



Hemodynamic Monitoring During Transcatheter Aortic Valve Replacement – Another Tool in the Shed



Daniel H. Steinberg
 Medical University of South Carolina, Charleston, SC
 E-mail address: steinbe@musc.edu

As transcatheter aortic valve replacement (TAVR) becomes increasingly applied across a wider spectrum of patient age and clinical risk, focus must always remain centered on the intraprocedural outcomes and safety. However, with lower-risk patients comes an increased need to focus on longer-term outcomes and the potential downstream effects of currently accepted “costs of business” in TAVR including, but not limited to, greater degrees of aortic insufficiency (AI) compared to surgical aortic valve implantation.

In patients undergoing TAVR, AI occurs centrally as a result of improper valve sizing or suboptimal deployment, or it may be paravalvular as a result of inadequate apposition of the prosthesis against the aortic annulus [1]. Regardless of the cause, significant AI results in acute pressure overload, a condition that can be poorly tolerated in hypertrophied hearts with underlying diastolic dysfunction. This clearly accounts for the impact of moderate or greater AI on short and mid-term outcomes. However, the impact of mild AI is less consistently associated with adverse short- and mid-term outcomes, though it stands to reason that a downstream effect may exist [2–4]. As such, efforts to minimize post-TAVR AI, be it through optimal planning, valve technology, implantation technique, or procedural monitoring, should remain at the center of current focus, and longer-term results of the pivotal clinical trials are eagerly awaited.

It is standard practice to monitor for AI during TAVR, multiple modalities exist, and the preferred means for evaluation vary by institution and procedural setup (i.e., conscious versus general anesthesia). Transesophageal echocardiography is commonly utilized to evaluate the presence and significance of AI, but its use is limited in patients undergoing TAVR with conscious sedation. In these cases, transthoracic echocardiography is often the standard applied, but limitations exist in echocardiographic windows and the consistency of high-quality imaging. Aortography provides a relatively crude method of evaluating with variations based on positioning of the pigtail, angles of view, and additional contrast used.

Hemodynamic analysis is another method to monitor, and quantitative measures such as the aortic regurgitation index ($100 \times (\text{aortic diastolic pressure} - \text{left ventricular end diastolic pressure}) / \text{systolic blood pressure}$) have been shown to have an inverse correlation with the degree of AI, with values < 25 suggestive of moderate or greater AI and associated with adverse outcomes. Even cardiac magnetic resonance imaging has been proposed as a means to measure early AI, but limited availability, patient convenience, and patient incompatibility all pose significant barriers to this being part of common practice [5–7].

In this issue of the journal, Ristalli et al. evaluate the utility of a Pressure Recording Analytical Method (PRAM), a pulse-contour analysis based on invasive, real-time hemodynamics to evaluate the intraprocedural presence and severity of AI during TAVR [8]. The technology is well-described, and it has been validated in prior work that included patients with left sided valve disease [9]. Measurements include systolic, diastolic, mean, and diastolic aortic pressures along with pulse rate, cardiac output, stroke volume, cardiac cycle efficiency, dP/dt and mean arterial pressure – diastolic pressure (MAP-Pdic). The last of these – particularly, alterations in this difference – represents an index that is thought to correlate with AI. The acute pressure overload accompanying AI will cause aortic valve closure at a higher pressure. Thus, the diastolic pressure will be higher, and the MAP-Pdic will have a lower value in the setting of acute AI.

In addition to standard management at their institution, the authors obtained radial access in 43 patients for PRAM monitoring. Of these patients, 3 developed moderate-severe AI post-TAVR, which was detected by conventional imaging and managed according to the investigators' institutional practice. On pre-discharge echocardiographic imaging, at least mild AI was detected in 20 patients. Of the variables measured by PRAM, MAP-Pdic showed greatest discrimination in that the difference observed was significant for the patients with no or trace AI, but it was not significant in those with mild or greater AI. With the goal of

identifying a cut-off value for the presence of at least mild AI by PRAM, the authors established a delta MAP-Pdic of 4.8 with a sensitivity of 90%, specificity of 43%, and correct classification of 65%. The also established an absolute MAP-Pdic of -1.93 with a sensitivity of 85%, specificity of 65%, and correct classification of 74% [8].

The authors should be commended for their efforts to investigate an alternative means to assess intraprocedural AI that does not require the use of additional staff, significant expense or bulky imaging technology. There are obvious inherent limitations to a small, single-center trial including only 43 patients, and one particular limitation is that only 3 patients developed moderate or greater AI, thus the ability to discriminate between AI severity. As common practice is to tolerate mild AI (especially in the setting of favorable hemodynamics) and treat moderate or greater AI by identifying the cause and modifying accordingly, a useful monitoring modality must help differentiate. Though it is likely that moderate or greater AI would create a larger delta MAP-Pdic or absolute MAP-Pdic, this study lacks the requisite numbers to demonstrate this notion. Further study is clearly necessary to determine the role this technology may have in procedural decision making.

In context, PRAM appears to be another way of measuring AI during TAVR. The question remains as to whether it can provide more accurate, more convenient or additive data to what is currently available. Potential advantages of PRAM monitoring include the ability to monitor real time throughout a TAVR procedure without the use of additional equipment. For instance, if priming valvuloplasty is performed, AI would be identified immediately. Additionally, the efficiency of real-time analysis compared to additional steps required to obtain appropriate echocardiographic windows or advance a pigtail across the valve for traditional hemodynamic assessment represents another, albeit relatively small, advantage.

On the other hand, PRAM monitoring requires an additional access site (transradial), equipment and familiarity which, with an accuracy rate of up to 74%, doesn't necessarily render this a must-have. With increased operator experience, enhanced procedural planning/imaging and improved valvular technologies, the incidence of significant AI has already decreased compared to first-generation devices and procedures [10], and it is likely to further decrease. While procedural monitoring

will always be paramount, operators have become comfortable with echocardiographic and/or conventional hemodynamic monitoring, decisions are often crisp, and registry outcomes suggest that current practice continues to evolve favorably. In the absence of a convincing study demonstrating superiority of one technique over another, PRAM monitoring, while interesting and potentially valid, will likely remain just another tool in the shed.

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