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Current Opinion on Physiological Pacing and New-Onset Left Bundle Branch Block after Transcatheter Aortic Valve Replacement

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Abstract

Transcatheter aortic valve replacement is increasingly used to treat patients with aortic stenosis who are considered to be high-risk for surgical replacement. The occurrence of new conduction abnormalities remains to be a vexing issue. New-onset left bundle branch block is a major concern and may affect prognosis after transcatheter aortic valve replacement. Understanding the intimate relationship between the conduction axis and the aortic root, in addition to elucidation of factors related specifically to the procedure, devices, and patients, might help to reduce these conduction abnormalities. Physiological pacing appears as a reasonable pacing modality for patients with cardiac insufficiency, especially when combined with left bundle branch block and should be applicable to patients post valve replacement. The purpose of this review is to summarize the current opinion on the incidence of new-onset left bundle branch block associated with transcatheter aortic valve replacement, to offer insights into its anatomical and procedural causes, clinical consequences, and more importantly, the prospect of applying physiologic pacing as a therapeutic method for these patients.

Keywords: Transcatheter aortic valve replacement; New-onset left bundle branch block; His bundle pacing; Left bundle pacing

Introduction

Transcatheter Aortic-Valve Replacement (TAVR) is an accepted alternative to surgery for certain patients with severe Aortic Stenosis (AS). The technology has been proved to be effective and has becoming a solid treatment option nowadays. However, conduction disturbances are major complications of this procedure. Conduction disturbances in this setting mainly include complete Atrioventricular Block (AVB) and New-Onset Left Bundle Branch Block (NO-LBBB) which partly offset the benefit of this remarkable technology. The mechanism of conduction abnormalities following TAVR may be explained by the close anatomical relationship between the implantation site of the aortic prosthesis and the conduction system, with incidence varies among different implantation techniques and the morphology of the prostheses used. These complications limit the application of TAVR in patients who are younger or of low-risk for surgical operations1-2. The incidence of complete AVB following TAVR is well described and Permanent Pacemaker Implantation (PPI) is recommended as a remedy. However, the reported incidence of NO-LBBB after TAVR has a huge variation. For NO-LBBB, there is still controversy regarding the definition, cause, incidence of the variation, and its effect on cardiac function. The optimal strategy for NO-LBBB management in this population hasn't been clearly established yet.

Pathogenesis, Influence Factors of NO-LBBB

The anatomical relationship between the aortic valve and the cardiac conduction system is the basis of postoperative conduction abnormalities in TAVR. His bundle is close to the aortic valve when it crosses the central fibrous body and reaches the interventricular septal membrane, and the left bundle branch is close to the bottom of the fibrous triangle between the non-coronary sinus valve and the right coronary valve. Direct mechanical damage to the conduction system, including edema, inflammation, and ischemia, may occur during the insertion of the guide wire, balloon dilation, and valve implantation. In addition, the following factors may affect the occurrence of LBBB. Anatomical factors: such as pre-existed conduction abnormalities and aortic valve calcification increase the incidence of new conduction block after TAVR; Procedural factors, especially the implantation depth of the valve in the Left Ventricular Outflow Tract (LVOT). The risk of LBBB increased by 15% to 40% for each 1 mm further in depth of valve implantation. Currently, the recommended depth of valve implantation is less than 6 mm; Device-related factors: novel transmission conduction delay is also affected by the prosthesis type and size. The self-expanding valve system will expand further after implantation, exerting a higher radial force on LVOT and resulting in a higher incidence of conduction block.

Incidence, Variation and Timing of NO-LBBB after TAVR

NO-LBBB is a specific concern of TAVR given its estimated incidence ranging from 5% to 65%. To date, the incidence of TAVR related LBBB has been reported as high as 77%. The great variation in incidence of LBBB following TAVR in different studies are most likely due to different inclusion criteria and the use of different valve types. For example, it is known that the Core Valve prosthesis has a higher incidence of NO-LBBB than the Edwards SAPIEN prosthesis. Another important reason for the hugely varied incidence of NO-LBBB is these studies have not addressed whether or not patients classified as having post-procedural LBBB were strictly diagnosed LBBB. However, no study up until now has evaluated the incidence of LBBB with the strict criteria and it is therefore possible that the

outcome was affected due to patients without true LBBB were analyzed as LBBB patients. Alqarawi et al described the ECG findings of new LBBB post TAVR and proposed a new ECG definition of LBBB which includes 2 novel findings: notching/slurring of the R wave in at least one lateral lead and an R wave ≤ 20 ms in V15. A recent Expert Panel suggested that patients with unresolved NO-LBBB on day 2 post TAVR, which defined as QRS duration >150 ms or PR interval >240 ms could be considered for PPI. In addition, approximately 90% of TAVR related NO-LBBB occurs within 24 h, and may be associated with mechanical damage of the guide system. The damage may be temporary, some NO-LBBB can be recovered within hours or days. However, nearly 60% of them will persist after discharge. Late-onset LBBB is very rare. Therefore, prolonged postoperative ECG monitoring is necessary.

Clinical Consequences of NO-LBBB

High-grade AVB after TAVR usually indicates a poor prognosis, however, patients with NO-LBBB often have insidious clinical symptoms and weak intervention indications. The effect on cardiac function and mortality of TAVR related NO-LBBB is also controversial. Houthuizen et al6 found that 34% （233/679） of patients developed NO-LBBB upon hospital discharge, and patients with LBBB post TAVR had an increased mortality and morbidity compared to those without LBBB, while Testa et al7 found that 27% (224/818) of patients developed NO-LBBB by hospital discharge, mortality and morbidity remained statistically insignificant after 1 year follow up. However, echocardiographic data of Testa's study were only available in 50% of the patients. However, only the Edwards SAPIEN prosthesis were implanted in those studies, and the number of patients developed persistent LBBB was significantly lower. The low incidence of LBBB makes it difficult to evaluate outcomes in this group. In a recent study of 1629 patients undergoing TAVR by Chamandi etc., after 3 years of follow-up, patients with NO-LBBB had a mean decrease in LVEF of (1.4 ± 0.9) % (P<0.001), and LVEF increased (1.9 ± 0.6) % in patients without LBBB (P=0.002), and PPI rate increased (15.5% vs. 5.4%, P=0.002) in patients with NO-LBBB10. Thus, NO-LBBB after TAVR implantation is associated with a deterioration in cardiac function and quality of life, but the effect on mortality was unsure.

Pacing Treatment of new LBBB

At present, there is no unified guideline for the indications for pacing therapy after TAVR, and the determination of pacing patients is usually based on clinician's personal judgment. Prompt pacing intervention is very necessary for patients with high-grade AVB, but whether pacing should be performed in patients with NO-LBBB remains controversial. American College of Cardiology published a guideline in 2019 in which a permanent pacemaker implantation was recommended in high-degree AVB and for late onset of high-degree AVB patients at high risk for LBBB (prolonged PR interval or QRS duration ≥ 20ms, or QRS duration ≥ 150ms or PR interval ≥ 240ms) after TAVR, the monitoring time of ECG was prolonged by at least 2~4 weeks, and further electrophysiological examination should be performed if necessary. This guideline does not provide specific guidance as to the management of LBBB after TAVR.

The timing of pacing therapy has not been determined. The European Society of Cardiology (ESC) recommends the use of a "delayed implantation" strategy, since part of the conduction block will resume as the edema and inflammation gradually decrease. As to the type of pacemaker and the choice of the way of pacing in NO-LBBB patients, it has not been clearly described yet. For patients combined with cardiac insufficiency, Cardiac Resynchronization Therapy (CRT) can be a better choice. His-Purkinje Conduction System Pacing (HPCSP) can directly capture His bundle or left bundle branch, which is a more physiological pacing mode. However, the correction of LBBB by His Bundle Pacing (HBP) usually requires a higher pacing output and has a relatively lower success rate. Conduction disorders may be beyond His bundle or even distal in patients with mechanical impairment after TAVR. Another recently described physiological pacing modality, could offer an alternative in post TAVR patients with unsuccessful HBP. Vijayaraman et al, reported their multicenter experience of conduction system pacing in 65 patients post-TAVR. The success rate for left bundle branch pacing (LBBP) was significantly higher than HBP (93% vs 63%, respectively) and the success rate for HBP significantly varied among different valve types (69% in the Sapien valve compared with 44% in patients with core valve; P<0 .05). LBBP is delivered by bypassing the pathologic region, although proximal LBB was probably impaired by TAVR while the distal network beyond the site of block was probably intact. In addition, LBBP was also associated with significantly lower pacing thresholds and higher R-wave amplitudes than HBP.

So far there is no study on pacemaker or cardiac resynchronization therapy pacing/Cardiac Resynchronization Therapy Defibrillator (CRTP/D) implantation for patients with cardiac failure in TAVR induced NO-LBBB. Ventricular electrical activity dyssynchrony caused by LBBB can counteract the positive effect of TAVR on cardiac function, leading to poor recovery of LVEF. It's hard to tell how much LBBB contributes to a patient's EF decline. Therefore, it would be inappropriate to assess whether the patient requires bi-ventricular pacing or LBBP by traditional CRT indications. Further observational data on prospective studies are needed to evaluate benefit of physiological pacing with biventricular or HPCSP in patients requiring pacemaker implantation after TAVR.

Conclusion

NO-LBBB after TAVR should be treated with CRT as early as possible, physiological pacing is highly recommended. Actually, patients with normal QRS duration who develop LBBB immediately post TAVR, especially those combined with cardiac insufficiency provide an excellent model to re-study the mechanism of LBBB and the indication for CRT implantation. As rapid development of TAVR procedures, patients who develop NO-LBBB should be closely monitored for progression of heart failure, and LBBB correction using physiological pacing may serves as an effective treatment strategy. Further studies are needed to elucidate the pathophysiological basis of NO-LBBB, the factors that influence its outcome, the optimal timing and indication for pacing, and the concerns about the long-term performance of physiological pacing in this setting.

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