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The Journal of Biomedical Research, 2022 36(2): 73–76

JBR

Perspective

Is a designated arterial catheter indicated in transcatheter aortic valve replacement procedure?

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Aortic stenosis (AS) is the most common valvular disorder frequently affecting patients as they get older, and resulting in life-altering symptoms such as dyspnea, angina, pre-syncope, and syncope, which are often made worse with exertion. Often, AS is caused by age-related calcification of the valve; in addition, its pathogenetic mechanism also involves the fact that bicuspid aortic valves tend to narrow rapidly compared to other three-leaflet valve. As the aging population continues to grow, an increasing number of patients are seeking treatment for AS, which makes therapies for AS continuing to evolve and improve. Initially, surgical aortic valve replacement (SAVR), requiring a median sternotomy and an extended post-operative intensive care unit stay, was the predominant therapy for patients with AS. Over the past few years, with the trend toward minimally invasive surgery, transcatheter aortic valve replacement (TAVR) has become more popular, offering an alternative to the traditional surgical approach, especially for patients who would previously be denied surgical replacement[1–2]. Consequently, the candidates for TAVR are often older (age >70 years) and have multiple, frequently moderate-to-severe comorbidities[3].

Anesthetic management of patients undergoing TAVR has also evolved, from providers predominantly opting to perform general anesthesia (GA) to now trending toward monitored anesthesia care (MAC). GA has its benefits in this often older and sicker patient population. Control of airway and muscle relaxation, as well as the ability to induce intermittent apnea to facilitate valve deployment are just a few examples[4]. At the same time, GA allows for the use of transesophageal echocardiography (TEE) which can be useful in multiple capacities during these procedures. GA, however, has several systemic side effects and can result in prolonged hospitalization, so its use is often weighed[5]. Of course, GA is still the preferred method in the US for high-risk patients undergoing perceived lengthy or complex TAVR cases with alternative approaches, such as subclavian approach. However, as TAVR technology advances and complication rates decreased, MAC is quickly becoming the favored anesthesia method.

Induction of GA in TAVR patients commonly requires arterial line placement for close blood pressure monitoring. Bolus doses of any hemodynamically altering medications may result in disastrous blood pressure changes, even with perceived low doses. Thus, arterial line placement prior to induction has historically been a necessity when performing TAVR with GA. In contrast, opting for MAC in TAVR cases removes the notion of routine arterial line placement due to the lack of a true induction phase. Additionally, at major TAVR centers like our institution, most TAVR patients receive cerebral embolic protection devices in their right radial arteries, which further limits access for radial arterial line. Here we discuss various patient

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Received: 20 February 2022; Accepted: 02 March 2022; Published online: 28 March 2022

CLC number: R614, Document code: B

The authors reported no conflict of interests.

https://doi.org/10.7555/JBR.36.20220036

considerations that would likely require an arterial line placement when undergoing TAVR procedure, with the aim to increase utilization of MAC without routine arterial line placement.

Critical aortic stenosis: While AS already results in reduced amounts of blood flow distal to the aortic valve, patients deemed to have "critical" aortic stenosis are barely perfusing their end organs and often unable to perform >4 metabolic equivalents at baseline. The risk for sudden hemodynamic instability and decompensation is much higher in these patients, especially during GA induction and rapid ventricular pacing and valve placement periods, as a significant amount of forward flow is being obstructed at baseline. Having TEE for optimal valve placement and first attempt success is often essential, necessitating GA. Additionally, sharp declines in blood pressure are frequent and must be treated judiciously, requiring an arterial line to be placed.

Procedures requiring TEE guidance: In addition to cases mentioned above where patients would benefit from TEE guidance, some of the preoperative imaging and testing may suggest a complex case. Cases that are projected to be difficult, may require multiple episodes of rapid ventricular pacing for proper valve placement, have the potential to be lengthy, or have increased likelihood to convert to an open procedure, often require arterial line placement and GA.

Low coronary takeoff and Valve in valve (ViV) implantation: Low coronary takeoff indicates that there is a higher risk for the placement of the new valve to cut off adequate blood flow to the epicardium. This "jailing" of the coronaries can result in sudden and immediate cardiac ischemia and rapid decompensation. Given the high risk for this occurring due to anatomical factors, TEE is highly recommended to facilitate valve placement. Transcatheter ViV procedure has become an accepted treatment option for patients with deteriorated bioprostheses. Coronary obstruction potentially limits its use[6]. Bioprosthetic or native aortic scallop intentional laceration to prevent iatrogenic coronary artery obstruction (BASILICA) is a new technique developed to mitigate this risk by creating a lengthwise laceration of the left and/or right aortic valve leaflets prior to TAVR[7]. Given the complex and potential lengthy natures of these cases, patients with these conditions should have an arterial line placed and GA to facilitate accurate valve placement.

Alternate approach (other than transfemoral): There are several reasons why interventional cardiologists are unable to proceed with a TAVR with a traditional transfemoral approach, especially in patients with severe peripheral arterial diseases, such as plaque burden or vessel tortuosity. Transcarotid or transaxillary approaches have been known to be done under MAC; however, most of them were performed under GA due to patient intolerance[8]. Additionally, more invasive approaches, such as those requiring a mini-thoracotomy, absolutely require GA and intermittently single lung ventilation. These cases often require arterial line placement, but should be determined on a case-by-case basis. Some alternative approaches, such as trans-axillary or trans-subclavian, require using both radial arteries for access. In these cases, femoral arterial lines should be considered, however, the reason for alternate approach often due to the pathology of femoral arteries which could also affect the arterial line placement. A discussion with the proceduralists is recommended.

Low cardiac output: Patients with moderate-to-severe AS usually have hypertrophied but functional left ventricles. While it is unclear specifically what ejection fraction is considered "low" enough to warrant an arterial line, patients with global dyskinesia and ejection fractions <20% are noted to be of very high risk for hemodynamic instability[9–10]. Regardless of whether the patient is being induced for GA or a slow titration of MAC, these patients have the tendency to rapidly decompensate[11–12]. Thus, a designated radial arterial line should be placed.

Inability to lay flat: Patients with multiple comorbidities, such as chronic back pain, are more likely to be intolerant of MAC, as they often require additional managements for their chronic back pain. They are more prone to movement, which could lead to deleterious consequences especially during phases such as rapid ventricular pacing. These patients are also more likely to require bolus doses of pain or sedation medications simply because of their underlying diseases. Additionally, patients with severe chronic obstructive pulmonary diseases and/or asthmas have difficulty with lying flat due to dyspnea. While most patients under MAC receive a nonrebreather mask with constant oxygen administration, these patients may require additional CPAP and are more likely to have episodes of apnea under sedation[13–14]. Lastly, patients with moderate-to-severe heart failure may have significant orthopnea, and thus cannot tolerate this procedure merely with sedation. These patients may simply require a GA due to intolerance of MAC and the placement of an arterial line should be considered.

Moderate/severe pulmonary hypertension: Maintaining CO_2 and O_2 levels within normal ranges are critical in maintaining pulmonary vasodilation and

preventing a pulmonary hypertensive exacerbation. Additionally, avoiding Valsalva or bearing down, and emotional outbursts aids in maintaining normal pulmonary pressures. These variables are increasingly difficult to control without routine arterial blood gases and positive pressure ventilation, thus making arterial lines with induction of GA often the best way to manage these patients[15].

Uncontrolled atrial fibrillation: Often, these patients do not have a well-titrated rate control medication or chronic antiarrhythmic therapy, which makes them of very high risk for hemodynamic instability. These patients have the propensity to become unstable quickly, transitioning into RVR or being unable to maintain normal blood pressures[16]. They could benefit from arterial line placement with induction of GA by allowing rapid titration of vasoactive medications as needed.

Renal failure: The contrast during computerized tomography is frequently used to guide the interventional cardiologists in their valve choice and placement. However, patients with renal failure cannot tolerate the contrast, so another method of guidance is needed. TEE is useful in this setting, which usually requires induction of GA[17]. Also, these patients require judicious fluid administration which can be guided by pulse pressure or stroke volume variation, all of which is facilitated by arterial line placement.

The above discussed are the most common indications suggested for potential designated arterial access. At the same time, the reason for routine arterial access comes into question, as most patients (80%) tolerate MAC well without the need for invasive monitoring. Additionally, the most critical moments for hemodynamic instability and potential decompensation are during induction of GA and rapid ventricular pacing. Induction of GA is entirely avoided with the MAC technique, as starting sedation early and providing enough time for optimal medication titration remains the best method for maintaining depth of sedation without the consequences of apnea or hypotension. Also, it's worthy to note that at the phase of rapid ventricular pacing, the interventional cardiologists display continuous arterial pressure *via* their arterial access, which can be closely followed by the anesthesiologists.

In summary, it is widely accepted that routinely placing invasive monitors on patients is unnecessary and can even be harmful. It is notable that most of these indications are atypical to the usual TAVR patients. Thus, the need for additional arterial cannulation should be actively discussed and not inherently placed, simply because of the procedure that the patient is undergoing. As TAVR techniques advance, reducing length of procedures and the risk of complications, anesthetic techniques must co-evolve taking into consideration whether the need for invasive monitoring, such as arterial cannulation, is truly warranted.

Acknowledgments

This work was supported in part by the University of California Davis Health Department of Anesthesiology and Pain Medicine and National Institutes of Health grant UL1 TR001860 of the University of California Davis Health.

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