

Original article

Predictors of Conduction Disturbances after Aortic Valve Replacement: A Prospective Observational Study

Dr. Gandharbaraj Majhi¹, Prof. Dr. Harpreet Singh^{2*}

1.Senior Resident, Department of Cardiothoracic and Vascular Surgery (CTVS), G. B. Pant Hospital, New Delhi, India.

2.Director and Head of Department, Department of Cardiothoracic and Vascular Surgery (CTVS), G. B. Pant Hospital, New Delhi, India.

Corresponding Author- Prof. Dr. Harpreet Singh

Abstract

Background: Conduction disturbances are recognized complications following surgical aortic valve replacement (SAVR), resulting from the close anatomical relationship between the aortic valve complex and the atrioventricular conduction system. These abnormalities may range from transient first-degree atrioventricular (AV) block and bundle branch block to complete heart block requiring permanent pacemaker implantation.

Materials and Methods: This prospective observational study included 35 consecutive adult patients undergoing isolated SAVR during a six-month study period. Preoperative clinical characteristics, electrocardiographic parameters, echocardiographic findings, operative variables, and postoperative ECG changes were recorded. Patients were monitored for development of new conduction abnormalities during hospitalization. Associations between potential predictors and postoperative conduction disturbances were analyzed using appropriate statistical tests, with $p < 0.05$ considered statistically significant.

Results: Of 35 patients, 11 (31.4%) developed a new postoperative conduction disturbance. New left bundle branch block was the most common abnormality, occurring in 4 (11.4%) patients, followed by first-degree AV block in 3 (8.6%), complete AV block in 2 (5.7%), and new right bundle branch block in 2 (5.7%). Pre-existing conduction abnormalities, greater interventricular septal thickness, prolonged cardiopulmonary bypass time, and prolonged aortic cross-clamp time were significantly associated with postoperative conduction disturbances. Two patients (5.7%) required permanent pacemaker implantation.

Conclusion: Conduction abnormalities are relatively frequent following SAVR, although most are transient. Pre-existing conduction defects, septal hypertrophy, and prolonged operative times appear to identify patients at increased risk. Careful preoperative ECG assessment and postoperative rhythm surveillance are therefore important.

Keywords: Aortic valve replacement, conduction disturbance, atrioventricular block

Introduction

Aortic valve replacement remains the definitive intervention for patients with severe symptomatic aortic stenosis and selected patients with severe aortic regurgitation. Surgical aortic valve replacement (SAVR) continues to play an important role, particularly in younger patients, those requiring concomitant cardiac procedures, and patients whose anatomical or clinical characteristics favour surgery [1,2]. Despite improvements in operative techniques, myocardial protection, prosthetic valves, and perioperative care, conduction abnormalities remain important complications following SAVR.

The atrioventricular node, bundle of His, and proximal left bundle branch are located in close anatomical proximity to the aortic annulus and membranous interventricular septum. Surgical manipulation, annular

decalcification, local oedema, ischemia, suturing, and mechanical compression may therefore injure the conduction system [3,4]. Postoperative abnormalities may include first-degree AV block, bundle branch blocks, advanced AV block, and complete heart block. Although many disturbances are transient, persistent high-grade AV block may require permanent pacemaker implantation [5].

Identification of high-risk patients may facilitate appropriate monitoring and early intervention. Pre-existing conduction defects, calcification, septal hypertrophy, operative duration, and prosthesis-related factors have been implicated [3,6]. The present study was therefore undertaken to evaluate conduction abnormalities after SAVR and determine their clinical and perioperative predictors.

Materials and Methods

This was a prospective observational study conducted in the Department of Cardiovascular and Thoracic Surgery at a G.B. Pant hospital over a period of six months.

01/01/2026 to 30/06/2026

Study Population

A total of **35 consecutive adult patients** undergoing surgical aortic valve replacement during the study period were enrolled after satisfying the eligibility criteria.

Inclusion Criteria

Patients aged ≥ 18 years undergoing isolated SAVR for severe aortic stenosis, severe aortic regurgitation, or mixed severe aortic valve disease were included. Both mechanical and bioprosthetic valve replacements were considered eligible.

Exclusion Criteria

Patients with a previously implanted permanent pacemaker, previous cardiac surgery, congenital heart disease requiring complex repair, concomitant mitral or tricuspid valve surgery, emergency surgery, active infective endocarditis with periannular abscess, or incomplete perioperative ECG information were excluded.

Preoperative Evaluation

Detailed history was obtained regarding age, sex, hypertension, diabetes mellitus, coronary artery disease, functional status, syncope, and other cardiovascular risk factors. All patients underwent routine hematological and biochemical investigations.

A standard 12-lead ECG was obtained before surgery. Heart rate, rhythm, PR interval, QRS duration, AV block, left bundle branch block (LBBB), right bundle branch block (RBBB), and fascicular blocks were documented.

Transthoracic echocardiography was performed to assess aortic valve pathology, peak and mean transvalvular gradients, left ventricular ejection fraction (LVEF), interventricular septal thickness, left ventricular dimensions, and associated abnormalities.

Operative Technique

SAVR was performed under general anaesthesia through median sternotomy using standard cardiopulmonary bypass (CPB). Following aortic cross-clamping, myocardial protection was achieved with cardioplegia according to institutional protocol. The diseased native valve was excised and annular calcification was carefully debrided.

An appropriately sized mechanical or bioprosthetic valve was implanted.

Relevant intraoperative variables included CPB time, aortic cross-clamp time, prosthetic valve type and size, and operative findings regarding annular calcification.

Temporary epicardial pacing wires were placed according to routine surgical practice.

Postoperative Monitoring

Continuous ECG monitoring was performed in the intensive care unit. Standard 12-lead ECGs were obtained immediately after surgery, daily during the early postoperative period, before discharge, and whenever a rhythm abnormality was suspected.

A postoperative conduction disturbance was defined as a newly developed first-degree AV block, second-degree AV block, complete AV block, new LBBB, new RBBB, or other clinically significant intraventricular conduction abnormality occurring after SAVR.

Patients developing advanced AV block were managed with temporary pacing and observation. The decision for permanent pacemaker implantation was based on persistence and clinical significance of the conduction disturbance. Contemporary pacing guidance recommends observation after cardiac surgery when clinically appropriate because some postoperative AV blocks recover spontaneously [7].

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were expressed as frequencies and percentages. Continuous variables were compared using independent-samples t-test or an appropriate non-parametric test. Categorical variables were compared using Chi-square or Fisher's exact test. Variables demonstrating clinically relevant associations were assessed as potential predictors. A **p-value <0.05** was considered statistically significant.

Results

A total of 35 patients undergoing SAVR were studied. The mean age was 58.3 ± 9.6 years, with the majority of patients between 51 and 70 years of age. Twenty-two (62.9%) patients were male and 13 (37.1%) were female. Aortic stenosis was the predominant valve lesion.

Table 1. Baseline characteristics of the study population (n=35)

Variable	Value
Age, years, mean $\pm$ SD	58.3 ± 9.6
Male	22 (62.9%)
Female	13 (37.1%)
Hypertension	18 (51.4%)
Diabetes mellitus	9 (25.7%)
Coronary artery disease	5 (14.3%)
Predominant aortic stenosis	23 (65.7%)
Predominant aortic regurgitation	7 (20.0%)
Mixed aortic valve disease	5 (14.3%)
Mean LVEF (%)	54.8 ± 7.9
Septal thickness (mm)	12.8 ± 2.1
Pre-existing conduction abnormality	7 (20.0%)
Mechanical prosthesis	21 (60.0%)
Bioprosthetic valve	14 (40.0%)

Preoperative conduction abnormalities were documented in seven patients. These included first-degree AV block, bundle branch blocks, and fascicular conduction defects.

Following surgery, **11 of 35 patients (31.4%)** developed at least one new conduction disturbance. Twenty-four patients (68.6%) maintained their baseline conduction pattern without significant new abnormalities.

Table 2. Pattern of postoperative conduction disturbances

Postoperative ECG finding	Number	Percentage
No new conduction disturbance	24	68.6%
New first-degree AV block	3	8.6%
New LBBB	4	11.4%
New RBBB	2	5.7%
Complete AV block	2	5.7%
Total with conduction disturbance	11	31.4%
Permanent pacemaker required	2	5.7%

New LBBB was the most frequently observed abnormality, accounting for 4 patients (11.4%). Three patients developed first-degree AV block, while two developed RBBB. Complete AV block occurred in two patients. The lower-grade abnormalities resolved or improved during postoperative follow-up in most patients. Both patients with persistent complete AV block underwent permanent pacemaker implantation.

The characteristics of patients who developed conduction disturbances were compared with those who did not.

Table 3. Preoperative predictors of postoperative conduction disturbances

Variable	Conduction disturbance (n=11)	No disturbance (n=24)	p-value
Age (years)	61.6 ± 8.1	56.8 ± 9.9	0.17
Male sex	8 (72.7%)	14 (58.3%)	0.47
Hypertension	7 (63.6%)	11 (45.8%)	0.46
Diabetes mellitus	4 (36.4%)	5 (20.8%)	0.42
Predominant aortic stenosis	9 (81.8%)	14 (58.3%)	0.25
Pre-existing conduction abnormality	5 (45.5%)	2 (8.3%)	0.019
LVEF (%)	52.1 ± 8.4	56.0 ± 7.5	0.18
Septal thickness (mm)	14.2 ± 2.0	12.2 ± 1.8	0.006

Patients with pre-existing ECG conduction abnormalities had a significantly greater incidence of postoperative disturbances (45.5% vs. 8.3%; p=0.019). Similarly, interventricular septal thickness was significantly greater among patients developing conduction disturbances (14.2 ± 2.0 mm vs. 12.2 ± 1.8 mm; p=0.006).

Age, sex, hypertension, diabetes, and baseline LVEF were not significantly associated with postoperative conduction abnormalities in this small cohort.

Operative characteristics were also evaluated.

Table 4. Operative predictors of postoperative conduction disturbances

Variable	Conduction disturbance (n=11)	No disturbance (n=24)	p-value
CPB time (minutes)	104.6 ± 18.5	88.2 ± 15.4	0.009
Aortic cross-clamp time (minutes)	76.8 ± 14.2	63.5 ± 12.8	0.008
Mechanical valve	7 (63.6%)	14 (58.3%)	0.99
Bioprosthetic valve	4 (36.4%)	10 (41.7%)	0.99
Prosthesis size ≤21 mm	5 (45.5%)	7 (29.2%)	0.45
Marked annular calcification	8 (72.7%)	9 (37.5%)	0.07
Permanent pacemaker	2 (18.2%)	0	0.09

Mean CPB and aortic cross-clamp times were significantly longer among patients who developed conduction abnormalities. Marked annular calcification was also more frequent in this group, although statistical significance was not reached, possibly because of the limited sample size.

Overall, the findings suggested that pre-existing conduction abnormalities, increased interventricular septal thickness, prolonged CPB time, and prolonged aortic cross-clamp time were important predictors of postoperative conduction disturbance.

Discussion

Conduction disturbances are well-recognized complications of aortic valve replacement because of the anatomical proximity between the aortic annulus and cardiac conduction system. The penetrating bundle of His traverses the membranous septum near the junction of the right and non-coronary aortic cusps before dividing into bundle branches. Consequently, surgical excision of the valve, annular debridement, suturing, local edema, ischemia, and mechanical pressure can produce transient or permanent conduction injury [3,4].

In the present study, 31.4% of patients developed a new conduction abnormality following SAVR. However, clinically significant persistent complete AV block requiring permanent pacing occurred in only 5.7%. This distinction is important because minor and transient ECG changes are considerably more common than permanent high-grade AV block.

Current literature indicates that permanent pacemaker implantation is less frequent after conventional SAVR than after transcatheter aortic valve implantation. Reviews of contemporary valve intervention data have reported permanent pacemaker rates after SAVR around a few percent, although rates vary according to population, operative technique, concomitant procedures, and definitions [8]. TAVI, in contrast, has historically demonstrated substantially higher rates of new LBBB and permanent pacing [8,9]. The mechanisms nevertheless overlap, particularly mechanical injury or compression of the His-Purkinje system.

New LBBB was the commonest conduction abnormality in our study, occurring in 11.4% of patients. This finding is anatomically plausible because the left bundle branch lies close to the aortic annulus and left ventricular outflow tract. Trauma or edema involving the upper interventricular septum may therefore result in LBBB. Persistent LBBB is clinically relevant because ventricular electrical dyssynchrony may adversely affect left ventricular mechanics in susceptible patients.

Complete AV block occurred in two patients (5.7%), both of whom subsequently required permanent pacemaker implantation. High-grade postoperative AV block deserves particular attention because the decision regarding permanent pacing must balance the possibility of spontaneous recovery against the risks associated with prolonged temporary pacing and bradyarrhythmia. ESC pacing guidelines recommend a period of clinical observation of at least approximately five days for high-degree or complete AV block after cardiac surgery when the clinical circumstances permit, although this period may be shortened when recovery is considered unlikely and there is complete AV block with a poor escape rhythm [7].

One of the strongest findings in our study was the association between pre-existing conduction abnormalities and postoperative conduction disturbances. Among patients developing a new disturbance, 45.5% had a baseline conduction abnormality compared with only 8.3% of patients without postoperative disturbances. Pre-existing conduction disease probably represents reduced functional reserve within the His-Purkinje system. Additional perioperative trauma can convert subclinical or partial conduction impairment into clinically evident high-grade block.

This principle has been particularly well established in TAVI populations, where pre-existing RBBB is consistently identified as one of the strongest predictors of subsequent permanent pacing [7,9,10]. Contemporary ESC recommendations therefore specifically emphasize pre-existing RBBB when assessing conduction risk after TAVI. Although TAVI findings should not be directly extrapolated to surgical patients, they reinforce the biological importance of pre-existing His-Purkinje disease.

Another significant observation was the relationship between interventricular septal thickness and postoperative conduction abnormalities. Mean septal thickness was 14.2 mm in affected patients compared with 12.2 mm in unaffected patients. Severe aortic stenosis produces chronic pressure overload and compensatory left ventricular hypertrophy. Greater septal hypertrophy may alter the anatomical relationship between the left ventricular outflow tract, valve annulus, and conduction tissue. Hypertrophied and potentially fibrotic myocardium may also possess less electrophysiological reserve.

Prolonged CPB and aortic cross-clamp times were additional significant predictors. Mean CPB time was approximately 16 minutes longer and cross-clamp time approximately 13 minutes longer among patients developing conduction abnormalities. Longer operative durations may indicate greater technical complexity, more extensive annular debridement, difficult valve implantation, or prolonged myocardial ischemia. Each of these mechanisms could increase the probability of injury to the conduction system.

Marked annular calcification was present in 72.7% of patients developing conduction abnormalities compared with 37.5% without disturbances. Although this difference did not achieve conventional statistical significance, the magnitude of the difference may be clinically meaningful. Extensive calcification necessitates more aggressive annular debridement and manipulation, potentially increasing trauma near the membranous septum. With only 35 patients, the present study has limited statistical power for detecting moderate associations.

Recognition of conduction abnormalities is important beyond the immediate postoperative period. Although many transient blocks recover as edema and local inflammation resolve, delayed or persistent high-grade conduction abnormalities may occur. Continuous rhythm surveillance in the intensive care unit, serial ECGs, correction of electrolyte abnormalities, and temporary epicardial pacing capability remain important components of postoperative care.

The clinical relevance of minimizing unnecessary permanent pacing should also be recognized. Long-term right ventricular pacing may adversely affect ventricular synchrony and function in selected patients. Modern pacing guidelines therefore emphasize appropriate patient selection and physiological pacing strategies where applicable [7]. The 2020 ACC/AHA guideline also emphasizes individualized management of patients undergoing valve intervention based on clinical, anatomical, and procedural characteristics [1].

Our findings support a simple risk-stratification approach. Patients with preoperative bundle branch or AV conduction abnormalities, substantial septal hypertrophy, extensive annular calcification, or technically prolonged operations should be regarded as higher risk. Such patients may benefit from particularly close telemetry, serial ECG evaluation, retention of temporary pacing capability, and timely electrophysiological consultation when advanced block persists.

Conclusion

Conduction disturbances are relatively common following surgical aortic valve replacement, although the majority are transient and do not require permanent pacing. In the present study, 31.4% of patients developed a new postoperative conduction abnormality, while 5.7% required permanent pacemaker implantation.

Pre-existing conduction abnormalities, increased interventricular septal thickness, prolonged cardiopulmonary bypass time, and prolonged aortic cross-clamp time were significantly associated with postoperative conduction disturbances. Extensive annular calcification also demonstrated a clinically relevant trend toward increased risk. Careful preoperative ECG assessment, evaluation of ventricular and septal morphology, meticulous operative technique, and systematic postoperative rhythm monitoring are essential. Identification of high-risk patients may permit earlier recognition of clinically significant AV block and facilitate appropriate temporary or permanent pacing decisions.

References

1. Otto CM, Nishimura RA, Bonow RO, et al. 2020 ACC/AHA guideline for the management of patients with valvular heart disease. *J Am Coll Cardiol.* 2021;77(4):e25-e197.
2. Vahanian A, Beyersdorf F, Praz F, et al. 2021 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J.* 2022;43(7):561-632.
3. Dawkins S, Hobson AR, Kalra PR, Tang ATM, Monro JL, Dawkins KD. Permanent pacemaker implantation after isolated aortic valve replacement: incidence, indications, and predictors. *Ann Thorac Surg.* 2008;85(1):108-112.
4. Erdogan HB, Kayalar N, Ardal H, et al. Risk factors for requirement of permanent pacemaker implantation after aortic valve replacement. *J Card Surg.* 2006;21(3):211-215.
5. Limongelli G, Ducceschi V, D'Andrea A, et al. Risk factors for pacemaker implantation following aortic valve replacement: a single centre experience. *Heart.* 2003;89(8):901-904.
6. Matthews IG, Fazal IA, Bates MGD, Turley AJ. In patients undergoing aortic valve replacement, what factors predict the requirement for permanent pacemaker implantation? *Interact Cardiovasc Thorac Surg.* 2011;12(3):475-479.
7. Glikson M, Nielsen JC, Kronborg MB, et al. 2021 ESC guidelines on cardiac pacing and cardiac resynchronization therapy. *Eur Heart J.* 2021;42(35):3427-3520.

8. Bruno F, D'Ascenzo F, Vaira MP, et al. Predictors of pacemaker implantation after transcatheter aortic valve implantation according to kind of prosthesis and risk profile: a systematic review and contemporary meta-analysis. *Eur Heart J Qual Care Clin Outcomes*. 2021;7(2):143-153.
9. 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. *J Am Coll Cardiol*. 2020;76(20):2391-2411.
10. Siontis GCM, Jüni P, Pilgrim T, et al. Predictors of permanent pacemaker implantation in patients with severe aortic stenosis undergoing TAVR: a meta-analysis. *J Am Coll Cardiol*. 2014;64(2):129-140.
11. Van Mieghem NM, Head SJ, de Jong W, et al. Persistent annual permanent pacemaker implantation rate after surgical aortic valve replacement in patients with severe aortic stenosis. *Ann Thorac Surg*. 2012;94(4):1143-1149.
12. Bagur R, Rodés-Cabau J, Gurvitch R, et al. Need for permanent pacemaker as a complication of transcatheter aortic valve implantation and surgical aortic valve replacement in elderly patients with severe aortic stenosis and similar baseline electrocardiographic findings. *JACC Cardiovasc Interv*. 2012;5(5):540-551.
13. Baraki H, Al Ahmad A, Jeng-Singh S, et al. Pacemaker dependency after isolated aortic valve replacement: do conductance disorders recover over time? *Interact Cardiovasc Thorac Surg*. 2013;16(4):476-481.
14. Moskowitz G, Hong KN, Giustino G, et al. Incidence and risk factors for permanent pacemaker implantation following mitral or aortic valve surgery. *J Am Coll Cardiol*. 2019;74(21):2607-2620.
15. Schurr UP, Berli J, Berdajs D, et al. Incidence and risk factors for pacemaker implantation following aortic valve replacement. *Interact Cardiovasc Thorac Surg*. 2010;11(5):556-560.