Senile calcific aortic stenosis (AS) is the most common acquired valvular heart disease with an increasing prevalence attributable to an aging population. Survival is poor in patients with severe or critical AS, chiefly after the onset of symptomology that primarily includes angina, dyspnea, or syncope. On the onset of symptoms, mortality occurs at very high rates during the ensuing 2 to 3 years.1 Until recently, surgical aortic valve replacement represented the sole therapy that definitive reduced mortality and morbidity in patients with severe symptomatic AS, with medical therapy generally ineffective of these patients. Given the advanced age commonly associated with severe AS, a high proportion of these patients are denied surgical intervention because of multiple comorbidities and excessively high surgical risk.3

Recently, transcatheter aortic valve replacement (TAVR) has emerged as a novel disruptive technology that serves an alternative therapy to surgical AVR and has been shown to be an effective therapy in nonoperable and high-risk patients with severe symptomatic AS.3,4 TAVR was first described in humans by Cribier et al in 20025 by a transvenous approach delivered in an antegrade fashion. This technique requires a transseptal puncture and passage of the aortic stent valve across the mitral valve to the aortic position. Subsequently, array of alternative transvascular approaches have arisen, including transfemoral, transaortic, trans-subclavian, and aortic methods. Of these, the retrograde transarterial approach through the femoral artery, developed by Webb et al,6 has been the commonly used approach, with >60,000 such procedures performed worldwide to date.

To date, the global experience with TAVR as documented in both single and multicenter registries as well as through multicenter trials have shown good clinical outcomes with improvement in hemodynamic and clinical status, establishing TAVR to be a feasible alternative therapy to traditional surgical aortic valve replacement to treat high-risk or nonsurgical patients.3,4 In recent randomized prospective trials involving patients with severe AS who were considered high risk or excessive risk for standard surgical therapy, TAVR was shown to result in a 20% all-cause mortality reduction at 1 year in the nonsurgical arm,7 and TAVR provided equivalent clinical outcomes to conventional surgery in a high-risk cohort.7 Importantly, these results hold true at 2 years as well with a significant reduction in all-cause mortality, death from cardiac causes, and rehospitalization in the nonsurgical arm.7

In this era of escalating medical expenditures, any assessment of a new treatment strategy must be framed in the context of comparative and cost-effectiveness. Recently, Reynolds et al8,9 performed cost-effectiveness subanalyses on cohorts A and B of the Placement of Aortic Transcatheter Valves (PARTNER) trial. Within the nonsurgical arm, the incremental cost-effectiveness ratio of TAVR compared with standard care was estimated at $50,200 per year of life gained, or at $62,000 per quality-adjusted life year gained, these results seemed to be stable across a range of sensitivity analyses. The incremental cost-effectiveness ratio of TAVR in this cohort places it below the generally accepted benchmark of $70,000 per quality-adjusted life year for hemodialysis and within the range of other cardiovascular technologies, including defibrillators for primary event prevention. In a similar prospective analysis of the PARTNER A arm, TAVR cost-effectiveness was shown to be equivalent to surgical AVR with 12-month costs and quality-adjusted life years that were found to be comparable, such that neither treatment strategy could be designated as the preferred strategy on the basis of health economics.8,9 Although this initial evaluation is promising, continued prospective cost-effectiveness analyses are needed to better understand the health economics of TAVR across varied patient populations and across the globe.

Although TAVR has seen rapid evolution and advancements since its introduction with good clinical outcomes and early positive cost-effectiveness data, procedure-related complications remain non-negligible and a significant concern for worsening morbidity and mortality. These complications include postprocedural paravalvular aortic regurgitation, aortoiliacofemoral vascular injury, cardiac conduction disturbances, aortic root injury, and coronary artery obstruction.
The purpose of this review is to provide an overview of these significant complications encountered at the time of TAVR, and discuss how advanced imaging techniques by computed tomography (CT) may help mitigate their occurrence.

Paravalvular Aortic Valvular Regurgitation
Paravalvular aortic valvular regurgitation (PAR) remains a significant concern with TAVR. PAR, as defined by post-TAVR deployment transesophageal echocardiography, is typically defined by severity as trivial, mild, moderate, and severe. Moderate-to-severe PAR was observed in 12.9% and 6.8% of TAVR patients at 30 days and 1 year in PARTNER A, compared with 0.9% and 1.8% in the surgical arm. In PARTNER B, moderate or severe PAR was present in 11.8% of the patients at 30 days and in 10.5% at 1 year. Importantly, there is increasing awareness that even a mild degree of PAR portends a worse prognosis than those patients who do not experience mild or greater PAR. Although PAR seems to be multifactorial with factors, such as severity and eccentricity of valvular calcification and malpositioning important in its pathogenesis, there is growing awareness that undersizing of the aortic stent valvular relative to the aortic annulus is a significant contributing factor.

One essential principle to consider when attempting to reduce the incidence and severity of PAR is the realization that the aortic annulus is almost uniformly noncircular or ovoid. This geometry has not been historically appreciated with the integration of MDCT into the transcatheter heart valve (THV) selection process (5.3% versus 12.8%; \(P=0.03\)). As well, self-expanding TAVR prosthesis is currently selected almost exclusively on the basis of annular sizing with MDCT.

From our own experience, postdeployment MDCT may also provide some explanation for postprocedural PAR, such as incomplete apposition of the native commissures. However, optimal TAVR stent positioning and expansion on MDCT does not rule out PAR. About preprocedural stent sizing, there remains debate about which MDCT measurements should be adopted for preprocedural TAVR stent sizing. Some have advocated the integration of MDCT perimeter–based sizing; however, there is apparent significant variability across workstation platforms. Regardless of the use of perimeter/circumference or area, these measures are chosen to help guide spatial delineation and 3D capabilities, has been shown to be a reproducible and accurate tool for annular diameter assessment and measurement across the cardiac cycle. Furthermore, area and perimeter measurements of the aortic annulus by MDCT have also been studied, and have been shown to be powerful predictors of PAR. Indeed, a recently proposed TAVR stent sizing algorithm—based on area rather than diameter—has been shown to be more consistent and stable for sizing by encouraging mild oversizing of the TAVR valve in relation to the annulus. This technique has been shown to be valuable for prevention of PAR and, when compared with transthoracic echocardiography, reduces extreme oversizing and undersizing. Consequently, several groups have begun to integrate MDCT area measures in TAVR stent valve selection to optimize annular sizing and ensure controlled oversizing of the aortic annulus (Figure 1). Jilaiwahi et al showed a significant reduction in greater than mild PAR in a single-center study after the integration of MDCT-based sizing for balloon-expandable TAVR stent valves (Figure 2). Our group also recently presented data from a prospective multicenter sizing trial, showing that greater than mild PAR can be reduced with the integration of MDCT into the transcatheter heart valve (THV) selection process (5.3% versus 12.8%; \(P=0.03\)). As well, self-expanding TAVR prosthesis is currently selected almost exclusively on the basis of annular sizing with MDCT.

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![Figure 1. Pretranscatheter aortic valve replacement (TAVR; A and B) and after TAVR imaging (C and D) in an 84-year-old male patient with severe symptomatic aortic stenosis showing the value of 3-dimensional (3D) of the aortic annulus. Double oblique transverse reconstruction of the annulus on multidetector computed tomography displays an annulus with a mean annular diameter of 25.3 mm and an area of 5.0 cm². The parasternal long-axis 2-dimensional echo suggests an annular diameter of 21.0 mm. A 23-mm balloon expandable prosthesis was selected on the basis of the 2D echocardiographic imaging. Importantly, with a nominal area of 4.15 cm² this is significantly smaller than the native annular area of 5.00 cm². While a circular deployment is noted on computed tomography (C) the post-deployment echocardiogram displays significant paravalvular regurgitation (D).](http://circimaging.ahajournals.org/doi/fig/10.1161/CIRCCVIMAGING.113.002547)
TAVR size selection for controlled annular oversizing. The degree of optimal oversizing to reduce PAR while controlling the risk of annular rupture remains uncertain but will almost certainly vary between balloon expandable and self-expanding valves. Likely, a lesser degree of oversizing may be more appropriate in the setting of balloon-expandable valves because of a higher risk of potential annular injury during balloon inflation. As well, it is important to recognize that the degree of annular stretch is significantly different when targeting the same degree of annular oversizing between perimeter and area. Thus, future studies will be needed to determine the optimal method for annular sizing to balance the minimization of PAR versus vascular injury.

Beyond annular sizing and THV selection, some groups have shown that aortic valve calcification and its location of calcification correlates post-TAVR PAR\(^21,22\) because exuberant calcium may result in a degree of nonapposition and incomplete expansion of the THV. These findings have not been consistent across series with higher correlation with self-expanding prostheses perhaps because of the lower radial force and conformability of the stent to the native annulus (Table 1). A number of recent single and multicenter studies of patients undergoing balloon-expandable TAVR have found that aortic valve calcification by Agatston score was not predictive of post-TAVR PAR, which is concordant with additional single-center studies.\(^13,21\)\(^,\)\(^22\) Other studies have found that an elevated Agatston score (threshold \(-3000\)) was predictive of moderate or severe aortic regurgitation (AR) with a self-expanding prosthesis.\(^21,22\)

It is also important to recognize that the grading of paravalvular regurgitation remains difficult with significant variability in the severity of PAR depending on the point in time in relation to the procedure that it is assessed. The goal of advanced imaging is not to eradicate all PAR, which is both unrealistic and potentially harmful, but rather reduce the burden of significant PAR and its potential deleterious impact on clinical outcomes. Finally, it cannot be emphasized enough that THV selection remains an integrated process with interdisciplinary review of clinical factors as well as all imaging available rather than a decision that can be made supported by any individual imaging modality.

**Aortoiliofemoral Vascular Injury**

One important complication not infrequently observed during the TAVR procedure is that of vascular injury. Vascular injury has emerged as a major limiting factor when using the large sheaths and catheters required for such procedures, as was required for the first generation stent valves.\(^23\) Initially, single plane x-ray angiography, typically performed at the time of coronary artery assessment, was considered a minimum requirement for evaluation of the aortoiliofemoral system in the early phases of TAVR, but this 2D technique yields limited information concerning true vessel lumen, calcification, and tortuosity.

When using large 22- to 24-F sheaths for transfemoral access, vascular complication rates of 30.7% were observed in the pivotal North American PARTNER 1B trial.\(^3\) MDCT has been proven to be an effective screening tool for the evaluation of vascular access, to facilitate appropriate site selection, and to reduce access complications.\(^24,26\) MDCT offers high spatial resolution of all imaging planes in a 3D fashion that is enabled by its isotropic voxels as well as rapid data acquisition; thus, allowing it to overcome some of the limitations of conventional angiography and digital subtraction angiography. To take advantage of the 3D nature of MDCT, measures of iliofemoral diameters are typically done by a centerline technique. This centerline technique allows the operator to elongate the vessel in question, and multiple luminal measurements can then be made in a plane orthogonal to the vessel.

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Figure 2. Multimodality imaging in a 76-year-old female patient with symptomatic severe aortic stenosis shows the benefit of biplane and 3-dimensional (3D) imaging of the annulus. Transthoracic echocardiography (TTE) measurement of the annulus is 19 mm, which would suggest a 20- or 23-mm prosthesis. Biplane transesophageal echocardiography (B; 21.7×25.1 mm) and multidetector computed tomography (C; annulus area, 5.17 cm\(^2\)) measurements of the annulus, however, suggest that a 26-mm prosthesis would be more appropriate. A 26-mm balloon expandable prosthesis was implanted without complication and with trivial paravalvular aortic valvular regurgitation as noted on the postprocedural echocardiogram (D).
rather than in the transverse axial plane, which may falsely overestimate the iliofemoral arterial lumen. Using these 3D techniques, MDCT permits evaluation of vessel size, degree of calcification, minimal luminal diameter, plaque burden, vessel tortuosity, and also identifies high-risk features, including dissections and complex atheroma. Importantly, assessment of vascular access with CT also requires that images be displayed on appropriate window and level settings to minimize partial volume averaging (blooming) of calcified plaque. The most accurate measurement of vessel diameters has been shown to be achieved by using full-width half maximum of attenuation profile (Figure 3).

Along with better vascular closure devices, CT imaging has improved patient selection for the transfemoral access with vascular complications decreasing over time. Recently, several centers have reported propitious outcomes, with major vascular complications from 8% to 1% and minor vascular complications from 24% to 8% between 2009 and 2010.25 Numerous MDCT findings are predictive of vascular injury, and should be carefully considered. Among the most important of these is the vessel size. The presence of a minimal arterial lumen diameter less than that of the external sheath showed a 4-fold increase (23% versus 5%).26 This finding can be quantified by a sheath-to-femoral artery ratio, for which a value of ≥1.05 is predictive of vascular access–related complications and 30-day mortality.26 Further analyses have supported using a more lenient threshold (sheath-to-femoral artery ratio=1.10) in the absence of calcification of the iliofemoral access, and

| Table 1. Studies of Predictors of Paravalvular Regurgitation on Preprocedural MDCT |
|---------------------------------|-----------------|-----------------|-----------------|
| Study                          | Population      | Results          | Conclusion                   |
| Wilson et al,13 2012            | 109 patients underwent MDCT pre-TAVR with a balloon-expandable aortic valve | AUC for prediction of moderate-severe PAR | MDCT annular measurements are predictive of moderate or severe PAR after TAVR |
|                                |                 | • THV diameter−MDCT mean diameter: 0.81 (0.68–0.88) | Oversizing of THVs may reduce the risk of moderate or severe PAR |
|                                |                 | • THV area/MDCT annular area: 0.80 (0.65–0.90) | |
|                                |                 | • THV diameter−TEE annular diameter: 0.70 (0.51–0.88) | |
|                                |                 | Reduced the risk of moderate-severe PAR by | |
|                                |                 | • THV oversized to MDCT mean diameter by ≥1 mm | |
|                                |                 | • THV oversized to MDCT annular area by ≥10% | |
| Jilaihawi et al,14 2011         | 136 patients underwent TAVR with a balloon-expandable aortic valve | AUC for prediction of PAR | Three-dimensional cross-sectional measures, using MDCT is the new gold standard for aortic annular evaluation for TAVR |
|                                |                 | • MDCT maximal diameter − THV diameter: 0.82 (0.69–0.94), P<0.001 | |
|                                |                 | • MDCT circumference derived diameter − THV diameter: 0.81 (0.70–0.94), P<0.001 | |
|                                |                 | • TEE maximal diameter−THV diameter: 0.64 (0.46–0.81), P=0.087 | |
|                                |                 | Reduced the incidence of moderate-severe PAR with annular sizing using | |
|                                |                 | • MDCT: 7.5% | |
|                                |                 | • 2D TEE: 21.9% (P=0.045) | |
| Ewe et al,21 2012               | 79 patients underwent MDCT pre-TAVR with a balloon-expandable aortic valve | AUC for PAR grade ≥1 from aortic wall site | Both AVC severity and its exact location are important in determining PAR after TAVR |
|                                |                 | • AVC at aortic wall: AUC 0.93, P<0.001 | |
|                                |                 | • AVC at valvular edge: 0.58 | |
|                                |                 | • AVC at body: 0.67 | |
|                                |                 | AUC for PAR grade ≥1 from commissures | |
|                                |                 | • AVC at valvular commissure: 0.94 | |
|                                |                 | • AVC at valvular edge: 0.71 | |
| Koos et al,22 2010              | 57 patients underwent DSCT pre-TAVR with a self-expandable (38) and balloon expandable (19) aortic valve | Agatston AVC scores in patients with | Patients with severe AVC have an increased risk for a relevant PAR after TAVR |
|                                |                 | • PAR grade ≥3: 5055±1753 | |
|                                |                 | • PAR grade <3: 1723±967 (P=0.03) | |
|                                |                 | Agatston AVC scores >3000 were associated with a relevant PAR | |
| Wood et al,23 2009              | 26 patients underwent MSCT pre-TAVR with a balloon expandable (23) and self-expandable (3) aortic valve | No significant association between PAR and | Neither eccentricity nor calcific deposits seemed to contribute significantly to severity of PAR after TAVR |
|                                |                 | • Oval shape of the aortic annulus (P=1.0) | |
|                                |                 | • Amount of AVC (P=0.35) | |

AUC indicates area under the receiver-operating characteristics curves; AVC, aortic valve calcification; DSCT, dual-source computed tomography; MDCT, multidetector computed tomography; MSCT, multislice computed tomography; PAR, paravalvular aortic regurgitation; TAVR, transcatheter aortic valve replacement; TEE, transesophageal echocardiography; and THV, transcatheter heart valve.
...a stricter threshold (sheath-to-femoral artery ratio=1.00) is required in the presence of moderate-to-severe calcification. Particular care should be given if calcification is circumferential or horseshoe in distribution and located at vessel bifurcations. An important function of MDCT is to identify or exclude the presence of horseshoe calcification, which is defined by >90° circumferential calcification at any point in the iliofemoral vascular bed. Horseshoe calcification is an important risk factor for vascular complications. Qualitatively estimated moderate or severe vascular calcification is associated with a 3-fold increase in vascular (29% versus 9%).

An additional consideration of the iliofemoral tree is the presence of severe iliofemoral tortuosity, which can be defined as a >90° turn in the vascular bed. On diagnosis of severe tortuosity, a stiff wire can be used at the time of TA VR placement to see whether this tortuosity can be straightened, a finding more often seen for vessels with no or minimal atherosclerosis, followed by noncalcified and then calcified atherosclerosis. In the setting of unfavorable vascular pelvic anatomy as identified by MDCT, a transapical, subclavian, or transaortic approach can be considered. CT can provide similar anatomic detail for the subclavian system and provide preprocedural localization of the left ventricular apex to assist with transapical puncture as well as with the angle at which to advance the device (Table 2).

**Conduction Disturbances**

The atrioventricular node is situated adjacent to the membranous septum in the left ventricular outflow tract just below the aortic valve, and is at risk of compromise at the time of TAVR stent valve placement. As the atrioventricular node traverses the left ventricular myocardium—continuing as the Bundle of His, then giving rise to the fascicles of the left bundle branch along the membranous septum—any significant disruption to this area may result in significant and permanent conduction disturbances. As a result of local trauma to the Bundle of His, the incidence of permanent pacemaker placement attributable to high-degree atrioventricular block or symptomatic bradycardia is higher with both the balloon-expandable (2.5%–11.5%) and self-expanding (9.3%–43%) prostheses than with surgical aortic valve replacement (3.2%–8.5%). It has been recently shown that occurrence of new-onset and persistent LBBB after TAVR is associated with a

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**Table 2. Studies of Predictors of Vascular Injury on Preprocedural MDCT**

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Généreux et al, 2012</td>
<td>16 Studies including 3519 patients underwent TAVR</td>
<td>After adjusting for SFAR, female sex remained a strong independent predictor of major vascular complication after TAVR (OR, 2.31; CI, 1.08–4.98; P=0.03)</td>
<td>Female sex is a predictor of major vascular complication</td>
</tr>
<tr>
<td>Toggweiler et al, 2012</td>
<td>137 Patients underwent transfemoral TAVR (only 82 patients with MDCT pre-TAVR)</td>
<td>The incidence of adverse features in patients with/without vascular complications • Minimal artery diameter on MDCT &lt; sheath external diameter: 82% vs 42% (P=0.01) • Moderate or severe calcification on MDCT: 17% vs 46% (P=0.03) • History of peripheral vascular disease: 29% vs 11% (P=0.02)</td>
<td>Vascular complications occur more often if the minimal artery diameter is smaller than the external sheath diameter, in the presence of moderate or severe calcification, and in patients with peripheral vascular disease</td>
</tr>
<tr>
<td>Hayashida et al, 2011</td>
<td>130 Patients underwent transfemoral TAVR</td>
<td>HR for prediction of major vascular complication • SFAR: 186.20 (4.41–7855.11) • Femoral calcification: 3.44 (1.16–10.17) An SFAR threshold of 1.05 (AUC, 0.727) predicted • A higher rate of VARC major complications: 30.9% vs 6.9%, P=0.001 • 30-day mortality: 18.2% vs 4.2%, P=0.016</td>
<td>VARC major vascular complication are predicted by femoral calcification and SFAR</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; MDCT, multidetector computed tomography; OR, odds ratio; SFAR, sheath-to-femoral artery ratio; TAVR, transcatheter aortic valve replacement; and VARC, valve academic research consortium.
much higher risk for complete atrioventricular block requiring permanent pacemaker implantation, a finding that is associated with a significantly worsened prognosis. Although anatomic assessment of the annulus has limited ability to predict which patients will experience heart block, there is growing data suggesting that postimplantation geometry as noted on CT can provide insight into the drivers of conduction disturbances post-TAVR. Multiple groups have demonstrated that a more ventricular positioning of the valve prosthesis increases the risk of new-onset LBBB and as a result a higher need for permanent pacemaker implantation (Figure 4). This is thought to be related risk for mechanical stress and direct damage of the conduction system, leading to a higher risk for conduction disturbances. One additional risk factor for conduction disturbances is an excessively low positioning of the valve prosthesis, which is associated with increased requirement of permanent pacemaker implantation and which can be visualized well by MDCT.

During the time of the TAVR procedure, MDCT may be useful if used in combination with coregistration techniques. A 2D-3D coregistration between x-ray angiography and MDCT can enable—by identification of fiduciary points—concomitant live 3D visualization. However, caution must be applied because differences in patient positioning at the time of MDCT versus x-ray angiography may result in differences in registration.

In addition, although procedural positioning of the THV is supported currently by fluoroscopy and transesophageal echocardiography, recent advances in fusion technology have uncovered significant promise for CT Fluoroscopic fusion tools. There are 3 fundamental elements to fusion imaging: segmentation, registration, and real-time guidance. Image postprocessing with the creation of 3D reconstructions of axial CT angiography data with volume-rendering techniques is the first step for fusion imaging. This allows for the identification, labeling, and measuring of anatomic structures of the heart, which are identified on the 3D image. To allow for image registration, the 3D CTA images are to match the position and the scale of the fluoroscopic view. Both manual matching or automatic density tools can be used to the 3D image to 2D fluoroscopy in multiple planes.

The last step is to allow for live guidance imaging. Live guidance uses the volume-rendered CT data and projects it in a varied position and projection in the same fashion as the x-ray system. A change in position of the x-ray camera or table movement triggers an equivalent movement in the coregistered projection. Multiple anatomic landmarks, such as the sternum and spine, are placed on the segmented CTA image and are fused with real-time fluoroscopy to assist with the procedure (Figure 5).

### Aortic Root Contained/Noncontained Rupture

The desire to optimize THV selection and minimize PAR must be done in the context of an awareness of some potential risk for aortic annular injury. With TAVR, the occurrence of uncontained and contained aortic annulus rupture, periaortic hematoma, and ventricular septal rupture has been described previously. It is generally accepted that these entities are mechanistically similar most commonly resulting from disruption of the aortoventricular junction, caused by either the balloon valvuloplasty or THV implantation. The outcomes of those patients that experience annular injury is very poor with a high mortality rate. Recently, it has been shown that preprocedural CT imaging may allow for the identification of those at higher risk for annular injury. Two-dimensional annular sizing has led to variable degrees of annular oversizing because of the limited information it provides about the eccentricity of the annulus. The limitations in both imaging data and valve sizes resulted in a wide range of annulus oversizing by 9.4±17.4% (range, −21.5% to 65.9%; P=0.01). More specifically 66.6% (80/120) of annuli

![Figure 4](http://circimaging.ahajournals.org/Downloadedfrom)

*Figure 4.* Coronal oblique multiplanar reconstructions of a 79-year-old male patient who developed left bundle branch block (LBBB) after 26-mm balloon expandable valve deployment. Note the low position of the transcatheter heart valve greater than two thirds of the valve deployed below the native annulus.

![Figure 5](http://circimaging.ahajournals.org/Downloadedfrom)

*Figure 5.* An 83-year-old male undergoing transfemoral TAVR integrating computed tomography (CT) fusion imaging in the hybrid operating room. The silhouette of the aorta is generated from the CT angiogram and then uploaded to the catheterization laboratory fluoroscopy synchronized and changing with the gantry position (A and B). The coronary ostia are also colocalized (left, blue; right coronary, red) as is the basal ring of the annulus as defined by the nadir of all 3 aortic valve cusps (yellow dots). A virtual transcatheter valve can also be integrated to further help with transcatheter heart valve selection and positioning.
were oversized, 24.2% (29/120) were oversized by >20%, and 10.0% (10/120) were oversized by ≥30%. This variability in annular oversizing has been implicated as a potential cause of annular injury. Blanke et al showed a significantly higher degree of annular oversizing and stretching in those patients who experienced root injury than those patients who did not. Specifically, 3/6 patients who experience annular injury were oversized >20%. CT offers the opportunity to identify other factors that may play an important role, including the distribution of aortic valvular and LVOT calcification (Figure 6). There is also a suggestion that the distribution of calcification in the LVOT may also play a role in predicting risk. In small series of contained rupture, post-TA VR identified by MDCT occurred adjacent to the left coronary sinus. This has led to a growing belief that the tissue adjacent to the left coronary sinus is friable and may, therefore, represent a locus minoris resistentiae.

**Coronary Ostial Occlusion**

Obstruction of the left main coronary or the ostium of the right coronary artery is a rare complication but potentially fatal event. This complication has been documented in the setting of TAVR and is felt to be related to displacement of a calcified native leaflet during valve deployment and resultant covering of the coronary ostium. Alternatively, coronary occlusion can more rarely relate to covering of the coronary ostium by the valve frame or the sealing cuff of the THV. Coronary obstruction may occur either at the time of balloon valvuloplasty or after THV deployment itself. Known factors that increase the risk of coronary obstruction include a bulky native cusp with heavy cusp calcification, a low origin of the coronary ostium (often defined as <12 mm from the basal cusp insertion), a shallow sinus of Valsalva (currently poorly defined), an oversized prosthesis, and high prosthesis implantation. MDCT has been the defacto gold standard for the identification of those patients at risk for coronary obstruction. Through the creation of multplanar reformations after identifying the basal insertion of the aortic valve cusps, accurate measurements from the cups insertion to the inferior margin of the left and right coronary ostia can be obtained (Figure 7). Recently, the potential to accurately measure coronary ostial height with 3D echo has been validated. Current recommendations for the balloon-expandable prosthesis is largely anecdotal with a vendor recommendations of minimum ostial height of 10 and 11 mm, respectively. There are currently registries in development of those patients that experienced coronary occlusion to help facilitate a better understanding of the mechanism behind coronary occlusion anatomic features that may leave patients at risk. Similar guidelines are now also available with the most commonly used self-expanding prosthesis.

**Conclusions**

TAVR has very much transformed the management of severe symptomatic AS in the high-risk surgical and nonsurgical patient population. Although it has been consistently shown to be a robust procedure, it remains limited by complication...
profile. The integration of advanced imaging tools, such as CT, has been shown to reduce the vascular complication rate, and in single-center studies to help reduce the burden of postprocedural paravalvular regurgitation with larger multicenter studies addressing this issue being performed. With further technological advancements allowing fusion of CT imaging in the hybrid operating room, there is growing hope that CT may allow for reduction in the rate of coronary occlusion, annular injury, and potentially conduction disturbances.

Disclosures
Dr Leipsic received modest speakers’ bureau and consultancy fees from Edwards Lifesciences.

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Leipsic et al. CT to Reduce TAVR Complications


Computed Tomographic Imaging of Transcatheter Aortic Valve Replacement for Prediction and Prevention of Procedural Complications
Jonathon Leipsic, Tae-Hyun Yang and James K. Min

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