Added value of modified transoesophageal echocardiography in the diagnosis of atherosclerosis of the distal ascending aorta in cardiac surgery patients

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Aims
Accurate visualization of the distal ascending aorta (DAA) can guide the surgical management and hence prevent dislodgment of atherogenic emboli during cardiac surgery. Conventional transoesophageal echocardiography (TEE) has a poor sensitivity; modified TEE was previously shown to accurately visualize atherosclerosis of the DAA. We studied the added value of modified TEE beyond the patient history and TEE screening.

Methods and results
Included were 421 patients from a previous diagnostic study, which compared the diagnosis of severe atherosclerosis with modified TEE and epiaortic ultrasound (EUS; reference test). We fitted three models, which predicted presence of atherosclerosis Grade ≥ 3 of the DAA. Model 1 included preoperative patient characteristics; in Model 2 conventional TEE was added; Model 3 additionally included modified TEE results. For each model, the area under the receiver-operating curve (AUC), the ‘net reclassification improvement’ (NRI) and the ‘integrated discrimination improvement’ (IDI) were determined. Missing data were imputed.

The AUCs of Models 1, 2, and 3 were 0.73 (95% CI: 0.68–0.78), 0.80 (95% CI: 0.76–0.85), and 0.93 (95% CI: 0.90–0.96), respectively. Comparing Model 3 with Model 2, the AUC was significantly higher (P < 0.001), the NRI was 0.60 (95% CI: 0.54–0.66; P < 0.001), and the IDI was 0.30 (95% CI: 0.28–0.32; P < 0.001), indicating that visualization of the DAA with modified TEE significantly improved reclassification.

Conclusion
Visualization of atherosclerosis of the DAA with modified TEE provided information beyond patient history and conventional TEE screening, which resulted in an improved diagnosis of atherosclerosis.

Keywords
Atherosclerosis • Cardiac surgery • Diagnostic Testing • Transoesophageal echocardiography

Introduction
In patients undergoing cardiac surgery, severe atherosclerosis of the ascending aorta is an independent predictor of post-operative cognitive dysfunction, stroke, and mortality.1–5 Release of atherogenic emboli in the cerebral circulation after aortic manipulation is assumed to play a pivotal role in the development of these complications.6 Atherogenic emboli can be elicited by external manipulation (e.g. placement of an aortic cross-clamp) or by direct endovascular trauma (e.g. aortic cannulation, or delivery of a transcatheter aortic valve). The distal ascending aorta (DAA) is an area of particular interest, since most of these manipulations are applied on this part of the aorta.7

Transoesophageal echocardiography (TEE) can accurately visualize atherosclerosis of the proximal ascending- and descending-aorta. However, a well-known caveat of TEE is the poor accuracy to visualize the DAA, caused by the interposition of the air-filled trachea.
between the oesophagus and DAA.\(^6\) Modified TEE (‘A-View method’) aims to address this limitation of transoesophageal echocardiography. With this novel diagnostic test, a balloon is introduced in the trachea and left main bronchus during conventional TEE. After inflation of the balloon with saline, a sonographic window to the aorta is created.\(^9\–\)\(^11\) A previous diagnostic accuracy study showed that the overall diagnostic accuracy of modified TEE was good (AUC 0.89; 95% CI: 0.86–0.92), with a high negative predictive value (97%; 95% CI: 95–99%) and a somewhat lower positive predictive value (67%; 95% CI: 60–73%).\(^11\)

We followed a widely recommended phased approach for the evaluation of modified TEE.\(^12\–\)\(^14\) which was initiated with a feasibility study,\(^7\) and followed by a single-test diagnostic accuracy study.\(^11\) The logical next step before performing a large and costly randomized trial to quantify the impact of modified TEE on clinical endpoints was to study the added diagnostic value beyond information already known. We hypothesized that modified TEE screening would improve the diagnosis of aortic atherosclerosis beyond clinical characteristics and conventional TEE imaging.

**Methods**

**Study design and population**

The study followed a cross-sectional diagnostic design and has been described in detail previously.\(^11\) In short, between May 2006 and December 2008, 465 patients were included in a multi-centre cross-sectional diagnostic study aimed at evaluating the single-test diagnostic accuracy of modified TEE. The outcome of interest was the presence of severe atherosclerosis of the DAA visualized with modified TEE (index test) compared with epiaortic ultrasound (EUS; reference test). In the current study, we included patients who had been operated at one of the participating centres (Isala Clinics, Zwolle, the Netherlands), since the clinical characteristics essential to quantify the added value of modified TEE were available for that centre only. Included were patients who underwent any cardiothoracic procedure that required sternotomy and an inflation of the balloon with saline, a sonographic window to the aorta is created.\(^9\–\)\(^11\) A previous diagnostic accuracy study showed that the overall diagnostic accuracy of modified TEE was good (AUC 0.89; 95% CI: 0.86–0.92), with a high negative predictive value (97%; 95% CI: 95–99%) and a somewhat lower positive predictive value (67%; 95% CI: 60–73%).\(^11\)

We followed a widely recommended phased approach for the evaluation of modified TEE,\(^12\–\)\(^14\) which was initiated with a feasibility study,\(^7\) and followed by a single-test diagnostic accuracy study.\(^11\) The logical next step before performing a large and costly randomized trial to quantify the impact of modified TEE on clinical endpoints was to study the added diagnostic value beyond information already known. We hypothesized that modified TEE screening would improve the diagnosis of aortic atherosclerosis beyond clinical characteristics and conventional TEE imaging.

**Conventional transoesophageal echocardiography**

Before sternotomy, but after induction of general anaesthesia and endotracheal intubation, a general echocardiographic assessment of the cardiac function and of the thoracic aorta was performed with conventional TEE (S7–2 omniplane, Philips, Eindhoven, the Netherlands). The proximal ascending- and descending-aorta were screened for atherosclerosis. Furthermore, an attempt was made to visualize the DAA, aortic arch, and the innominate artery.

**Modified TEE (index test)**

After TEE assessment, the transoesophageal probe stayed in situ. A separate TEE A-View catheter (Stroke2prevent, Hilversum, The Netherlands) was introduced via the endotracheal (ET) tube until the 24 cm marker lined up with a 24 cm marker on the ET-tube. After an echocardiographic check of an adequate position of the catheter in the left main bronchus, the balloon was inflated with 20–50 mL of sterile saline. Ventilation was not possible during balloon-inflation; pre-oxygenation of the patient provided a time span of 2–3 min in which the imaging could be safely performed.\(^9\),\(^10\) According to a standard protocol, three views of the aorta were acquired. First, the DAA TEE A-View short-axis view was obtained by retracting the TEE probe to a depth of 25–30 cm of the incisors, starting from a conventional transoesophageal proximal ascending aorta short-axis view. Upon rotating the multi-plane to 70–120 degrees the TEE A-View DAA long-axis view appeared. Upon further retracting the probe in a zero degree multi-plane angle, the aortic arch and its branch vessels were visualized by the TEE A-View aortic arch view.\(^10\)

**Epiaortic ultrasound (reference test)**

EUS (L15-7io epiaortic probe, Philips, Eindhoven, the Netherlands) served as the reference test. Short- and long-axis images of the proximal and DAA were obtained.\(^15\) EUS was performed after sternotomy and opening of the pericardium, the surgeon performing and interpreting the EUS was unaware of the results of modified TEE.

**Data collection**

During surgery, the attending anaesthesiologist registered the highest degree of atherosclerosis visualized with TEE, modified TEE, and EUS on dedicated forms. For all three modalities, the degree of atherosclerosis was recorded in four segments of the thoracic aorta, i.e. the proximal and DAA, the aortic arch and descending aorta. Severity of atherosclerosis was determined according to the Katz’s classification (figure 1; see Supplementary data online, SA for streaming image of Grade V mobile atheroma), severe atherosclerosis was defined as Grade 3 or greater.\(^16\) The DAA was defined as the aorta distal from the crossing with the right pulmonary artery until the innominate artery. Patient characteristics and perioperative data were extracted from a prospective ongoing registry in which pre-, peri- and post-operative data from all patients undergoing cardiothoracic surgery in the Isala Clinics were collected.

**Statistical analysis**

Baseline characteristics were described by mean (± standard deviation) for normally distributed and median (interquartile range) for non-normally distributed variables; statistical differences were assessed using a Student’s \(t\)-test or Mann–Whitney \(U\) test, respectively. Nominal variables were presented as frequencies and percentages of total; statistical difference was tested using a \(\chi^2\) or Fisher’s exact test as appropriate. A contingency table was constructed to compare the diagnosis of severe atherosclerosis of the DAA with the index and reference test, respectively. From this table, we calculated sensitivity and specificity, the positive and negative predictive value (PPV and NPV, respectively) and positive and negative likelihood ratios of modified TEE.

To quantify the added diagnostic value of modified TEE, we fitted three multivariable logistic regression models with presence of severe atherosclerosis (diagnosed with EUS) as the outcome or dependent variable. In the first model, we included known predictors of aortic atherosclerosis derived from literature: logistic EuroSCORE, age, sex, diabetes mellitus, hypertension, preoperative creatinine, peripheral atherosclerosis, neurological dysfunction, aortic stenosis, and previous vascular intervention (percutaneous coronary intervention (PCI) and/or coronary artery bypass grafting surgery (CABG)).\(^17\–\)\(^21\) In the second model, the grade of atherosclerosis (Grade I–V) of the proximal ascending- and descending-aorta visualized with conventional TEE was added to Model 1. Finally, in Model 3 we added the grade of atherosclerosis of the DAA visualized with modified TEE.

**Diagnostic performance**

For each model, we assessed its discrimination (the ability to distinguish between patients with and without severe aortic atherosclerosis) and calibration (the ability to correctly predict the probability of having
severe atherosclerosis) with a receiver-operating characteristic (ROC) curve, the accompanying area under the receiver-operating curve (AUC), and a calibration plot, respectively. Furthermore, a reclassification table comparing Model 2 with Model 3 was constructed, and the inherent ‘Net Reclassification Improvement’ (NRI) was calculated. The predicted probabilities of the separate models were stratified into three strata, arbitrarily defined as low (<0.25), intermediate (0.25–0.75), or high (>0.75). The NRI was calculated according to formula S1 (see Supplementary data online). A correct reclassification was a patient with atherosclerosis classified into a higher risk stratum, or a patient without atherosclerosis classified into a lower risk stratum by the larger model, respectively.

As the NRI depends on subjectively defined probability thresholds, we also estimated the integrated discrimination improvement (IDI). This measure of reclassification calculates the difference in the mean predicted probabilities derived by two models, for patients with and without atherosclerosis (see Supplementary data online, formula S2). The IDI can be interpreted as a change in the sensitivity given that the specificity remains constant.

Finally, the cumulative proportions of the predicted probabilities of the respective models were graphically displayed in a predictiveness curve. On the X-axis of this curve, the cumulative percentage of patients was depicted, while on the Y-axis the corresponding predicted probabilities were shown. Unlike other indices of diagnostic accuracy, the predictiveness curve does not require dichotomization, but offers insight in the full range of predicted risks.

Missing data were imputed, as it is well known that data are seldom missing completely at random, but rather selectively, i.e. subjects with missing values are different than those with completely observed data. Accordingly, discarding patients with missing data may lead to biased results and a loss in precision. Imputation was performed in R using the MICE library; five imputed datasets were created. The above analyses were performed for each separate dataset, and then pooled according to Rubin’s rule. Throughout the analyses, tests were performed two-sided and a P-value of <0.05 was regarded statistically significant. Analyses were performed in R 2.13.1 and SPSS 19.0.0.

### Results

Included were 421 patients operated at the Isala Clinics, Zwolle, The Netherlands. In 316 (77.0%) of these patients, both the index and reference test had been performed. There were no significant differences in baseline characteristics between patients with or without missing outcome data, except for non-elective surgery, which was more common in patients with a missing index- or reference-test (2.9 vs. 0.3%; P = 0.05; see Supplementary data online, SA). To account for this (selective) missingness, all analyses presented below were based on imputed data. However, our findings did not change substantially when performed with the complete data (see Supplementary data online, SB–SD).

![Figure 1](image_url) Distal, long-axis view of the DAA as imaged with modified TEE, showing, (A) Normal aorta, (B) extensive intimal thickening, (C) protruding atheroma < 5 mm, (D) protruding atheroma > 5 mm, (E) mobile plaque (1, anterior wall; 2, posterior wall; 3, inflated A-View balloon; arrow indicated atheroma).
Table 1: Baseline characteristics

<table>
<thead>
<tr>
<th></th>
<th>Atherosclerosis DAA (with EUS)</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Grade ≤ 2 Total n = 253</td>
<td>Grade ≥ 3 Total n = 168</td>
</tr>
<tr>
<td>Male gender</td>
<td>164 (64.8)</td>
<td>102 (60.8)</td>
</tr>
<tr>
<td>Age, median (IQR)</td>
<td>73 (69–77)</td>
<td>73 (70–78)</td>
</tr>
<tr>
<td>History of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>143 (56.3)</td>
<td>94 (56.3)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>56 (22.0)</td>
<td>47 (28.1)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>36 (14.3)</td>
<td>33 (19.5)</td>
</tr>
<tr>
<td>Extracardiac atherosclerosis</td>
<td>25 (9.8)</td>
<td>45 (26.9)</td>
</tr>
<tr>
<td>Neurological dysfunction</td>
<td>33 (13.0)</td>
<td>29 (17.3)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>24 (9.3)</td>
<td>18 (11.0)</td>
</tr>
<tr>
<td>Percutaneous coronary intervention</td>
<td>24 (9.6)</td>
<td>33 (19.5)</td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td>10 (3.9)</td>
<td>18 (10.8)</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal ascending aorta</td>
<td>160 (63.3)</td>
<td>138 (82.2)</td>
</tr>
<tr>
<td>Descending aorta</td>
<td>214 (84.5)</td>
<td>166 (99.0)</td>
</tr>
</tbody>
</table>

Values are number (%) of patients in corresponding group; continuous variables are presented as the median (interquartile range).

Table 1 presents the baseline characteristics, stratified by presence of severe atherosclerosis of the DAA as diagnosed by EUS. Median age of all patients was 73 (IQR: 69–77) years, 63.2% of patients were male, and the median EuroSCORE was 7.5% (IQR: 4.3–14.7%). Patients with atherosclerosis of the DAA more often had atherosclerosis Grade ≥3 of the proximal ascending (82.2% vs. 63.3%, P < 0.001) and descending (99.0% vs. 84.5%, P < 0.001) aorta, compared with those without severe atherosclerosis of the DAA. The NPV of absence of atherosclerosis in both the proximal ascending- and descending-aorta was 98.8% (95% CI: 76.1–99.9%), while the PPV of presence of severe atherosclerosis in both segments was 49.6% (95% CI: 43.6–55.7%).

The contingency table of EUS and modified TEE is depicted in Table 2. Sensitivity and specificity of modified TEE to detect atherosclerosis Grade ≥3 of the DAA were 94.6% (95% CI: 89.8–97.4%) and 77.6% (95% CI: 72.0–82.2%), respectively, with a PPV of 73.7% (95% CI: 67.2–79.3%) and NPV of 95.6% (95% CI: 91.6–97.9%).

Model performance

For Model 1, which included baseline characteristics, the AUC was 0.73 (95% CI: 0.68–0.78; Figure 2). When adding severity of aortic atherosclerosis visualized with TEE, the AUC increased to 0.80 (95% CI: 0.76–0.85; Model 2). Finally, after adding the grade of atherosclerosis of the DAA visualized with modified TEE, the AUC significantly increased to 0.93 (95% CI: 0.90–0.96; Model 3). Calibration of the three models is depicted in Figure 3, indicating good calibration of each model.

Reclassification

The net reclassification index comparing Model 3 with Model 1 was 0.84 (95% CI: 0.77–0.91; reclassification table not shown), with an IDI of 0.41 (P < 0.001). The reclassification table comparing Models 3 and 2 is presented in Table 3. As can be interpreted, 73 (43.5%) of
the 168 cases were correctly reclassified into a higher risk category, while eight (4.8%) were incorrectly reclassified into a lower risk category, resulting in a net gain in reclassification of 38.7%. Similarly, among the 253 non-cases, the net gain in reclassification was 21.3%. The overall NRI was thus 0.60 (95% CI: 0.54–0.66), indicating that adding modified TEE greatly and significantly improved the classification of patients.

The mean predicted probabilities were 0.73 and 0.56 for Model 3 and 2 among cases, and 0.17 and 0.29 among non-cases, respectively. Following formula S2 (see Supplementary data online), this resulted in an IDI of 0.30 ($P < 0.001$). Finally, the predictiveness curves of the three models are depicted in Figure 4. As an example, the previously mentioned risk categories have been indicated in this figure. Applying the second model, 36% of patients were classified in the low-, 52% in the intermediate-, and 12% in the high-risk group. In contrast, applying Model 3 these figures were 46, 30, and 24%, respectively.

**Discussion**

The main finding of this study was that modified TEE improved the diagnosis of atherosclerosis of the DAA considerably and significantly, beyond information available from patient history and visualization of the thoracic aorta with conventional TEE. The improved diagnosis of atherosclerosis of the DAA should guide the operative management and prevent perioperative cerebral embolic complications.

Accurate visualization of the (distal) ascending aorta during cardiothoracic aorta is of great importance, as presence of aortic atherosclerosis can guide subtle (e.g. change of positioning aortic cannula or cross-clamp) and more extensive (e.g. off-pump surgery, femoral cannulation) changes in the surgical management. Indeed, multiple guidelines recommend perioperative screening for aortic atherosclerosis during cardiothoracic surgery,$^{15,29}$ as well as during transcatheter aortic valve replacements.$^{30}$

EUS is considered the gold standard of visualization of the DAA in cardiac surgery, in daily practice it is not routinely used however.$^5$ Furthermore, it cannot be applied in a growing volume of closed-chest or minimally invasive procedures, as direct access to the ascending aorta is required. Transoesophageal echocardiography is widely used during cardiothoracic surgery, but its sensitivity to diagnose severe atherosclerosis of the DAA is only 21% (95% CI: 13–32%).$^8$ Also, the agreement between TEE and EUS is very poor (kappa 0.12, 95% CI: 0.0–0.25) due to an underestimation of the degree of aortic atherosclerosis with TEE in 66% of patients.$^{31}$ As mentioned, the main reason for this poor accuracy is the so-called ‘blind-spot’ caused by the interposition of the trachea between oesophagus and the DAA.

Previously, modified TEE was shown to accurately detect, and especially exclude, atherosclerosis of the DAA in a single-test diagnostic accuracy study.$^{11}$ Alike most diagnostic work-ups, however,

![Figure 2](image2.png)

**Figure 2** Receiver operating characteristic curves for the prediction of severe atherosclerosis of the distal ascending aorta with Model 1 (patient characteristics), Model 2 (Model 1 + conventional TEE), and Model 3 (Model 2 + modified TEE). AUC, area under the receiver operating characteristic curve.

![Figure 3](image3.png)

**Figure 3** Calibration plots of Model 1 (patient characteristics), Model 2 (Model 1 + conventional TEE), and Model 3 (Model 2 + modified TEE).
the diagnosis of aortic atherosclerosis with modified TEE is a multi-
variable process. The perioperative management can only
improve if additional information is obtained beyond parameters
already known. Indeed, patients’ characteristics (AUC 0.73; 95% CI: 0.68–0.78) and additional TEE imaging (AUC 0.80; 95% CI:
0.76–0.85) already predicted the presence of atherosclerosis in
the DAA reasonably well. However, addition of modified TEE
further improved the diagnostic accuracy (AUC 0.93; 0.90–0.96),
and improved patient classification as shown by an IDI and NRI of
0.60 and 0.30, respectively (both P < 0.001).

A more accurate diagnosis of aortic atherosclerosis is a prerequi-
site, but obviously not a guarantee that the implementation of modi-
fied TEE will also improve clinical outcomes. The timing of the test
is another important parameter. In contrast to EUS, with modified
TEE the thoracic aorta can be visualized before start of surgery
after intubation. In our experience, this time span is sufficient also
for the performance of major adaptations such as transfemoral can-
nulation or conversion to off-pump surgery.

Computed tomography and magnetic resonance imaging can offer
a more timely diagnosis of aortic atherosclerosis. An increased
CT-detected atherosclerotic burden has been associated with a
worse prognosis after cardiac surgery, and its implementation as
a preoperative screening modality may result in changes in the surgi-
cal management and a reduction of post-operative ischaemic
strokes. In contrast to real-time imaging with echocardiography-based
techniques, this cannot be offered with these offline modalities. It has indeed been shown that the sensitivity
of CT-imaging for aortic atherosclerosis was inferior to EUS and
TEE. In the latter study, 47% of TEE-detected severe atherosclerot-
ic plaques were missed with CT imaging.

Another interesting new technique for the intraoperative visual-
ization of aortic atherosclerosis is phased-array intra-cardiac eco-
chocardiography (ICE). In this technique, an ultrasound unit is placed
in the right atrium, through which the aortic valve and proximal ascend-
ing aorta can be visualized. Direct intra-aortic echocardiography of

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**Table 3** Reclassification table comparing the risk of atherosclerosis of the DAA predicted by Model 2 (patient history and TEE) to Model 3 (Model 2 + modified TEE)

<table>
<thead>
<tr>
<th>Atherosclerosis (n = 168)</th>
<th>Model 3: Modified TEE</th>
<th>Model 2: TEE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Model 2: TEE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Intermediate</td>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>High</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>8* (4.7)</td>
<td>64* (38.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No atherosclerosis (n = 253)</th>
<th>Model 3: Modified TEE</th>
<th>Model 2: TEE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Model 2: TEE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>107</td>
<td>24</td>
</tr>
<tr>
<td>Intermediate</td>
<td>78</td>
<td>28</td>
</tr>
<tr>
<td>High</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>186 (68.4)</td>
<td>59 (27.8)</td>
</tr>
</tbody>
</table>

Table depicts the number of patients classified to a low (<0.25), intermediate (0.25–0.75), or high (≥0.75) probability of atherosclerosis in the DAA. The upper panel represents patients with presence of severe atherosclerosis (Grade ≥ 3) diagnosed with EUS, the lower panel with absence of atherosclerosis. The white cells contain the number of patients in the same risk group; patients in the green cells were correctly reclassified by Model 3, while patients in the red cells were incorrectly reclassified. The NRI of Model 3 vs. Model 2 = 0.60 (95% CI: 0.54–0.66). Figures are n (%).

*Counts do not add up to total due to rounding of imputed data.

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**Figure 4** Curves depict the cumulative proportion of predicted probabilities for Model 1 (patient characteristics), Model 2 (Model 1 + TEE), and Model 3 (Model 2 + modified TEE).
the descending aorta using the same device has also been described.\textsuperscript{42} To our knowledge, the diagnostic accuracy of both methods for aortic atherosclerosis has not yet been studied however.

Some limitations apply to our study. First, since EUS served as the reference test, we could not study the added value of modified TEE compared with the added value of EUS. In daily practice, however, screening for aortic atherosclerosis is initiated with modified TEE, as this is performed before sternotomy. Given its high negative predictive value, surgery can continue as planned when severe atherosclerosis is absent. Depending on location and severity of atherosclerosis, a subsequent EUS examination may be considered to confirm a positive result of modified TEE.

Secondly, generalizability may be impaired as modified TEE was mainly performed by two senior anesthesiologists, and all patients were included at a single institution with extensive experience in the field of cardiothoracic surgery. Future research will have to show whether these results can be replicated in other settings and with other, less experienced, observers.

Finally, there was a substantial amount of missing data, especially for the results of the index and reference test. The main reason for not undergoing these tests was an unavailability of trained personnel to operate modified TEE or EUS. Thus, it seems reasonable to assume that the missingness of these variables did not depend on patient characteristics, and did therefore not affect validity of the results. Indeed, there were only minor imbalances in the distribution of pre-operative characteristics in patients with and without a missing index and/or reference test (see Supplementary data online, SI). Also, we aimed to minimize any possible bias through multiple imputation of the missing data.

To conclude, detection of atherosclerosis in the DAA with modified TEE was not only accurate, but also offered information beyond that obtained from patient characteristics and transoesophageal echocardiography, which resulted in an improved classification of patients.

Supplementary data

Supplementary data are available at European Heart Journal – Cardiovascular Imaging online.

Acknowledgements

We thank Arno Nierich for his contributions to the A-View II study.

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Funding

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References

2. Evered LA, Silbert BS, Scott DA. Postoperative cognitive dysfunction and aortic ath.
A 67-year-old man with a history of paclitaxel-eluting stent implantation in the right coronary artery (RCA) 4 years previously needed below-the-knee amputation of the right leg due to uncontrollable foot infection. The patient had acute high fever and leukocytosis, and performed repeatedly transthoracic echocardiography (TTE) to rule out infective endocarditis. TTE revealed the presence of a mass (4.7 × 3.4 cm) (head arrows) adjacent to the sinus of Valsalva (Panel A). A giant pseudoaneurysm (5.1 × 3.7 cm) (head arrows) at the proximal site of the stent (arrows) was confirmed by the cardiovascular computed tomography (CCT; Panel B) and also a three-dimensional volume rendered CCT image (Panel C). The angiography in the left anterior oblique projection showed contrast agent extravasation into a giant mycotic pseudoaneurysm (arrows) (Panel D). We performed emergent surgery to decrease the risk for acute rupture since the mycotic pseudoaneurysm progressed rapidly in 2 weeks. An intraoperative image showed the pseudoaneurysm after opening and aspiration of the cavity (head arrows), and the stent removed from the RCA (arrow) (Panel E). Haematoyxlin–eosin stain (×250) showed only fibrous tissue without normal arterial walls and the presence of inflammation with accumulation of neutrophils and cocci (Panel F).

Coronary stent infection is a rare complication, but it is associated with high mortality. Late stent infection may be caused by drug-eluting stent (DES)-related local problems (delayed endothelialization of the stent struts, inhibition of neointimal growth, late acquired incomplete stent apposition, and coronary aneurysm formation). These local reactions to the DES may provide a nidus for stent infection during an episode of bacteraemia.