Crossing Stenotic Aortic Valves During TAVR: Technical Review and Thoughts

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The first successful transcatheter aortic valve replacement (TAVR) procedure was performed in France on April 16, 2002, by Alain Cribier. The last 20 years has experienced drastic growth in the space of percutaneous valvular therapeutics, with TAVR at the leading edge. A million and a half people in the United States suffer from aortic stenosis (AS), and approximately 500,000 within this group of patients suffer from severe AS.[1-4] An estimated 250,000 patients with severe AS are symptomatic.[1-4] As of 2020, more than 276,000 patients have undergone a TAVR procedure in the United States.[5] According to a report from the Society of Thoracic Surgeons (STS)/American College of Cardiology (ACC) Transcatheter Valve Therapy (TVT) Registry, TAVR volumes have increased annually and in 2019, TAVR procedures exceeded all forms of surgical aortic valve replacement (SAVR) for the first time.[5]

Problems crossing the aortic valve (AV) can have a significant impact on procedural times and may lead to complications. Even in patients with aortic stenosis that have "favorable" valves (ie, larger aortic valve area, annulus perimeter, lower AV gradient, etc.), crossing isn't always straightforward. Sometimes, even in the hands of the most skilled operators, crossing stenotic AVs can be an arduous task.

Retrograde crossing of the aortic valve (AV) is an important step during TAVR procedures. Several factors can factor into the crossing of a stenotic AV, including aortic valve area, AV gradient, valve orientation, degree/distribution of calcification, aortic annulus perimeter, operator experience, type of catheter, and systolic duration. Techniques for crossing stenotic aortic valves vary, but typically, operators use a pigtail catheter or an Amplatz Left (AL)1 with an .035-inch straight-tip wire to facilitate crossing into the left ventricle. These techniques are effective and work the majority of the time. However, there are times when operators need to change technique due to an inability to cross.

Crossing stenotic AVs has been studied as early as 1986. Harrison et al[6] studied 447 consecutive patients with aortic stenosis, of whom 156 underwent subsequent balloon aortic valvuloplasty from 1986 to 1989. Their technique, not dissimilar to modern-day techniques, utilized a Judkins Right (JR)4 catheter stationed 2 cm to 4 cm superior to the aortic valve in the right anterior oblique (RAO) 30° view, with the tip positioned toward the left coronary sinus. The catheter tip was further positioned into the systolic jet, probing for the valve opening. Small adjustments were made in catheter tip position while using the wire to interrogate the area beneath the systolic jet, which usually facilitated crossing. Harrison et al reported the vast majority of the valves were crossed in less than 2 minutes (a time interval a technologist would routinely indicate so that the wire could be removed and wiped down). Surprisingly, they ascribe crossing AVs to "experience, luck, and sheer determination."[6] Despite many operators having a great amount of experience, a certain degree of "luck" can come into play when crossing stenotic AVs. In recent years with advancements in echocardiography, crossing the AV is done less frequently to obtain a left ventricular end-diastolic pressure (LVEDP) and left ventriculograms. The use of simultaneous LV/aortic (AO) pressure gradients has also declined for the same reason. Even though crossing AVs isn't a lost art, crossing may be more difficult for novice operators because of a lack of everyday practice in the cath lab.

Roback et al[7] describe a common technique for AV crossing. With a pigtail catheter parked in the noncoronary cusp, and an AL1 catheter sitting above the AV, a straight, soft Glidewire (Terumo Interventional Systems) is used for crossing, in a 20° left anterior oblique view. The pigtail catheter in the noncoronary cusp is used as a reference point for valve implantation, because it represents the lowest and rightmost cusp, and defines the inferior-most plane of the native AV, and catheters are adjusted accordingly until crossing. Thirty-five consecutive patients undergoing TAVR were studied in a prospective manner. AL1 was the most common catheter used to cross. Of all the preprocedure planning aspects, only lower AV peak velocity and larger aortic annulus perimeter were significantly associated with lower AV crossing times.[7] Therefore, AV peak velocity and aortic annulus perimeter can be important factors to take into account during preprocedural planning for TAVR.

Several innovative methods have been described in the literature. Schoels et al[8] describe a pigtail/J-wire technique where the catheter is placed 3–4 cm above the AV and turned anteriorly in the 30° RAO view. A J-wire pushed out of the pigtail catheter will reach the anterior wall of the ascending aorta, forming a u-shaped curve above the AV. The height of the pigtail catheter determines the width of the curve and rotation will help to find an orientation where the vertex of the curved J-wire easily passes the AV. Schoels et al studied 100 patients with severe AS using a crossing technique specific to their study design. Their valve crossing technique had an 86% success rate and crossing took 48.2±34.6 seconds. In 14% of patients, the AV had to be crossed with an alternative method. Schoels et al offer an attractive technique due to the less traumatic use of a J-wire. Errant straight wires traversing coronary ostia can manifest in devastating complications.

Another group, Hawatmeh et al,[9] focused on AV crossing as a diastolic phenomenon, because the leaflets of critically stenosed AVs are essentially immobile, producing not only a high-velocity systolic jet leading to a systolic supravalvular vortex, but also resulting in a high-velocity diastolic jet rapidly receding into the LV cavity during diastole. Thus, the more critical the stenosis, the greater the velocity of either jet, leading essentially to a systolic impediment to the wire crossing the AV, and a strong diastolic suction drawing the wire into the LV cavity and potentially facilitating valve crossing. Ten patients were studied with successful crossing in the diastolic phase for all patients. Interestingly, Hawatmeh et al establish the cadence of forward-wire movement occurring only during diastole by murmuring under one's breath the word "diastole" with every forward bob of the wire and by only advancing the wire in small increments each time to attempt to cross.[9]

Rapid pacing is another frequently mentioned technique for trying to cross the AV.[10] Theoretically, if the AV is opening more frequently, the chances of crossing may improve. The caveat is that the AV is closing equally as fast, which may actually impede crossing. Rapid ventricular pacing may affect coronary filling from 25% with an 8-second rapid-pacing run, up to 50% with an 18-second rapid-pacing run.[10] This could be deleterious if a long pacing run was required to facilitate crossing. Further investigation of this technique is warranted.

One case report[11] described a severely calcified stenotic AV (0.6 cm^2) with bicuspid anatomy. After an hour of attempts using conventional methods failed, the operators exchanged a XB4 6 French (Fr) left coronary guide catheter (Cordis) and an .014-inch hydrophilic Pilot 50 intracoronary guidewire (Abbott Vascular) to cross the AV. Astonishingly, the approach was successful in 5 minutes. A 6 Fr guide catheter extension system was mounted on the wire and advanced to the left ventricular apex. The .014-inch guidewire was replaced by an .035-inch extra-stiff guidewire by removing both the guide and guide extension catheters. This could be considered a "Hail-Mary" technique, but operators may like to keep it in their armamentarium if all other methods have been exhausted.

Problems crossing the AV can have a significant impact on procedural times and may lead to complications. Even in patients with AS that have "favorable" valves (ie, larger aortic valve area, annulus perimeter, lower AV gradient, etc.), crossing isn't always straightforward. Sometimes even in the hands of the most skilled operators, crossing stenotic AVs can be an arduous task. When AV crossing times become exceedingly long, it leads to longer procedural times and poor turnover. In institutions with only one hybrid operating room, it may lead to subsequent patients being pushed back further into the afternoon/night and possibly to a later date according to room availability. Longer valve crossing times may also lead to increased risk of procedural complications such as coronary artery dissection, cerebral embolism, left ventricular perforation, aortic dissection, or hemopericardium.[12] This may occur with repeated passes with a straight wire. Clinically significant stroke rates for aortic valve crossing have been quoted at 1%-3%.[13] Embolizing calcific debris can be catastrophic for a patient. The use of embolic protection devices may add some benefit; however, in a propensity-weighted analysis, the association between embolic protection use for TAVR and in-hospital stroke found only a modestly lower risk of in-hospital stroke.[14] On the flip side, a recent meta-analysis[15] showed that cerebral embolic protection might reduce disabling stroke in patients undergoing TAVR. Patients at high and intermediate surgical risk were most likely to derive benefits.[15]

Thoughts

Crossing AVs is a critical skill required in present-day TAVR procedures. Although methodical methods have been described and are utilized, there are times that operators need to be innovative in order to achieve results. Experience in crossing AVs in the cath lab has diminished due to modern echocardiography techniques as TAVR volumes have steadily increased. It is essential that senior operators impart AV crossing skills to junior operators due to the decline in everyday practice of AV crossing. Although crossing AVs isn't as common a practice as it has been in the past, it may be more difficult for junior operators due to the of lack of everyday practice in the cath lab. This may have an effect on AV crossing and procedural complications, particularly for neophyte structural/TAVR operators. This skill remains of paramount importance to reduce complications while simultaneously maintaining efficiency for a TAVR program. Operators need to be versed in various AV crossing techniques that provide safety and efficiency. ■

Although crossing aortic valves isn't as common a practice as it has been in the past, it may be more difficult for junior operators due to the of lack of everyday practice in the cath lab. This may have an effect on aortic valve crossing and procedural complications, particularly for neophyte structural/TAVR operators.

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