An intensive interactive course for 3D echocardiography: is 'crop till you drop' an effective learning strategy?

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Background Three-dimensional echocardiography (3DE) appears to show incremental benefit over two-dimensional echocardiography (2DE), but it’s uptake has been slow. We tested attendees before and after an intensive interactive training course to identify its efficacy.

Methods Attendees (n = 35, 23 cardiologists, 12 sonographers) were shown how to use 3D review software and asked to identify the pathology of five patients (wall motion abnormality, periprosthetic mitral regurgitation, subaortic membrane, small ventricular septal defect, submitial stenosis) on 2D and 3D images. In the following one and a half-day interactive teaching course, brief presentations on application of 3DE for assessment of wall motion, valve and congenital abnormalities were followed by review of 3D datasets, during which the attendees made their own interpretations before being shown the optimal viewing strategy. Test cases were not discussed and the test was repeated at the end of the course.

Results Most attendees (57%) had access but with little or no use of a 3DE system. Three-dimensional echocardiography had no incremental value before training. After training, overall correct responses significantly improved compared with baseline interpretation, although improvement was not the same for all diagnoses. All groups (cardiologists vs. sonographers, inexperienced vs. moderately experienced reviewers) improved similarly.

Conclusions Incorporation of 3DE into standard practice may be limited by inexperience. An interactive teaching course with rehearsal and direct mentoring appears to overcome this limitation and may improve the uptake of this technique.

Three-dimensional echocardiography (3DE) has recently become more accessible for clinical use because of the feasibility of ‘live’ 3D acquisition.¹ This technique adds value to the standard 2D examination by improving quantitation – for example, in the measurement of LV volumes,² ⁶ and providing more effective visualization through the additional dimension⁷ – for example, in evaluation of mitral valve disease⁸ and congenital abnormalities.⁸ ⁹ However, despite these potential benefits, the uptake of 3DE as a clinical tool has been slow. There are many potential reasons for this, including the cost and availability of new equipment, but one that could be easily rectified is unfamiliarity with the new technology. We therefore sought to test attendees before and after a brief interactive training course in order to define its efficacy.

Methods

Study design

Attendees (n = 35) at a 3DE training course were shown how to use 3D review software and asked to identify the pathology on 2D and 3D images of five patients (wall motion abnormality, periprosthetic mitral regurgitation, subaortic membrane, small ventricular septal defect, submitial stenosis). In a one and a half day interactive teaching course, brief presentations on application of 3DE for...
assessment of wall motion, valve and congenital abnormalities were followed by more than 50 different 3D datasets from three different hospitals, on which the attendees made their own interpretations before being shown the optimal viewing strategy. The test cases were not discussed in the course. Finally, a second test was performed, involving 3D analysis of the same five baseline test cases after 3D training.

Image acquisition

Two- and three-dimensional echocardiographic images were obtained for both the test and training cases. An experienced sonographer acquired standard 2D echocardiographic views using harmonic imaging with a transthoracic 3 MHz phased array transducer (iE33, Philips Medical Systems, Andover, MA). Images were stored in digital format and then the most relevant were selected for viewing; 3DE were obtained in the same manner as 2DE. ‘Live’ (one cardiac cycle) and full volume without colour (over four cardiac cycles) and with colour (over eight cardiac cycles) 3DE images (Figure 1A) were also gathered using a matrix array transducer (×4 transducer, Philips iE33 system). Three-dimensional echocardiographs were reviewed using commercially available software (QLab 4.2, Philips Medical Systems, Andover, MA) (Figure 1B).

Case 1: prosthetic mitral regurgitation

In this patient with a mitral valve replacement, 2DE showed significant mitral regurgitation with one valvular and one peri-valvular regurgitant jet (Figure 2A).
viewing the mitral valve through the left atrium showed three peri-valvular jets and one valvular jet of mitral regurgitation (Figure 2B).

Case 2: wall motion abnormality
In this stress echocardiogram, five views and one full volume 3DE were taken before and immediately after exercise. Foreshortening of the apex at peak stress prevented the detection of wall motion abnormalities (Figure 3A), but use of 3DE to open up the apex demonstrated an apical wall motion abnormality at peak stress (Figure 3B).

Case 3: ventricular septal defect
Increased pulmonary flow was detected on 2DE, with no cause identified (Figure 4A). Cropping into the 3DE acquisition from a parasternal long axis-equivalent view revealed a small membranous VSD (Figure 4B).

Case 4: left ventricular outflow tract mass
Two-dimensional echocardiography showed a large echogenic mass in the left ventricular outflow tract. The nature of the mass was unclear and the point of attachment could not be shown (Figure 5A). Cropping from an apical long axis-equivalent plane into 3DE acquisition showed the point of attachment to be in the intra-ventricular septum (Figure 5B).

Case 5: subvalvular mitral stenosis
Despite an increased Doppler gradient (10 mmHg) across the mitral valve, grey scale 2DE showed the valve to open well (Figure 6B). On the full volume 3DE, cropping from the parasternal long axis equivalent view showed the increased Doppler gradient to arise from the thickened chordae and not the valve itself (Figure 6B).
Statistical analysis

Results are represented as percentage of correct answers, with comparisons using the chi-square test – a P value of <0.05 was considered to be significant. Data analyses were performed using SPSS statistical software (SPSS v10, Chicago, IL).

Results

Course attendees

Of the attendees (n = 35), 23 were cardiologists and 12 sonographers, from both adult and paediatric backgrounds. Most attendees had access to a 3DE system before the course, but had used it little or not at all (n = 57%).

Incremental value of 3DE

Table 1 shows that 3DE had little incremental value on baseline testing. After training, the overall number of correct responses significantly improved compared with baseline 2DE and 3DE interpretations. All groups (cardiologists vs. sonographers, inexperienced vs. moderately experienced reviewers) improved similarly (Figure 7).

Figure 3  (A) Stress echocardiogram 2DE apical four chamber (top panels) and two chamber (bottom panels) views with rest (left panels) and stress (right panels) images. Green arrows show apical foreshortening on peak imaging. (B) Views of 3DE imaging of rest full volume (left panel) and peak full volume (right panel). Using the 3DE cropping tool and elongating the left ventricle, an apical wall motion abnormality is shown (green arrow).
Improvement was not the same for all diagnoses (Table 1). The recognition of apical wall motion abnormality from the 3DE (case study 2), recognition of the membranous VSD and recognition of subvalvular mitral stenosis improved after training. However, assessment of the number of regurgitant jets in the case of prosthetic mitral regurgitation and recognition of the subaortic membrane did not significantly improve from pre- to post-3DE.

Discussion
The introduction of new technology mandates the acquisition of new skills, and the learning curve needed to apply 3DE viewing and cropping techniques is so far undefined. The results of this study indicate that a short course including direct interaction with 3D datasets can improve the interpretation of complicated echocardiograms.

Defining the learning curve in echocardiography
Current training guidelines propose various numbers of reviewed studies for different levels of echocardiographic training, based on expert opinion. A limited literature shows that short courses and other training strategies are of value for teaching the requisite skills to non-cardiologists. The strongest evidence base for defining the learning curve is for stress echocardiography. Current guidelines do not address the training required to use new technologies such as 3DE, but they do acknowledge that there is a certain procedure-specific learning curve for advanced studies. They also suggest that special procedures are best learnt under a qualified expert and that performing and interpreting a certain number of cases is required to reach certain levels in training.

Limitations
Although workstations were provided for attendees to interact with the datasets, the circumstances of reviewing the case studies in a classroom setting do not correspond to real life. In the interests of time, the studies were shown in the course of an hour, necessitating significant editing to a handful of clips. Review of a complete study under more usual circumstances might have improved accuracy, which (although improved) was still suboptimal at the end of the learning curve.
of the course. This increment in accuracy of 3D interpretation might be further improved by a longer or more intensive training course.

Alternative study designs to define the efficacy of the course were considered, for example, application of the test to independent groups at baseline and after training. However, the use of the same test cases has the advantage of permitting paired comparisons, and we sought to minimize bias based on earlier viewing of the cases by not discussing them during the course.

Conclusions
The incorporation of 3DE into the standard practice of clinical laboratories has been slow, and may be limited by inexperience. An interactive teaching course with rehearsal

Figure 5  (A) Grey scale and colour 2DE images from a zoomed apical long axis views (left panel), zoomed apical five chamber colour view of the aortic valve (right panel). Green arrow shows the LVOT mass and colour Doppler showing flow acceleration. (B) Images of 3DE showing LVOT (blue arrow) echo density point of attachment (green arrow) noted to be on the septum (subaortic membrane – red arrow). Ao – aorta; LV – left ventricle; LA – left atrium; LVOT – left ventricle outflow tract.
Figure 6  (A) Zoomed 2DE image of mitral valve from the parasternal long axis window (left panel). A four chamber colour image showing a Doppler gradient across (green arrow) the mitral valve (centre panel). Parasternal short axis view of the mitral valve opening in systole (right panel). LV – left ventricle; LA – left atrium; MV – mitral valve. (B) Parasternal 3DE images showing mitral chordae thickening and normal mitral valve area (1.8 cm²).

Table 1  Percentage of correct answers with correlations between interpretations for case studies pre-2DE, pre- and post-3DE

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<tr>
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<th>Overall</th>
<th>Prosthetic MR</th>
<th>Wall motion</th>
<th>VSD</th>
<th>LVOT mass</th>
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<td>Pre-2DE interpretation (%)</td>
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<td>44</td>
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<td>Pre-3DE interpretation (%)</td>
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<td>26</td>
<td>43</td>
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<td>Post-3DE interpretation (%)</td>
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<td>43</td>
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<td>0.81</td>
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and direct mentoring appears to overcome this limitation and may improve the uptake of this technique.

Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.euje.2007.06.011.

References