REVIEW

Transcatheter Aortic Valve Implantation and Complications Regarding Cardiac Conductance

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Abstract

Degenerative aortic stenosis is an inflammatory process, affecting up to 12% of patients aged over 85 years. Transcatheter aortic valve implantation (TAVI) has become the preferred option for symptomatic, high and intermediate risk patients, including those denied for surgical valve replacement. Aortic stenosis is associated with prolonged atrio-ventricular (AV) conduction time, as well as higher degree of AV conduction disorders. In addition, it was observed that TAVI patients have a higher incidence of conduction abnormalities during the procedure, as well as during the following days, many of them requiring the implantation of a permanent pacemaker. Definitive guidelines for management of the conduction disorders are not yet available, the burden of choosing the best approach being put on each individual clinician.

Keywords: aortic stenosis, transcatheter aortic valve replacement, conduction disorders, left and right bundle branch block, high grade atrio-ventricular block, permanent pacemaker implantation.

Introduction

Degenerative calcific aortic stenosis is a progressive inflammatory process. Severe aortic stenosis (AS) is currently defined by an aortic valve area (AVA) <1.0 cm^2 and/or a mean transaortic pressure gradient (MPG) >40 mm Hg and/or a peak aortic jet velocity (V_{max}) >4 m/s [1]. Aortic stenosis is the most frequent valvular heart disease in the Western world, estimations being that approximately 1-2% of patients aged over 65 years have moderate to severe aortic stenosis. Furthermore, this rate increases up to 12% in patients aged over 85 years [2].

Transcatheter aortic valve implantation (TAVI) is an expanding, catheter-based procedure that allows the implantation of a prosthetic valve, without the requirement of an open-heart surgery for the management of

severe aortic stenosis. Since its introduction in 2002, TAVI has emerged as the preferred option of treatment for symptomatic severe aortic stenosis in high and intermediate risk patients, including the cases denied for opened surgical approach [3-5]. In 2017, during the European Society of Cardiology (ESC) meeting, TAVI indications were extended to intermediate risk patients when transfemoral approach (TFA) is feasible [6]. However, due to its adverse effects, mainly concerning conduction abnormalities (bundle branch block – BBB and high grade atrio-ventricular block - HAVB) requiring permanent pacemaker implantation – PPMI, the procedure has failed to address a younger, lower surgical risk population [7].

Apart from increasing hospital length of stay and financial burden, conduction abnormalities have been associated with adverse long term clinical outcomes. Considering that, the next step in improving TAVI results might be represented by preventing and treating conduction abnormalities.

Anatomy of the aortic valve and the conduction system

The aortic valve, which is tricuspid in most cases, is attached to the aortic wall. The root, made up by the valvular leaflets and their supporting sinuses, is related to all four chambers of the heart. The atrio-ventricular (AV) node is located inferior to the apex of the triangle of Koch, adjacent to the membranous septum, meaning that the AV node is near the subaortic region. The AV node continues as the bundle of His, which is located in the membranous septum and branches into the left and right bundle. Inter-individual variations of the penetrating bundle length and depth of septal penetration and variation in the location of the proximal portion of the left bundle determine the susceptibility of a patient to developing complete block or LBBB [8].

Three major variants were described that, depending on which is present, determine the susceptibility of a patient developing complete block or LBBB. LBBB likelihood is determined by how soon the left bundle appears on the left side of the septum, and injury is affected by the relative positioning of the membranous septum with respect to the aortic cusps [9].

Conduction abnormalities

Aortic stenosis is associated with prolonged AV conduction time, as well as higher degree of AV conduction disorders.

MacMillan et al performed a study on 48 consecutive patients with aortic stenosis undergoing cardiac catheterization and electrophysiologic studies to record HV interval (the interval from the first rapid deflection of the His potential to the earliest onset of ventricular depolarization as seen on the surface electrogram or the His electrogram) [10]. It was observed that there is an inverse correlation between the duration of the HV interval and the aortic valve area ($p<0.02$), meaning that while the severity of the stenosis increases, the intraventricular conduction worsens.

In addition to these conduction abnormalities, PARTNER trial [3] showed an incidence of atrial fibrillation of approx. 40% between the prohibitive and the high surgical risk cohorts.

Conduction disorders and need for PPM after TAVI

It was observed that in patients undergoing TAVI, conduction disorders occur early during the procedure [11, 12]. Not only that more than half of the new conduction abnormalities appear before the actual valve implantation, but new disorders may appear at some time after TAVI [12].

Widening of QRS was noted in almost 50% of patients during the procedure – most of them after the implantation of the device, and one third after percutaneous aortic valvotomy or guidewire crossing of the native aortic valve [13].

Considering all these aspects, new-onset LBBB and high grade atrio-ventricular block, as well as the need for permanent pacemaker implantation (PPMI) represent important clinical problems after TAVI.

The pathophysiology behind all conduction disturbances has not been fully elucidated. Several studies took into account both patient and procedure-related factors, such as septal wall thickness, non-coronary cusp thickness, pre-existing RBBB, post-implant prosthesis expansion, type of prosthesis and depth of valve implantation within LVOT [14-16]. Independent from the type of prosthesis used, deeper implantation was correlated with higher risk of new conduction disturbance.

Due to the high frequency of BBB and HAVB, PPMI is an important aspect to consider in patients' management post TAVI. Peri-procedural heart block has proven to be a challenge, especially determining when to implant a permanent pacemaker. AV block after TAVI is exhibiting dynamic properties, some research recommending 7-day ECG monitoring [17].

AHA/ACC/STS guidelines give little guidance regarding timing of PPMI, leaving the decision to individual physicians [18].

However, delaying PPMI is associated with increase length of stay in the hospital, higher costs, and increased risk of acquiring hospital infections.

The effect a new permanent pacemaker has on survival after TAVI is unclear. In addition to the PPMI procedure risks, long-term right ventricular pacing was shown to increase re-hospitalization for cardiac failure and to increase mortality [19]. In a retrospective analysis of 2,599 patients from PARTNER Trial, patients after PPMI were more likely to have repeated hospitalizations (23,9% vs 18,2%, p=0.05) [3]. In REPRISE III, a prospective, randomized TAVI trial, analysis of the 864 patients discharged from the hospital, revealed that patients with PPMI before the procedure had highest rate of all-cause death compared to patients never receiving a pacemaker or having PPMI after TAVI [20].

Conclusions

Considering the presence of severe cardiac pathological features, in conjunction with other noncardiac comorbidities, patients undergoing TAVI are characterized by a very high-risk profile. One of the most frequent adverse effects of the procedure, conduction abnormality, is increasing the overall risk of poor outcome. With progress being done in understanding the mechanisms behind the development of conduction disorders, as well as finding out the best approach for permanent pacemaker implantation, lower risk patients might benefit from TAVI in the future.

Author Contributions:

A.M. conceived the original draft preparation. A.C., A.M., and O.P. were responsible for conception and design of the review. VA.I., and O.P. were responsible for the data acquisition. VA.I, A.M., and O.P. were responsible for the collection and assembly of the articles/published data, and their inclusion and interpretation in this review. A.C., A.M., VA.I., and O.P. contributed equally to the present work. All authors contributed to the critical revision of the manuscript for valuable intellectual content. All authors have read and agreed with the final version of the manuscript.

Compliance with Ethics Requirements:

"The authors declare no conflict of interest regarding this article".

Acknowledgements:

None

References

[1] Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease. *Journal of the American College of Cardiology*. 2014;63(22).

[2] Nkomo VT, Gardin JM, Skelton TN, et al. Burden of valvular heart diseases: a population-based study. *Lancet* 2006; 368:1005–1011.

[3] Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *N Engl J Med*. 2010;363(17):1597-1607. doi:10.1056/NEJMoa1008232

[4] Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med*. 2016;374(17):1609-1620.

[5] Smith CR, Leon MB, Mack MJ, et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med.* 2011;364(23):2187-2198.

[6] Baumgartner H, Falk V, Bax JJ, De Bonis M, Hamm C, Holm PJ, et al. ESC Scientific Document Group, ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J*. 2017;38:2739–91.

[7] Chakos A, Wilson-Smith A, Arora S, et al. Long term outcomes of transcatheter aortic valve implantation (TAVI): a systematic review of 5-year survival and beyond. *Ann Cardiothorac Surg* 2017;5: 432-43.

[8] Karyofillis P, Kostopoulou A, Thomopoulou S, et al. Conduction abnormalities after transcatheter aortic valve implantation. *Journal of Geriatric Cardiology* 2018;15(1)105-112.

[9] Kawashima T, Sato F. Visualising anatomical evidences on atrioventricular conduction system for TAVI. *Int J Cardiol* 2014;174:1–6.

[10] MacMillan RM, Demorizi NM, Gessman LJ, et al. Correlates of prolonged HV conduction in aortic stenosis. *Am Heart J* 1985;119:56-60.

[11] Roten L, Stortecky S, Scarcia F, et al. Atrioventricular conduction after transcatheter aortic valve implantation and surgical aortic valve replacement. *J Cardiovasc Electrophysiol* 2012;23:1115–1122.

[12] Nuis RJ, Van Mieghem NM, Schultz CJ, et al. Timing and potential mechanisms of new conduction abnormalities during the implantation of the Medtronic CoreValve System in patients with aortic stenosis. *Eur Heart J* 2011;32:2067–2074.

[13] Piazza N, Onuma Y, Jesserun E, et al. Early and persistent intraventricular conduction abnormalities and requirements for pacemaking after percutaneous replacement of the aortic valve. *J Am Coll Cardiol Intv* 2008;1:310–316.

[14] Gutiérrez M, Rodés-Cabau J, Bagur R, et al. Electrocardiographic changes and clinical outcomes after transapical aortic valve implantation. *Am Heart J* 2009;158: 302–308.

[15] Roten L, Wenaweser P, Delacretaz E, et al. Incidence and predictors of atrioventricular conduction impairment after transcatheter aortic valve implantation. *Am J Cardiol* 2010;106(10):1473-80.

[16] Bleiziffer S, Ruge H, Horer J, et al. Predictors for new-onset complete heart block after transcatheter aortic valve implantation. *JACC Cardiovasc Interv* 2010; 3:524–530.

[17] Erkapic D, De Rosa S, Kelava A, et al. Risk for permanent pacemaker after transcatheter aortic valve implantation: a comprehensive analysis of the literature. *J Cardiovasc Electrophysiol* 2012;23:391–397.

[18] Epstein AE, DiMarco JP, Ellenbogen KA, et al. ACC/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: a report of the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices) developed in collaboration with the AATS and STS. *J Am Coll Cardiol*. 2008;51(21):e1-62.

[19] Aljabbary T, Qui F, Masih S, et al. Association of clinical and economic outcomes with permanent pacemaker implantation after transcatheter aortic valve replacement. *JAMA Network Open*. 2018;1(1): e180088.

[20] Kereiakes DJ, Meduri CU, Makkar RR, et al. Pacemaker dependency following transcatheter aortic valve implantation: A subanalysis of the REPRISE III randomized controlled clinical trial. Presented at the American College of Cardiology Scientific Sessions, March 10th, 2018; Orlando, FL.