Echocardiography for transcatheter aortic valve implantation

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Aortic stenosis; Echocardiography; Transcatheter aortic valve implantation

Transcatheter aortic valve implantation (TAVI) is a new technology that treats severe aortic stenosis. The technology has specific and mandatory technical requirements that must be met to allow safe and successful procedures. The echocardiographic method for diagnosis of aortic stenosis, anatomical case selection, procedural guidance and management of complications is discussed in this context. The role of the imaging specialist is defined within the TAVI team aiming to provide good outcomes for this high risk cohort of patients.

Introduction
Transcatheter aortic valve implantation (TAVI) is a new technique that may transform the treatment of patients with aortic valve disease. The technology is currently being assessed in the treatment of patients with severe aortic stenosis who are at high risk from conventional open surgery.1 Procedural success rates of 75–88% have previously been published, in association with reduction in aortic valve (AV) mean pressure gradients from 37–46 to 9 mmHg2–4 and significant improvement in New York Heart Association class.3,4 However, these encouraging results must be placed in the context of 30 day or in-hospital mortality rates of 10–22%.2–8 The perioperative management of these unstable patients and their co-morbidities, therefore, requires a multidisciplinary approach involving interventionist, surgeon, anaesthetist, and nursing and imaging specialists. The role of imaging is central to achieve the technical requirements of the technology, specifically in case selection, procedural access, prosthetic choice, prosthetic sizing, procedural guidance, and treating complications.

Imaging techniques in the context of TAVI
Transcatheter aortic valve implantation presents unique challenges for specialists involved in interventional imaging. Imaging techniques are used to diagnose the condition of the AV and concurrent coronary, valvular, and cardiomyopathic disease. In addition, these techniques must also be used to assess the anatomical requirements of the TAVI and to guide the procedure. Individual units must therefore plan the combination of echocardiography, catheter-based angiography/fluoroscopy (CBAF), computed tomographic angiography (CTA), and cardiac magnetic resonance (CMR) imaging that will allow complete assessment, appropriate case selection, and successful treatment. The techniques should be complementary and used in accordance with local expertise and access.

The CoreValve ReValving® System patient selection matrix provides a guide on how imaging may be deployed in relation to technical requirements (Figure 1). In Leicester, we use transthoracic echocardiography (TTE) for primary screening of patients and diagnosis of aortic valve and other cardiac disease; transoesophageal echocardiography (TOE) for assessing aortic root anatomy, TAVI procedural guidance, and management of intraoperative complications. CBAF is designated for diagnosis/treatment of coronary disease, assessment of the aortic root/aortic/iliofemoral anatomy, TAVI procedural guidance, and management of complications. In our unit, CTA/CMR is used for aortic valve/aortic root diagnosis when echocardiography is inadequate, and for coronary/aortic/iliofemoral assessment when CBAF is inadequate.

Appearance of percutaneous aortic valve prostheses
There are currently two percutaneous aortic valve prostheses in clinical use: the CoreValve and Edwards–Sapien prostheses. A familiarity with their appearance and the ideal position of implantation is mandatory for echocardiographers. It avoids incorrect interpretation, particularly of two-dimensional cross-sectional images of the prostheses in vivo.

The CoreValve prosthesis (Figure 2, CoreValve ReValving® System, CoreValve Inc., Irvine, CA, USA) consists of porcine pericardial tissue surgically sewn to form a trileaflet valve....

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mounted within an asymmetrical self-expanding Nitinol frame. The prosthetic valve annulus is implanted above the native AV annulus (AVA). The frame has a cylindrical ventricular portion deployed within the left ventricular outflow tract (LVOT) and the AVA; a constrained mid-portion waist that is deployed at the level of the sinuses of Valsalva (SOV) and coronary ostia; and a flared aortic portion deployed at or above the sinotubular junction (STJ) within the ascending aorta. The prosthetic size is determined by the external diameter of the ventricular end; the 26 and 29 mm size prostheses have mid-portion diameters of 22 and 24 mm, aortic end-diameters of 40 and 43 mm, and prosthetic lengths of 55 and 53 mm, respectively (CoreValve product literature).

The Edwards–Sapien prosthesis (Figure 3, Edwards LifeSciences Inc., CA, USA) is a trileaflet valve constructed previously of equine and now bovine pericardium, mounted within a stainless steel balloon-expandable stent. The valve element is implanted at the level of the AVA. The deployed cylindrical stent is symmetrical and the valve size is determined by the external diameter of the cylinder; the 26 and 29 mm prostheses have mid-portion diameters of 22 and 24 mm, aortic end-diameters of 40 and 43 mm, and prosthetic lengths of 55 and 53 mm, respectively (CoreValve product literature).

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Implantation procedures

The interventional echocardiographer must be aware of the different implantation procedures before attempting to guide a procedure. In keeping with other forms of perioperative echocardiography, the usefulness and relevance of imaging-based guidance increases with this awareness. Procedural knowledge is vital in ensuring that good communication exists within the operating team, and that precise guidance is available to either avoid or treat haemodynamic instability and complications in these high-risk patients.

The third generation CoreValve prosthesis is implanted by the retrograde approach using iliofemoral arterial access usually under general, and occasionally under local anaesthesia. The prosthesis is loaded into an 18F delivery catheter system by a customized compression loading system. A minimum iliofemoral diameter of 6 mm is required for this catheter size. A transvenous pacing wire is positioned in the right ventricle for bradycardia or rapid ventricular pacing. An angled pig-tailed catheter is placed in the aortic root for contrast aortography. The aortic valve is crossed by a wire and BAV is performed during rapid ventricular pacing.

The balloon is exchanged for the deflectable catheter carrying the prosthesis. The prosthesis is positioned across the AV under echocardiographic and fluoroscopic guidance. Balloon inflation during rapid ventricular pacing is used to expand the stent and to implant the prosthesis at the AVA. Rapid pacing is required to prevent LV ejection and displacement of the prosthesis after balloon deflation.

For patients who do not meet the peripheral access requirements for retrograde implantation, a transapical approach using either prosthesis is an option. The TAVI procedures are similar except that the BAV and delivery catheters are introduced antegradely through the left ventricular apex. Provisions for fluoroscopic and TOE imaging support in a hybrid operating theatre or converted catheter laboratory should be made.

Role of echocardiography in anatomical case selection

Severity/morphology of aortic stenosis

Transcatheter aortic valve implantation is indicated for patients with severe aortic stenosis, defined by an AV effective orifice area (EOA) of <1 cm², mean AV gradient of >40 mmHg, or AV peak systolic velocity of >4 m/s. In this context, CoreValve Inc. recommends TAVI at an AV EOA of <1 cm² or an indexed AV EOA of <0.6 cm²/m² body surface area. This is acceptable in comparison with the prosthetic EOAs obtained in vivo (26 mm EOA 1.64 ± 0.37 cm², 29 mm EOA 2.07 ± 0.48 cm², Leicester data, n = 36). Edwards Inc. recommends TAVI at an AV EOA of <0.8 cm². This is also acceptable in comparison with reported prosthetic EOAs (23/26 mm transfemoral EOA 1.7 ± 0.4 cm², 26 mm transapical EOA 1.8 ± 0.8 cm²). There is an additional requirement that unicuspid and bicuspid valves are contraindicated for the Edwards prosthesis as there is a risk of incomplete prosthetic deployment within the abnormal valve geometry.

The methods of assessing the severity of AV stenosis by TTE and stress TTE are well documented and described elsewhere in this supplement. TTE is superior to TOE for aligning the transducer to jets crossing the AV and obtaining accurate Doppler data for continuity EOA calculation. Misalignment and underestimation of flow velocities in the transgastric views may be partially corrected by the use of angle correction software. Where possible, the same degree of angle correction on the cursor should be used when obtaining both LVOT and AV data.

In contrast, TOE is superior to TTE for 2D image quality and accurate measurements of the LVOT diameter required for the continuity EOA formula. This diameter is measured on TOE immediately below the hinge points of the non-right coronary cusps of a trileaflet AV, in a zoomed mid-systolic frame with maximal leaflet excursion, taken from a centred mid-oesophageal long-axis view at 110–150° rotation, which also shows maximal AV and mitral annular diameters and parallel aortic root and LV walls (Figure 4).

Planimetry of the maximum AV systolic area by TOE is a useful option when there is sufficient image quality to delineate the leaflet free edges. The true, mid-systolic short-axis plane of the AV can be defined in the orthogonal plane using same beat, biplane imaging in probes with three-dimensional capability. The image can also be found by probe extubation.
while scanning at planes of 35–50°: it should show the leaflet tips seen in systole but not in diastole, and the commissural attachments to the aortic wall near the STJ (Figure 5). In comparison, an image taken below the leaflet tips in systole will show the leaflets tips closing in diastole, calcific disease within the cusps, and sub-commisural leaflet separation near the aortic wall; the planimetered area will usually be overestimated at this level (Figure 6).

**Aortic root geometry**

The CoreValve prosthesis has an asymmetric shape and is relatively long for its width. Therefore, there are several anatomical requirements that must be met to allow safe implantation. The 26 mm prosthesis requires the following diameters: a native AVA of 20–23 mm, SOV of ≥27 mm, STJ or ascending aorta of ≤40 mm, and AVA-coronary ostial distance of ≥14 mm. The 29 mm prosthesis requires: AVA 24–27 mm, SOV ≥28 mm, STJ or ascending aorta of ≤43 mm, and AVA-coronary ostial distance of ≥14 mm (Table 1).

In comparison, the Edwards–Sapien prosthesis is symmetrical and relatively short in width. The 23 mm prosthesis requires a native AVA diameter of 18–21 mm, and an AVA-ostial height of ≥10 mm. The 26 mm prosthesis requires an AVA diameter of 22–24.5 mm and an AVA-ostial height of ≥11 mm. There are no SOV or STJ requirements (Table 1).

Precision in measuring the aortic root is therefore necessary. The AVA measurement is critical for choosing the prosthetic size appropriate for individual patients. The correct root-prosthetic match allows optimal prosthetic function and avoids complications. Deploying a prosthesis too small for the patient’s aortic root can lead to high deployment, prosthetic embolism, or paravalvar aortic regurgitation (AR). Implanting a prosthesis too large for the root can cause aortic root trauma, coronary ostial obstruction, sub-optimal stent expansion and impaired leaflet mobility, low deployment and trans-stent AR above the prosthetic tissue rim, or low deployment affecting mitral valve function.

The SOV diameter and AVA-ostial height requirements reflect the clearance necessary to avoid occlusion of the coronary ostia by TAVI-displaced native valve material or the prosthetic skirt. The STJ and ascending aorta diameters are specific for ensuring that the aortic end of the CoreValve has sufficient anchorage to prevent embolization.

The error in quantification is in the range of ±0.5 mm, particularly when measuring AVA for prosthetic sizing. This is especially the case when the measurement is close to a cut-off recommended by the manufacturers. In our experience, such precision may not be achievable by TTE as it requires clear images with sufficient speckle resolution when magnified for measurement. There is a mean difference of −1.36 mm between TTE and TOE measurements of the annulus, with differences of +1.75 and −4.48 mm at two standard deviations of this mean.13 This difference is more than sufficient to affect the choice of prosthetic size. TTE-based selection criterion should account for this underestimation and a simple AVA cut-off of ≤26 mm for TTE appears appropriate.13

We employ as many TOE, CBAF (calibrated against a graduated catheter), CT or CMR images of the aortic root as necessary to obtain the correct sizing measurements. For CoreValve ReValving System TAVI, the multimodality

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**Figure 4** TOE mid-systolic frame for the measurement of LVOT diameter.

**Figure 5** TOE AV short-axis view at the level of the leaflet tips in mid-systole, appropriate for planimetry of valve area.

**Figure 6** TOE AV short-axis view below the level of the leaflet tips in mid-systole, resulting in an overestimated planimetered valve area.
confirmation is important for annuli of 19–20 mm at the lower cut-off, annuli at 23–24 mm between the two sizes, and annuli at 26–27 mm at the higher cut-off. For Edwards–Sapien TAVI, confirmation is important for annuli of 17–18, 21–22, and 24–25 mm for the same reasons.

The aortic root is best visualized in the parasternal long-axis view on TTE and the mid-oesophageal long-axis view on TOE. The TOE images of the aortic root are similar to those taken for LVOT diameter assessment, mentioned above. The digital loop is frozen and a zoomed end-diastolic frame is chosen at the beginning of the QRS complex after closure of the mitral valve and before opening of the AV. The aortic root walls should be parallel and the AV orifice central in a trileaflet valve. All measured diameters are intraluminal from aortic wall to aortic wall, ignoring any protruberant calcium; this is appropriate for a procedure that uses BAV and an intraluminal prosthesis (Figure 7).

The AVA is a diameter perpendicular to the long axis of the root, measured between the endothelial point that trisects the posterior aortic wall, non-coronary cusp hinge and anterior mitral leaflet hinge, and the point that bisects the anterior aortic wall and the right coronary cusp hinge. It may be necessary to confirm the accuracy of these points by observing the motion of the cusps or mitral leaflet in the frames before and after the frame chosen for quantification.

The SOV diameter is also perpendicular to the long axis of the root and typically parallel to the AVA. It is measured as the widest intraluminal distance within the sinuses. The STJ diameter is the intraluminal diameter parallel to the SOV diameter, where the sinuses narrow and join the ascending aorta. The ascending aorta diameter is measured at the widest diameter visible by TOE in the long-axis view. The AVA-ostial height is the distance of the right coronary ostium to the AVA.

**Subaortic geometry**

Transoesophageal echocardiography can identify subaortic disease that can affect the implantation of the long CoreValve prosthesis and its LVOT component. This disease can co-exist with AV stenosis and take the form of protruberant calcification extending from the AVA into the LVOT or the anterior mitral leaflet, or moderate–severe hypertrophy of the septal walls. CoreValve Inc. recommends that the implantation should not be performed if subaortic disease is sufficient to cause stenosis or if the septal wall thickness of ≥17 mm (Figure 1).

In borderline cases where non-compliant subaortic disease is seen after BAV, the operator should consider the risk of low deployment and its complications. If hypertrophic obstructive cardiomyopathy is a cause for LV outflow obstruction, the implantation of either prosthesis is contraindicated.

**Other valve disease**

The presence of severe disease of the other valves on echocardiography will affect the decision to proceed to TAVI alone. Mitral regurgitation of more than grade 2 severity is a contraindication for CoreValve ReValving System TAVI, as the LV component of the prosthesis can potentially interfere with mitral function by disrupting the secondary chordae or restricting anterior leaflet mobility.

**Other cardiac/cardiovascular disease**

Co-existent coronary artery disease is important for any patient undergoing high-risk intervention. Recent myocardial infarction is a contraindication to TAVI. Stress TTE is used to diagnose the flow-limitation in proximal coronary stenoses of ≥70% (CoreValve exclusion) or large areas of ischaemic burden (Edwards exclusion) that will exclude patients from TAVI.

Left ventricular dysfunction is seen in patients with severe AV stenosis who are at high risk from open surgery. LV ejection fraction of <20% is a TAVI contraindication recommended by both manufacturers. TAVI has therefore been performed on patients with mean baseline LV ejection fraction ≥30%.

### Table 1  Selected anatomical requirements for TAVI

<table>
<thead>
<tr>
<th></th>
<th>Aortic stenosis EOA, cm²</th>
<th>AV annulus, mm</th>
<th>SOV, mm</th>
<th>STJ, mm</th>
<th>AVA-coronary ostial height, mm</th>
<th>Iliofemoral diameter, mm</th>
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<tbody>
<tr>
<td>CoreValve</td>
<td></td>
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<tr>
<td>26 mm</td>
<td>&lt;1 cm²</td>
<td>20–23</td>
<td>≥27</td>
<td>≤40</td>
<td>≥14</td>
<td>18F, ≥6</td>
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<tr>
<td>29 mm</td>
<td></td>
<td>24–27</td>
<td>≥28</td>
<td>≤43</td>
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<tr>
<td>Edwards–Sapien</td>
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<tr>
<td>23 mm</td>
<td>&lt;0.8 cm²</td>
<td>18–21</td>
<td>NA</td>
<td>&gt;10</td>
<td>22F, ≥7</td>
<td></td>
</tr>
<tr>
<td>26 mm</td>
<td></td>
<td>22–24.5</td>
<td>NA</td>
<td>&gt;11</td>
<td>24F, ≥8</td>
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Figure 7  TOE long-axis view of the aortic root at end-diastole, with measurements of the AV annulus, SOV and STJ diameters, and the SOV height.
fractions of \(>50\%).^2,3,14\) Patients with low ejection fractions but mean AV gradients of \(<40\) mmHg at rest, may still have sufficient contractile reserve to undergo valve replacement with an excellent outcome.\(^15\) Those patients with low ejection fractions and mean gradients of \(>40\) mmHg can be risk stratified by Dobutamine stress echocardiography;\(^16\) the subset with LV contractile reserve during stress may be suitable for TAVI.

Thirty day stroke rates of 2–12\% have been reported.\(^2–5\) Recent cerebrovascular accidents contraindicate TAVI.\(^2\) TTE/TOE is important for detecting the sources of cardiovascular embolism, and the procedure should not be performed in patients with thrombus in the left heart chambers.\(^2\) High-grade atheroma in the aorta is a contraindication to transfemoral TAVI; it may be possible to perform transapical or trans-subclavian TAVI to avoid aortic plaque disruption, embolization, and mural trauma.

Echocardiography is not used in the assessment of aortic root or arch angulation or the peripheral vasculature.

**Role of echocardiography in procedural guidance**

The choice of intraoperative imaging modality for transfemoral TAVI is determined by operator preference, imaging expertise, and the interaction between patient co-morbidity and anaesthesia. CBAF and TTE can be used in patients who are given sedative and local anaesthesia.\(^2\) We have tested two-dimensional intracardiac echocardiography under local anaesthesia, but found this of insufficient utility for the procedure. The alternative is CBAF and TOE guidance under general anaesthesia\(^2\) with ventilatory support. TOE guidance was feasible in 37 out of 50 (74\%) patients who underwent Edwards TAVI\(^13\) and 32 out of 36 (89\%) undergoing CoreValve TAVI (Leicester data). Transapical TAVI requires a limited thoracotomy and is therefore performed under general anaesthesia, commonly with both CBAF and TOE support.

When CBAF and TOE are used in conjunction, a compromise fluoroscopic plane must be agreed where the TOE probe does not obscure radiographic views of the area of operation.

**AV crossing**

The failure to cross a stenotic AV with a guide wire is uncommon. In transfemoral TAVI, this may be due to a failure of peripheral access in 2\% (Edwards 22–24F)\(^3\) to 2.8\% of cases (Leicester 18F CoreValve data), rather than an inability to cross the valve. However, this can be difficult in cases with angulated aortic roots or non-tricuspid valve morphology. AV crossing points can be imaged in the 30–50° AV short-axis and 110–150° long-axis scan planes. Biplane or X-plane TOE can be helpful in identifying the appropriate approach to the orifice, particularly when combined with fluoroscopic data. Figure 8 shows the tram-line echo of a catheter where it typically crosses the AV in the commissure between non- and right coronary cusps.

**Balloon valvuloplasty**

Difficulty in performing BAV is rare in the TAVI experience, 1/590 (0.2\%).\(^14\) The size of the balloon used is proportionate to the AVA diameter. The crossing of the AV and correct positioning of the waist of the balloon at AVA level is guided by fluoroscopy and TOE. The TOE views are identical to dose used in AV crossing. Successful or unsuccessful inflation and de-waisting of the balloon is documented (Figure 9). Systolic motion of the balloon caused by LV ejection should not be seen during balloon inflation and deflation. Full deflation should be confirmed prior to retrieval. In patients with small roots, native valve material can cause posterior root tenting. There is a 3/590 (0.5\%) risk of aortic root perforation\(^14\) and the immediate post-BAV scan should assess this risk and AV function.

**Prosthetic positioning and deployment**

Following successful BAV, the delivery catheter carrying the prosthesis is guided retrogradely across the AV by fluoroscopy and TOE. The TOE should show the long-axis plane of the aortic root, frequently requiring lateral rotation to the right to image the catheter tip. There is a 2.3–6\% failure to cross the AV with the delivery catheter of either
prosthesis.\textsuperscript{2,3} The precise positioning of the prosthesis relative to the AVA requires good CBAF and TOE imaging. Malplacements or embolism of the prosthesis can occur at rates of 1.2\textsuperscript{4} to 4.0\%\textsuperscript{3} resulting in conversion to open surgery or deployment of the device in an aortic position that does not obstruct branch vessels.

The CoreValve prosthesis requires precise placement with the ventricular end 5–10 mm below the native AVA. The end of the delivery catheter is easily identified on TOE. As the delivery catheter is withdrawn, TOE is used to closely observe the emergence and expansion of the ventricular end of the prosthesis. The device has a high radial force at its LV end and may forcefully descend into the LVOT as it expands against the rigid AVA. The partially deployed prosthesis may therefore adopt a low position that may affect mitral valve function. Manual adjustment in the position is required so that the LV rim of the prosthesis covers <50\% of the anterior mitral leaflet and lies above the attachment of the secondary chordae to the leaflet (Figure 10). The aortic end is then deployed and the prosthesis is released (Figure 11). Prosthetic function and expansion of the stent can be immediately assessed and if there is significant dysfunction, the external dimensions of the CoreValve can be measured (Figure 12). Smaller than expected dimensions indicate suboptimal expansion, and prosthetic balloon valvuloplasty can be performed. Valvuloplasty should be avoided if TOE shows the presence of native valve material adjacent to the coronary ostia.

Transoesophageal echocardiography in the long-axis view is useful in guiding the positioning of the Edwards–Sapien prosthesis in 97\% of cases.\textsuperscript{13} The steerable catheter containing the Edwards–Sapien prosthesis is manipulated across the AV to a position parallel to the long axis of the root within the AVA. The device may migrate towards the aorta for up to 5 mm during deployment, and the optimal position of the prosthesis requires the ventricular end to be positioned up to 5 mm below the native AVA, a point just ventricular to the anterior mitral leaflet hinge.\textsuperscript{13} The aortic end should be close to the tips of the native AV leaflets. Identification of the ventricular and aortic rims of the prosthesis can be difficult whether it is crimped or expanded, and a knowledge of the prosthetic length, the use of high-frequency imaging, and careful manipulation of the probe are required to improve visualization. At deployment, full expansion of the balloon and absence of LV contraction during rapid ventricular pacing is documented. Correct positioning of the expanded prosthesis and its function should be confirmed.

The continuity EOA of the prosthesis is obtained in the standard manner with the new LVOT diameter of the prosthesis measured. Paravalvar AR is frequently seen of implants, but is rarely more than grade 2 or moderate in severity (1.0\textsuperscript{14} to 3.0\%\textsuperscript{13} incidence). The eccentric nature of the AR makes grading difficult and the height of the AR jet in the long-axis view and the circumferential extent of the jet in the short-axis view can be used to qualitatively assess this.\textsuperscript{13}

Role of echocardiography in the management of complications

Transcatheter aortic valve implantation procedures are performed on high-risk patients who have log EuroSCORE
predicted mortalities of 23\textsuperscript{14} to 28\textsuperscript{3} at open surgery. Even though TAVI mortalities are substantially lower, haemodynamic instability is likely to occur and the operating team should be prepared to diagnose and treat the cause. Perioperative cardiopulmonary resuscitation for loss of cardiac output may be expected in 11\% of patients (Leicester data). Rapid ventricular pacing may induce ventricular fibrillation in 2.5\% of cases.\textsuperscript{17} Myocardial infarction or coronary occlusion is seen in 1.5\% of CoreValve\textsuperscript{14} and 2\% of Edwards TAVIs.\textsuperscript{3} Aortic dissection and perforation is seen in 1.9\% to 6\% of procedures. Bradycarrhythmias resulting in permanent pacing have not been reported following the Edwards implant, but this is an outcome in 11\% of CoreValve implants.\textsuperscript{14}

In this context, TOE can contribute to the diagnosis of patients who develop acute and severe hypotension during TAVI. The sonographer should look for the following complications: Coronal Occlusion, Mitral valve dysfunction, Prosthetic dysfunction, Loss of blood, Cardio-Aortic Trauma, ION problems (arrhythmias) and Stroke. The procedure is usually imaged in the mid-oesophageal long-axis or three-chamber view. Without manipulating the probe, the emergency assessment requires a glance at the electrocardiogram (to identify tachy- or bradyarrhythmia), a look at the left atrial wall for collapse due to hypovolaemia, an assessment of the prosthetic position and function with 2D and colour flow images, an assessment of mitral valve function, a look at the aortic root/ascending aorta for dissection or rupture causing blood to enter the transverse sinus, and an assessment for regional wall motion abnormalities in the anterior septum or inferolateral LV walls. The probe can then be manipulated to confirm any abnormality that is found. If there are no abnormalities, the planes at 40–80\textdegree are used to assess the LV walls, the AV short-axis image, and the left main ostium. The planes at 0–20\textdegree are used to assess the LV walls, the atria for hypovolaemia, the pericardium for effusion and right ventricular tamponade, and the mitral valve. The transgastric views are then used to assess the LV short-axis function, the prosthetic function and the pericardium (Figure 13). Lastly, images of the thoracic aorta should be obtained.

Conclusions

Echocardiography has an essential role in the planning and provision of TAVI for high-risk patients with severe AV stenosis. In combination with other imaging modalities, it allows appropriate case selection, correct choice of prosthetic size and type, guides successful implantation, and facilitates the treatment of complications. The interventional echocardiographer must possess procedural knowledge, and precision in quantification, scanning and communication in order to be part of a team that delivers good outcomes for these patients.

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