postoperative echocardiogram.

At follow-up, she displayed normal dual-chamber pacemaker function, with 99% right ventricular pacing noted over 2 years of follow-up. The patient was also noted to be dependent on a backup pacing rate of 30 beats/min, again consistent with permanent AV block.

## Case 2

An 81-year-old woman with a medical history of peripheral arterial disease, hypertension, rheumatoid arthritis, chronic kidney disease stage III, and severe aortic stenosis was again deemed a prohibitive risk for SAVR, but qualified for TAVR. Her preoperative evaluation revealed severe aortic stenosis with an aortic valve area of 0.9 $cm^2$ with moderate regurgitation. She had moderate pulmonary hypertension estimated at 50–55 mm Hg. Pre-TAVR baseline ECGs showed NSR with a normal PR interval (124–132 ms) and QRS duration (84–98 ms). The QRS axis was noted at $\sim +30°$–$40°$, with normal R-wave progression (Figure 2A).

She underwent successful and uncomplicated TAVR with a 23-mm Salus valve as part of a clinical research study. Serial ECGs were recorded over a 4-day postoperative stay in the hospital at 2, 20, and 102 hours after TAVR valve deployment. These ECGs showed fluctuation of the PR interval, which was still within the normal range (124–168 ms) but the QRS duration remained essentially unchanged (90–104 ms). Furthermore, QRS axis and R-wave progression remained unchanged (Figure 2B).

ECGs were also recorded at 1 month and then at 6.5-month duration after TAVR, which showed NSR with a normal PR interval (132–184 ms) and QRS duration (82–84 ms) and unchanged QRS axis and R-wave progression. Approximately 11 months postprocedure, she developed complete AV block requiring dual-chamber pacemaker implantation. A transesophageal echocardiogram recorded at presentation did not show any significant movement of the aortic valve prosthesis.

Her pacemaker follow-up data are not available. However, all 4 ECGs recorded post–pacemaker implantation over 2 months showed atrial paced/sensed and ventricular paced rhythm, again suggesting likely permanent AV block.

## Discussion

TAVR has shown similar or improved survival in patients with severe symptomatic aortic stenosis who are at intermediate and high or prohibitive surgical risk.[2] While the adoption and utilization of this technology is rapidly expanding with improvement in the valve prosthesis and inclusion of intermediate- to low-risk patients,[3] postprocedure AV conduction abnormalities remain a serious concern, underscoring a need to thoroughly understand the pathophysiology of this common complication.[4]

The reported incidence of AV block requiring implantation of a permanent pacemaker varies with the kind of aortic valve used for TAVR. The most widely available commercial valves in the United States are the self-expanding CoreValve and balloon-expandable Edwards Sapien valves (Edwards Lifesciences, Irvine, CA). The incidence of postprocedure permanent pacemaker implantation is higher for self-expanding CoreValve than for the balloon-expandable Edwards Sapien valve at 25% and 7%, respectively,[1] the most common indication being complete or high-grade AV block, which occurs in 19% of patient undergoing CoreValve implantation and 5% undergoing Edward Sapien valve implantation.[1] The new-generation Sapien 3 valve has a higher rate of post-TAVR pacemaker implantation at 16.8%.[5]

In comparison, patients who underwent SAVR have a 2.0% incidence of pacemaker insertion within 30 days and 4.0% thereafter at a median follow-up of 3.76 years.[6] There seems to be a persistent 1% annual risk for pacemaker insertion postsurgery in the first years after SAVR.[6]

The CoreValve is a self-expanding nitinol frame. The frame is unsheathed and recapturable. It can be enhanced with postdeployment balloon dilatation. The Salus valve that was implanted in our second patient has since been taken off the market and the trial stopped owing to lack of funding. It has a nonmetallic frame with a pressure support structure and conformable double-ring annular sealing design. The device allows repositioning, retrieval, and assessment of valve performance before permanent implantation. It is filled with polymer once in place. It is not self-expanding or balloon expandable. The incidence of permanent pacemaker

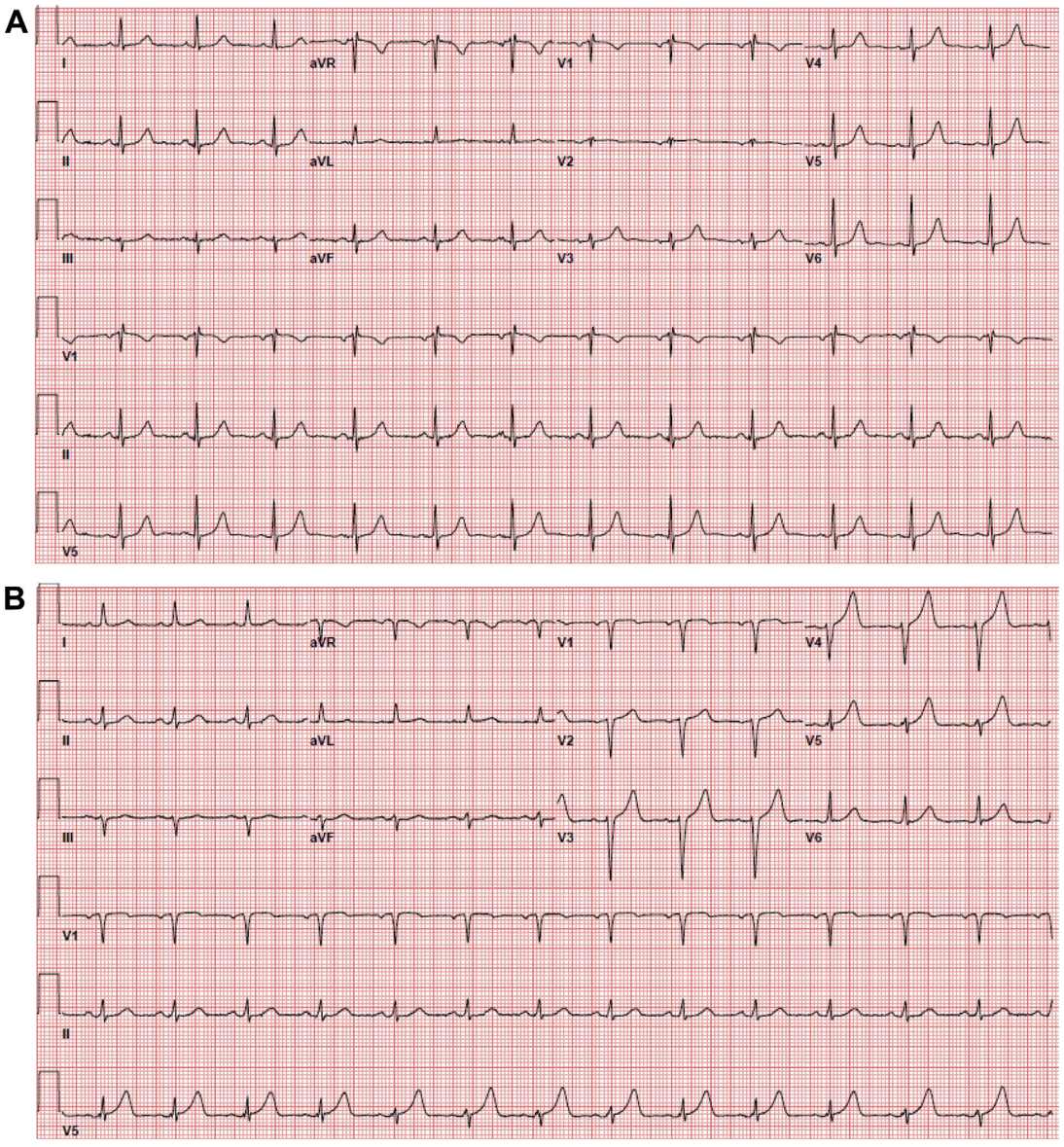


**Figure 1** **A:** Baseline 12-lead electrocardiogram (ECG) of case 1 before transaortic valve replacement, showing normal sinus rhythm with a normal PR interval as well as an rSR pattern in lead $V_1$ with normal QRS axis and duration. **B:** Twelve-lead ECG of the same patient 20 hours after transaortic valve replacement prosthesis deployment, showing minor changes in the septal depolarization as detailed in the case report. These changes resolved on follow-up ECG in 1 month.

implantation after the Salus valve implantation was 17% at 1 month and 21% at 1 year.[7]

Up to 90% of permanent pacemaker implantation is performed in the first week after TAVR,[1] with the majority (97%) being done during the index hospitalization.[8] Very late cases of AV block have been reported but are rare and have preexisting or newly acquired AV conduction abnormalities, such as LBBB, after TAVR.[9] Furthermore, post-TAVR sudden cardiac deaths, which amount to 5.6%–0.8% of all deaths,[10,11] are often putatively attributed to complete AV block, underscoring the need for pacemaker insertion, which may be lifesaving in these patients.[1,12] However, permanent pacemaker implantation in all patients with newly acquired LBBB after TAVR is controversial. A currently enrolling study is using ambulatory electrocardiographic monitoring with insertable loop recorders for the detection of high-grade AV block in patients with new persistent LBBB after transcatheter aortic valve implantation (MARE study: https://clinicaltrials.gov/ct2/show/NCT02153307). The results of this study are estimated to be available in 2018 and will shed more light on this controversy.

The risk for post-TAVR pacemaker implantation increases in men, self-expanding valves such as Medtronic CoreValve, baseline conduction disturbances (first-degree AV block, left anterior hemiblock, and right bundle branch block), intraprocedural AV block, and anatomical factors such as increase in the prosthesis to LV outflow tract diameter ratio (valve oversizing), short membranous septum, increased depth of implantation, and the presence of calcification in the basal septum.[4,8,13] Although risk factors for post-TAVR pacemaker implantation are well defined,

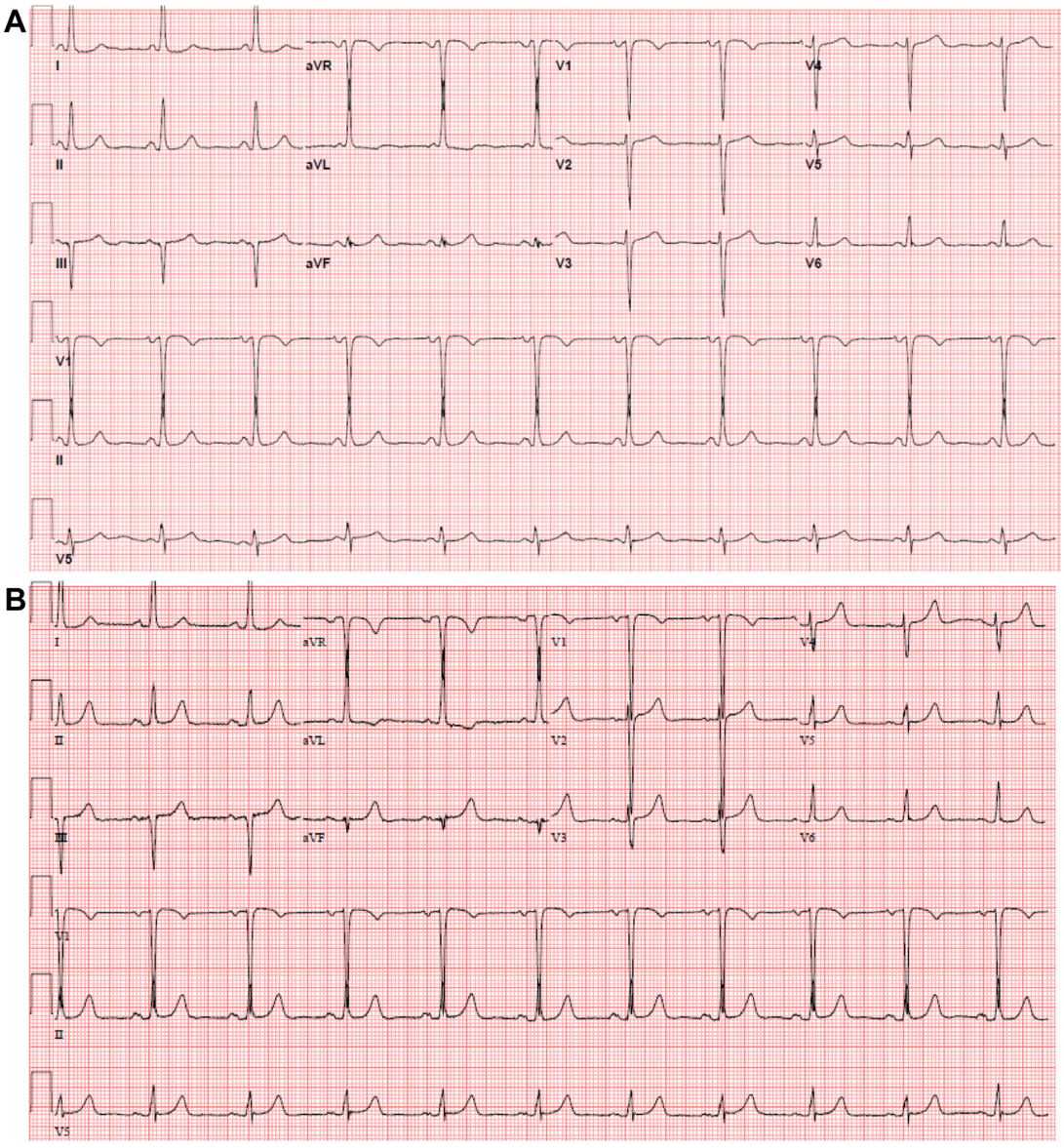


**Figure 2** **A:** Baseline 12-lead electrocardiogram (ECG) of case 2 before transaortic valve replacement, showing normal sinus rhythm with a normal PR interval as well as QRS axis and intervals. **B:** Twelve-lead ECG of the same patient on postprocedure day 4, showing no changes in the QRS axis or precordial septal activation. Mild prolongation of the PR interval, although still in the normal range, is noted.

long-term follow-up of patients who have undergone permanent pacemakers after TAVR show variable results, making it difficult to interpret the data. One study demonstrated significant worsening of the LV ejection fraction in patients with newly implanted pacemakers, even though it did not increase death or hospitalization from heart failure over a 2-year follow-up.[1] Conversely, in another study, new pacemaker implantation was associated with a longer duration of hospitalization and higher rates of repeat hospitalization and mortality at 1 year.[8]

Neither of our patients had significant infra-Hisian disease on pre- or post-TAVR 12-lead ECGs; however, one of them (Case 2) displayed mild prolongation of the PR interval but still within normal limits over time without evidence of any higher grades of AV block until she presented with complete heart block.

There were no known reversible causes for complete AV block in our patients. Routine clinical imaging did not reveal any significant TAVR prosthesis movement at the time of presentation with complete AV block; however, micromovement of the prosthesis cannot be completely ruled out. Furthermore, at follow-up after pacemaker implantation our patients remained pacemaker dependent, again suggesting the permanent nature of complete AV block.

## Conclusion

It is possible that the occurrence of complete AV block in our patients who underwent TAVR is coincidental and not directly linked to the valve prosthesis. However, making such an assumption would undermine the need to understand the pathophysiology of late-occurring complete AV block in

patients who underwent TAVR, which, as we have shown through our case reports, can occur without preexisting AV conduction abnormalities. This is especially important since complete AV block without substantial escape rhythm is one of the putative underlying mechanisms of sudden cardiac death after TAVR.

Indeed, early recognition of such high-risk patients in the absence of obvious AV conduction abnormalities on a 12-lead ECG poses a serious challenge and may require reevaluation of the indication and length of cardiac monitoring after TAVR.

## References


1. Urena M, Webb JG, Tamburino C, et al. Permanent pacemaker implantation after transcatheter aortic valve implantation: impact on late clinical outcomes and left ventricular function. Circulation 2014;129:1233–1243.
2. Huynh K. Interventional cardiology: TAVR improves survival in inoperable patients with severe aortic stenosis. Nat Rev Cardiol 2015;12:131.
3. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. N Engl J Med 2016;374:1609–1620.
4. Siontis GC, Juni P, Pilgrim T, Stortecky S, Bullesfeld L, Meier B, Wenaweser P, Windecker S. Predictors of permanent pacemaker implantation in patients with severe aortic stenosis undergoing TAVR: a meta-analysis. J Am Coll Cardiol 2014;64:129–140.
5. Herrmann HC, Thourani VH, Kodali SK, et al. One-year clinical outcomes with SAPIEN 3 transcatheter aortic valve replacement in high-risk and inoperable patients with severe aortic stenosis. Circulation 2016;134:130–140.
6. Van Mieghem NM, Head SJ, de Jong W, van Domburg RT, Serruys PW, de Jaegere PP, Jordaens L, Takkenberg JJ, Bogers AJ, Kappetein AP. Persistent annual permanent pacemaker implantation rate after surgical aortic valve replacement in patients with severe aortic stenosis. Ann Thorac Surg 2012;94:1143–1149.
7. Lefevre T, Colombo A, Tchetche D, et al. Prospective multicenter evaluation of the direct flow medical transcatheter aortic valve system: 12-month outcomes of the evaluation of the Direct Flow Medical Percutaneous Aortic Valve 18F System for the Treatment of Patients With Severe Aortic Stenosis (DISCOVER) Study. JACC Cardiovasc Interv 2016;9:68–75.
8. Nazif TM, Dizon JM, Hahn RT, et al. Predictors and clinical outcomes of permanent pacemaker implantation after transcatheter aortic valve replacement: the PARTNER (Placement of AoRtic TraNscathetER Valves) trial and registry. JACC Cardiovasc Interv 2015;8:60–69.
9. Rivard L, Schram G, Asgar A, et al. Electrocardiographic and electrophysiological predictors of atrioventricular block after transcatheter aortic valve replacement. Heart Rhythm 2015;12:321–329.
10. Urena M, Webb JG, Eltchaninoff H, et al. Late cardiac death in patients undergoing transcatheter aortic valve replacement: incidence and predictors of advanced heart failure and sudden cardiac death. J Am Coll Cardiol 2015;65:437–448.
11. Xiong TY, Liao YB, Zhao ZG, Xu YN, Wei X, Zuo ZL, Li YJ, Cao JY, Tang H, Jilaihawi H, Feng Y, Chen M. Causes of death following transcatheter aortic valve replacement: a systematic review and meta-analysis. J Am Heart Assoc 2015;4:e002096.
12. Salizzoni S, Anselmino M, Fornengo C, Giordana F, La Torre M, Moretti C, D'Amico M, Omede P, Marra S, Rinaldi M, Gaita F. One-year follow-up of conduction disturbances following transcatheter aortic valve implantation. J Cardiovasc Med (Hagerstown) 2015;16:296–302.
13. Hamdan A, Guetta V, Klempfner R, et al. Inverse relationship between membranous septal length and the risk of atrioventricular block in patients undergoing transcatheter aortic valve implantation. JACC Cardiovasc Interv 2015;8:1218–1228.