CASE REPORT

3D echocardiography allows rapid and accurate surgical planning in complex aortic root abscess cases

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Summary

Despite 3D echocardiography (3DE) acquiring significantly greater data than standard 2D echocardiography (2DE), it is underutilised in assessing cardiac anatomy and physiology. A key advantage is the ability of a single 3DE acquisition to be post-processed to generate volume-rendered 3D models and an unlimited number of multiplanar reconstruction (MPR) images. We describe the case of a highly anxious patient with life-threatening complex aortic valve endocarditis and aortic root abscess, refusing transesophageal echocardiography (TOE) under general anaesthesia with tachycardia, breathlessness and acute kidney injury precluding accurate or safe gated (computed tomography) CT, who was comprehensively assessed with a rapid 3D-TOE under sedation. This led to timely surgery and an excellent outcome for the patient.

Key Words

- 3D echocardiography
- 3D transoesophageal echocardiography
- aortic root abscess
- aortic valve endocarditis
- aortic valve surgery

Learning points:

- 3DE is of greater clinical value than 2DE as it is able to post-process a single 3DE image acquisition into volume rendered 3D models, and provide an unlimited number of multiplanar reconstruction (MPR) images.
- 3DE is highly effective in difficult cases where speed is important.
- 3DE is superior in the planning of complex surgical cases.

Background

This case strongly emphasises the superiority of 3D-TOE over 2D-TOE and makes the case for its routine use in clinical practice. Not only is it faster to perform, resulting in less patient discomfort and shorter sedation time, it also offers significantly greater data. This is because of its ability to produce volume-rendered 3D models and unlimited MPR 2D images from a single image acquisition to visualise pathology and plan for any intervention that may be necessary. TOE operators should be trained in and use 3DE ubiquitously in everyday practice. This is particularly important where high-quality imaging of complex pathology, such as the aortic root abscess

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in this case, benefits from comprehensive and versatile MPR reconstructions, improving pre-surgical planning and patient outcomes.

Case presentation

A 25-year-old-female intravenous drug user presented to our institution with collapse after a 1-month history of constitutional symptoms. Her background included bicuspid aortic valve disease with aortic stenosis. On admission, leucophilia (WCC 18×10^9/L), anaemia (Hb 70 g/L), acute kidney injury and *Staphylococcus aureus* bacteraemia were present. Transthoracic echocardiography (TTE) revealed thickening of the aortic valve leaflets and root suggestive of infection; however, echocardiographic windows and image quality were suboptimal. Cardiac surgeons recommended urgent surgery. Accurate imaging-based assessment was required. However, the patient was highly anxious and refused pre-operative TOE under general anaesthesia. Given her tachycardia, difficulty in breath-holding and acute kidney injury, gated cardiac CT would be of insufficient quality and unsafe for accurate aortic valve and root assessment. She reluctantly agreed to a 'fast' TOE under sedation. She tolerated a study of only 7 minutes. Despite this short study duration, 18 2D-TOE images and 3 3D-TOE datasets of the mitral valve, aortic valves and aortic root were acquired. These were sufficient for the post-processing generation of highly detailed anatomical and functional assessments of the aortic valve, aortic root and coronary arteries, facilitating surgical planning. The study demonstrated severe infection of both aortic valve leaflets, perforation of the major leaflet, severe mixed aortic valve disease and infection throughout the aortic root with multiple abscess cavities but no coronary artery involvement (Figs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14).

Investigation

Figs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 show images captured from 3D-TOE, while Figs 12, 13 and 14 show the equivalent 2D-TOE views for comparison.

Images of the coronary arteries (Figs 9, 10 and 11) are included to demonstrate their lack of involvement with the abscess.

Treatment and outcome

The patient subsequently underwent urgent bioprosthetic aortic valve replacement and root reconstruction, and made an excellent recovery.

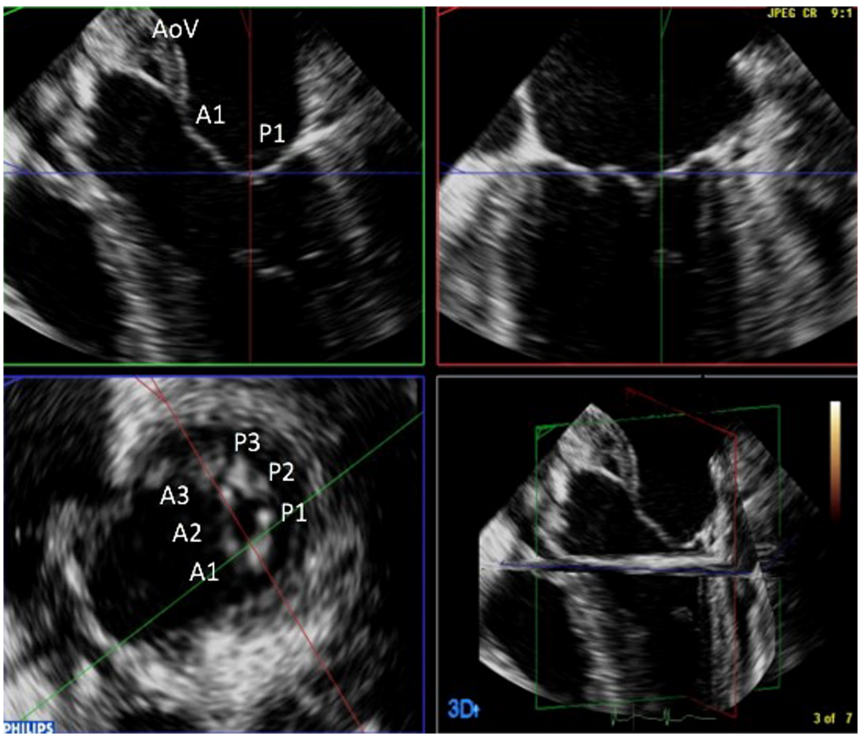

Figure 1
Mitral valve A1-P1 free of infection.

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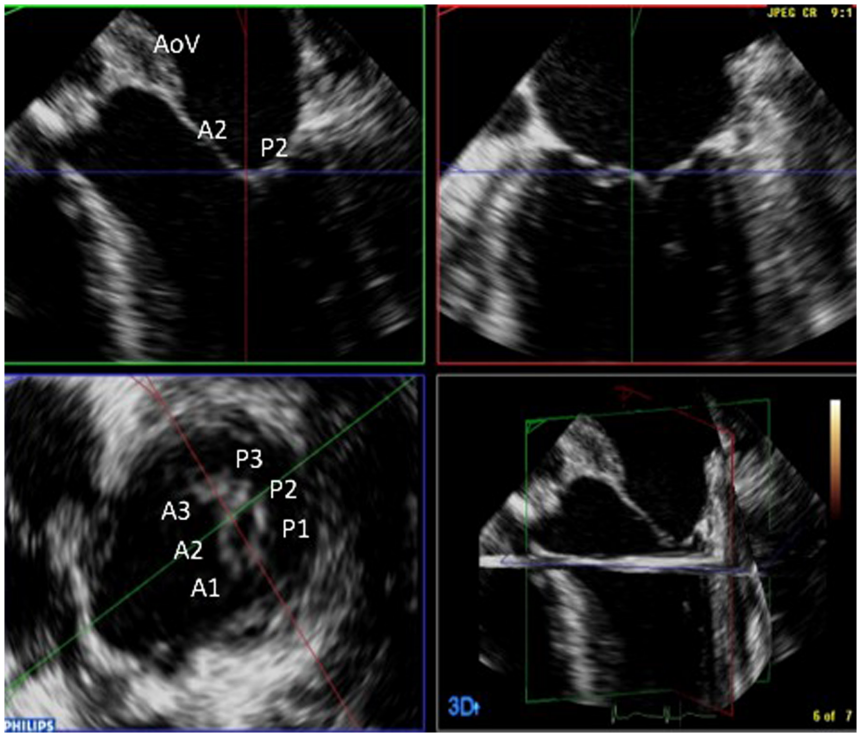

Figure 2
Mitral valve A2-P2 free of infection.

Discussion

Aortic valve endocarditis with leaflet destruction and aortic root abscesses are potentially fatal with a high mortality (1), and always warrant urgent surgical intervention. The preferred and recommended standard for assessing cardiac complications from endocarditis including leaflet destruction and aortic root infection is TOE over TTE (2). This is because of the greater anatomical resolution of the intracardiac structures obtained with TOE, crucial in

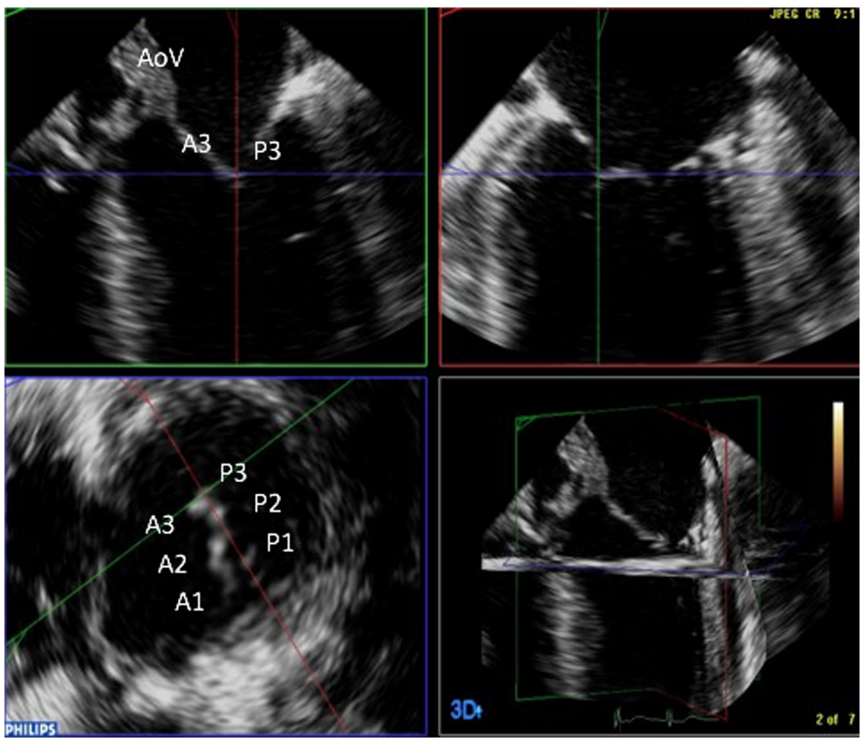

Figure 3
Mitral valve A3-P3 free of infection.

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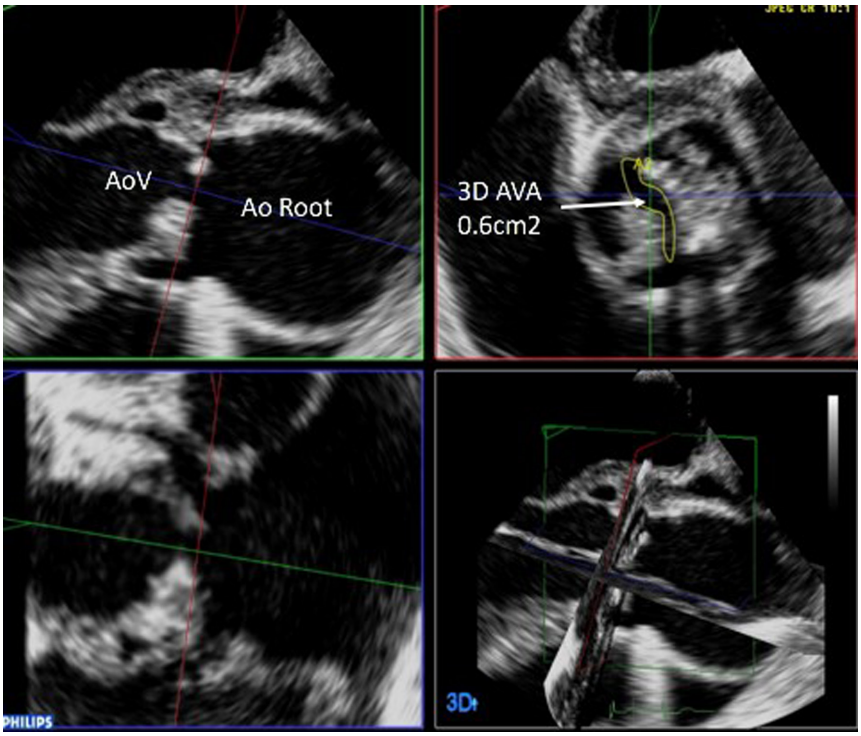

Figure 4
AVA 3D 0.6 cm² on 3D planimetry.

pre-operative surgical planning. TTE is recommended by the European Association of Echocardiography as the initial, first-line investigation because of its non-invasive nature.

Current clinical practice typically involves performing TOE with 2DE over 3DE. Whilst 2D-TOE produces higher quality images than 3D-TOE (Figs 12, 13 and 14), it also necessitates appreciation of geometric modelling and assumptions about cardiac shape, making obtaining images more time consuming, technically difficult and potentially inconclusive. Because abscesses are typically not limited to specific cross-sections, they commonly extend far beyond the planes that are routinely obtained by 2DE. This issue was demonstrated by a case series from Hill and colleagues (3) who found that only 48% of abscess detected intraoperatively actually correlated

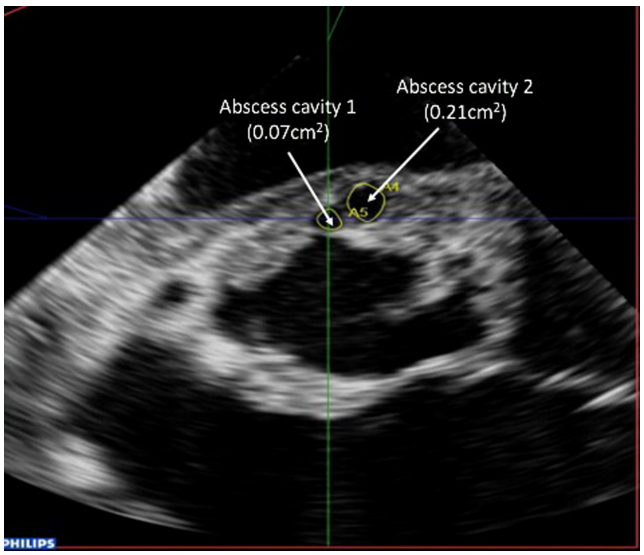

Figure 5
2x root abscess cavities (0.21 cm², 0.07 cm²).

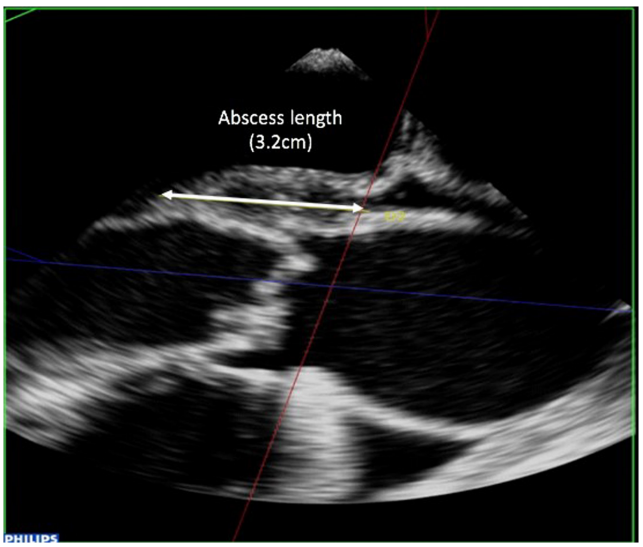

Figure 6
Aortic root infection extent (3.2 cm length).

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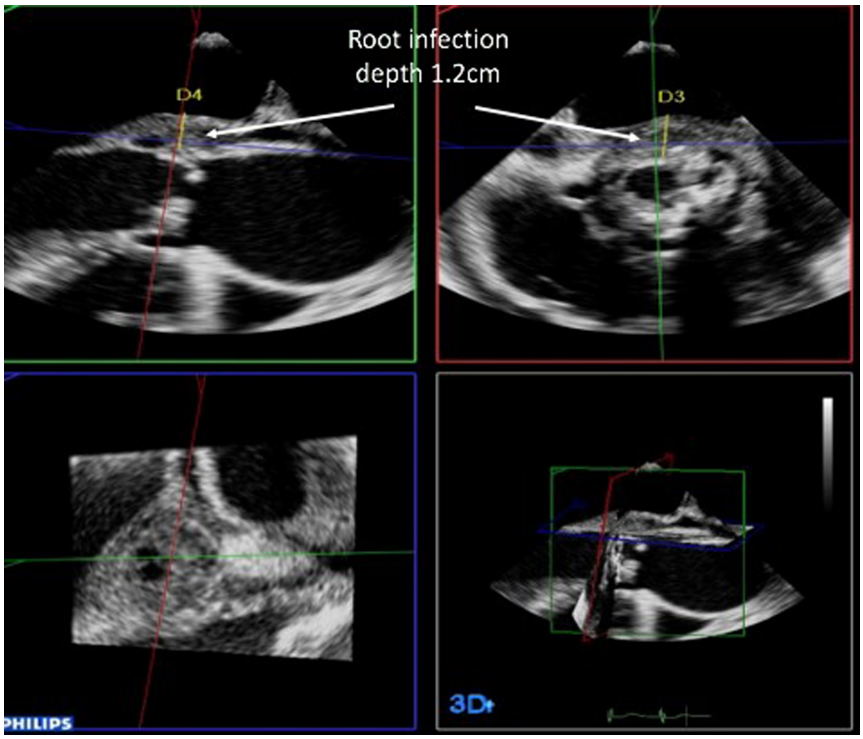

Figure 7
Root infection (max depth 1.2 cm superiorly).

with pre-operative 2D-TOE imaging. Whereas 2DE amounts to a single tomographic slice through a region of interest, 3D-TOE can provide visual information of that entire region through acquisition of a volume of data. This is especially important when large valvular vegetations or abscesses are present, as 2D-TOE can fail to provide sufficient information regarding the relationship between vegetations, prosthesis, and adjacent structures (4). 3D-TOE permits high levels of post-processing, with a single 3D-TOE volumetric image allowing (a) reconstruction of volume-rendered 3D images, (b) generation of MPR 2D images from unlimited planes

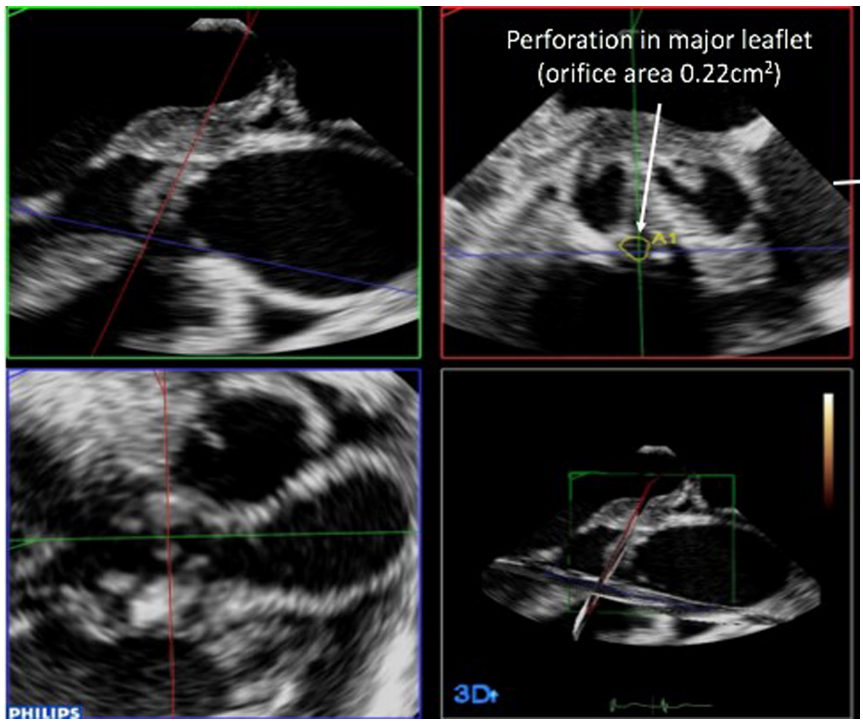

Figure 8
Perforation in major leaflet (orifice area 0.22 cm^2). This was confirmed on colour Doppler on short and long axis views.

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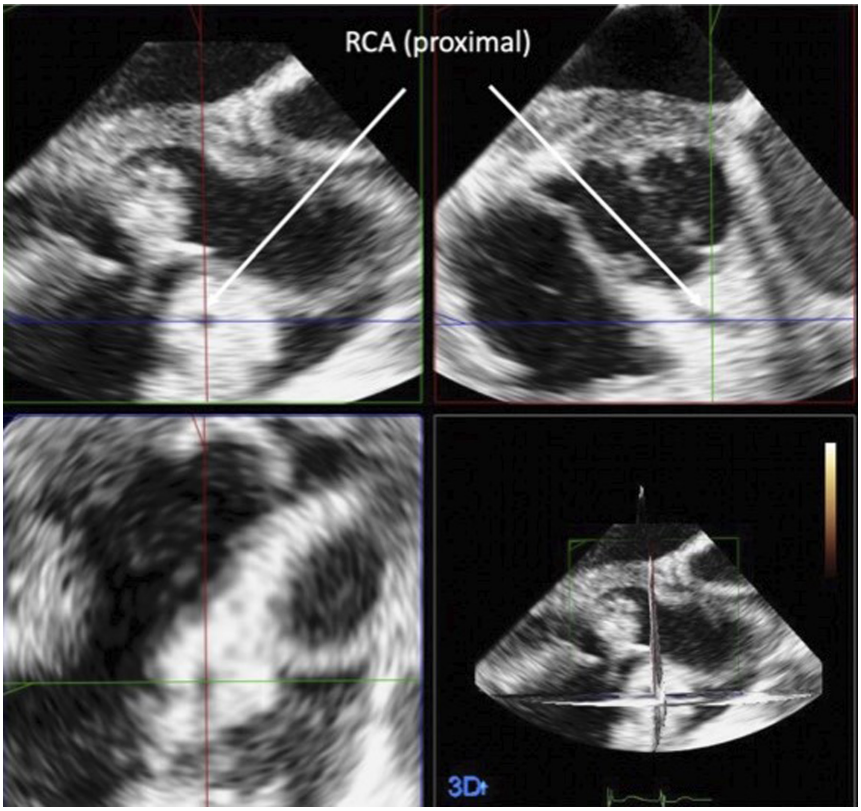

Figure 9
Right coronary artery (RCA) arising from 6 o'clock position. Infection and abscess clearly not involving the RCA.

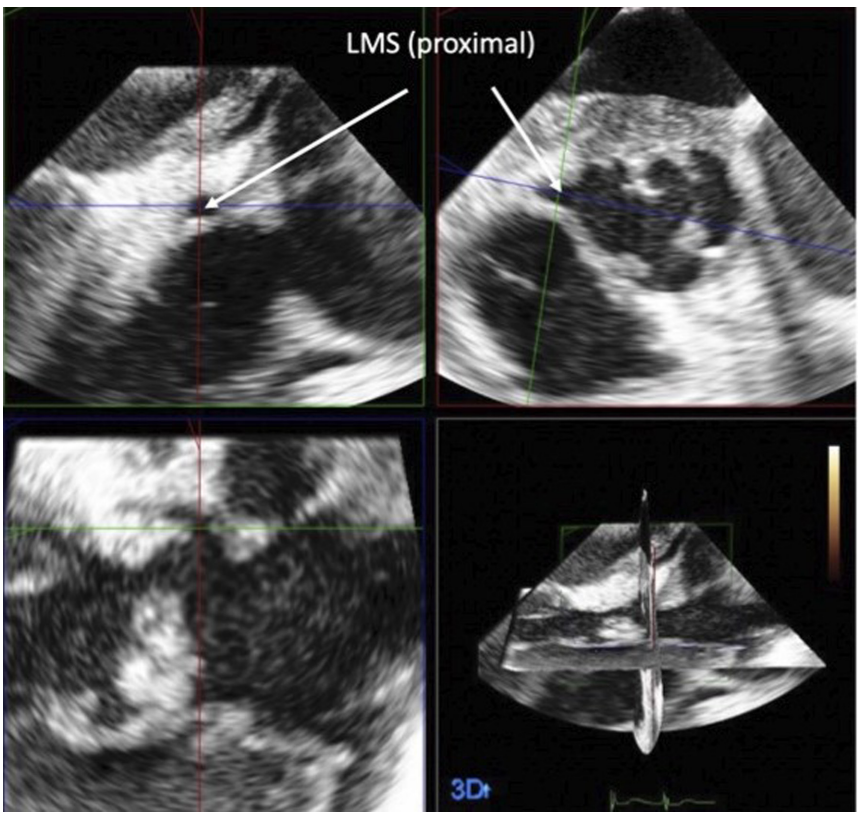

Figure 10
Left Main Stem (LMS) at the 10 o'clock position. Infection and abscess clearly not involving the LMS.

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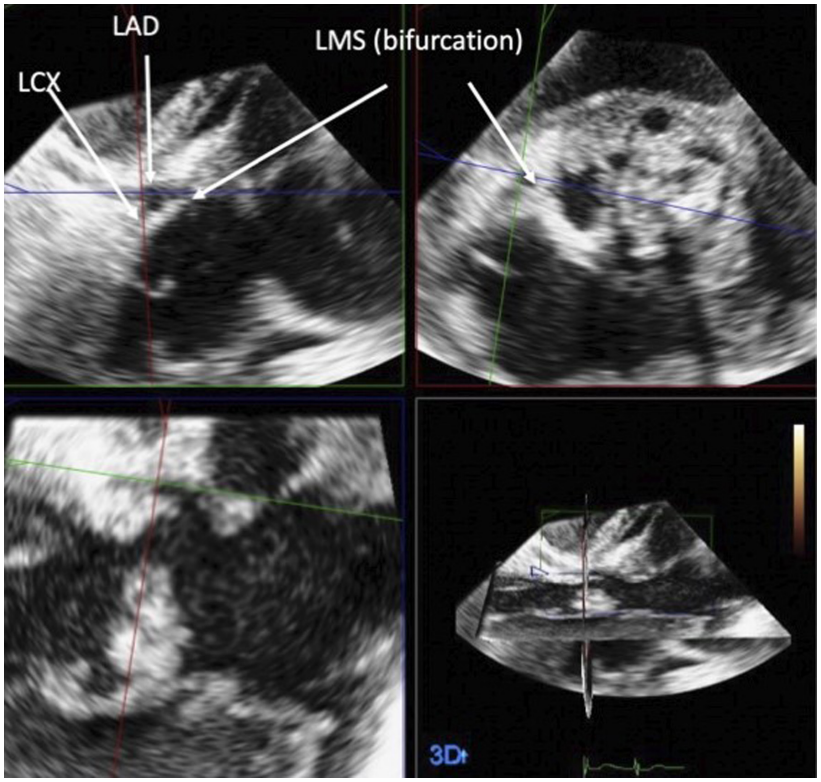

Figure 11
LMS arising at 10 o'clock position. Bifurcation of the left circumflex (LCx) and left anterior descending (LAD). No abscess involvement.

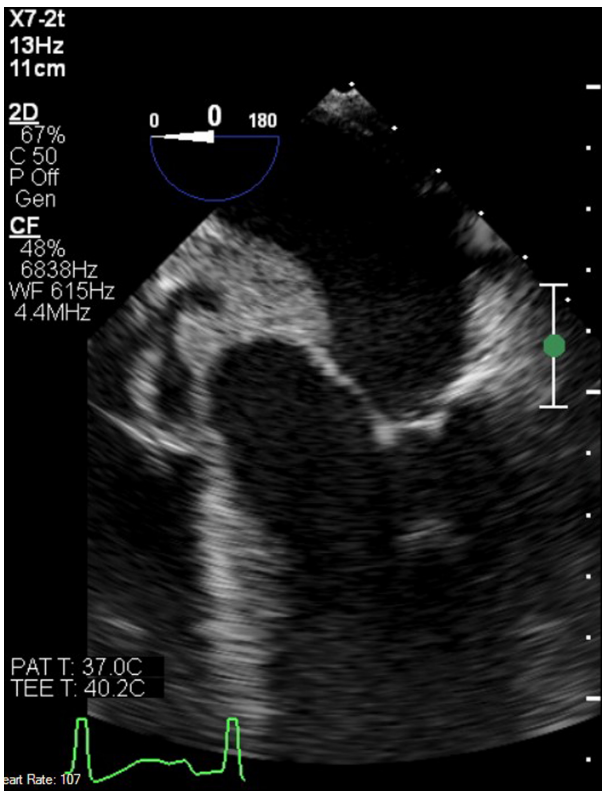

Figure 12
Comparative 2D-TOE image in same planar view as Fig. 1.

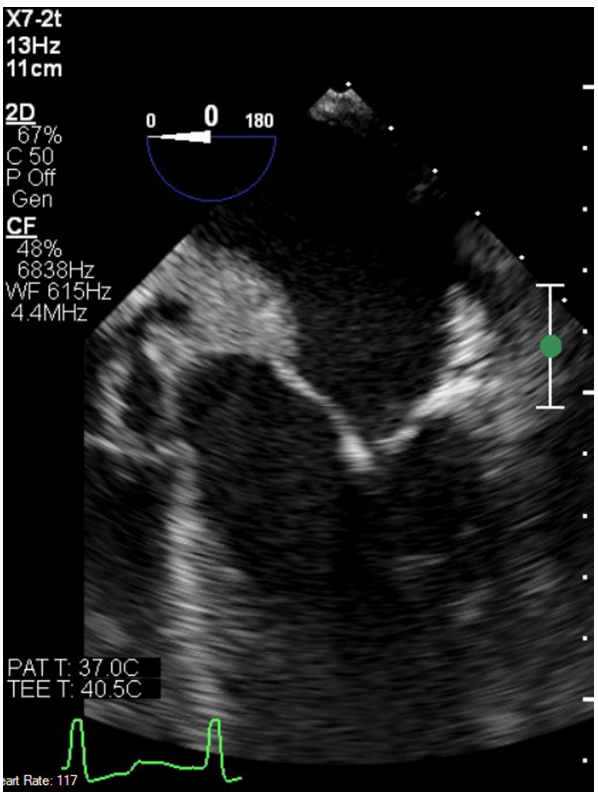

Figure 13
Comparative 2D-TOE image in same planar view as Fig. 2.

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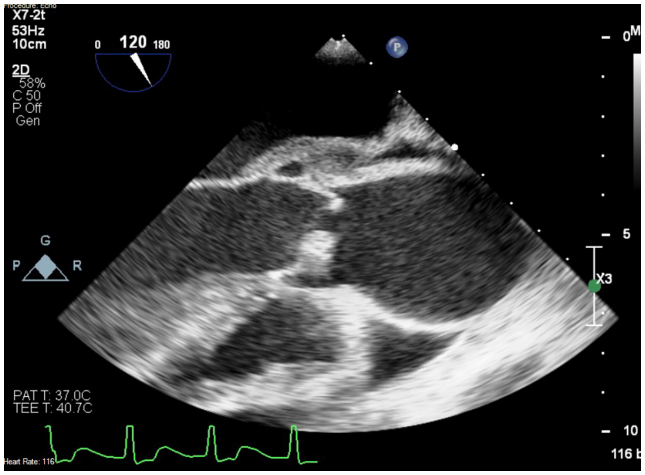

Figure 14
Comparative 2D-TOE image in same planar view as Fig. 6.

and (c) real-time live 3D imaging. 3D-colour Doppler TOE permits unrivalled assessment of complex and eccentric regurgitant jets.

Due to the need to complete a diagnostic TOE study rapidly in this complex case, the ability to obtain such a vast amount of post-processed data using two rapidly acquired 3D-TOE images under sedation (rather than under general anaesthesia) was crucial. Furthermore, in addition to being faster than the more commonly used 2DE (as fewer images need to be acquired, due to the volumetric nature of 3DE images) evidence shows that 3DE is superior in determining the exact site of valvular vegetations (5).

3D-TOE was the only imaging modality able to accurately assess this case of endocarditis for this patient. The rapid yet comprehensive study obtained provided the surgeon with crucial pre-operative aortic valve and root abscess data, improving planning and performance of surgery and ultimately benefitting clinical outcome.

Patient's perspective
Following a verbal discussion with the patient on the ward after her valve replacement:

'You hear that drugs can cause problems, but I never thought it would affect me as much as it has. I was told how I could die from this infection from my heart and that I needed surgery to chop it out, and that they needed to reconstruct my heart valve. I remember having a lot of scans before the operation. They told me about the camera test to look more closely at my heart infection. At first I was very reluctant after being told how it would involve me having a camera down my throat and be put to sleep which I didn't want. However I was told about another type of throat camera test that was much faster and meant I wouldn't need to be asleep. It wasn't all that bad in the end. To be honest I barely remember it. But I really don't understand why they don't use that faster test all the time. Especially if it does the same thing'.

Declaration of interest
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this case report.

Funding
This work did not receive any specific grant from any funding agency in the public, commercial or not-for-profit sector.

Patient consent
Written informed consent was obtained from the patient.

Author contribution statement
Dr Viren Ahluwalia: junior doctor tending to patient on ward and wrote first draft of manuscript. Prof. Faizel Osman: named physician of patient, reviewed and edited all second and subsequent drafts of manuscript. Jitendra Parmar: cardiothoracic surgeon who operated on patient, reviewed and edited all second and subsequent drafts of manuscript. Dr Jamal Khan: cardiology consultant who obtained 3D-TOE images, edited first draft of manuscript, guided first author in production of manuscript draft, provided echocardiographic images, reviewed and edited all subsequent drafts of manuscript.

References

1 Lee S, Chang BC & Park HK. Surgical experience with infective endocarditis and aortic root abscess. *Yonsei Medical Journal* 2014 **55** 1253–1259. (https://doi.org/10.3349/ymj.2014.55.5.1253)
2 Habib G, Badano L, Tribouilloy C, Vilacosta I, Zamorano JL, Galderisi M, Voigt JU, Sicari R, Cosyns B, Fox K, *et al*. Recommendations for the practice of echocardiography in infective endocarditis. *European Journal of Echocardiography* 2010 **11** 202–219. (https://doi.org/10.1093/ejechocard/jeq004)
3 Hill EE, Herijgers P, Claus P, Vanderschueren S, Peetermans WE & Herregods MC. Abscess in infective endocarditis: the value of transesophageal echocardiography and outcome: a 5-year study. *American Heart Journal* 2007 **154** 923–928. (https://doi.org/10.1016/j.ahj.2007.06.028)
4 Yong MS, Saxena P, Killu AM, Coffey S, Burkhart HM, Wan SH & Malouf JF. The preoperative evaluation of infective endocarditis via 3-dimensional transesophageal echocardiography. *Texas Heart Institute Journal* 2015 **42** 372–376. (https://doi.org/10.14503/THIJ-14-4375)
5 Hansalia S, Biswas M, Dutta R, Hage FG, Hsuing MC, Nanda NC, Singh P, Manda J, Kesanolla SK, Wei J, *et al*. The value of live/real time three-dimensional transesophageal echocardiography in the assessment of valvular vegetations. *Echocardiography* 2009 **26** 1264–1273. (https://doi.org/10.1111/j.1540-8175.2009.01042.x)

Received in final form 18 September 2019
Accepted 23 October 2019
Accepted Manuscript published online 23 October 2019