Sitting an accreditation examination is a daunting prospect for many trainee echocardiographers. And with an increasing drive for the accreditation of echocardiography laboratories and individual echocardiographers, there is an increasing need for an all-encompassing revision aid for those seeking accreditation.

The editors of this unique book have produced the only echocardiography revision aid based on the syllabus and format of the British Society of Echocardiography (BSE) national echocardiography accreditation examination and similar examinations administered across Europe. Written by BSE accredited members, fully endorsed by the BSE, and with a foreword by BSE past-President, Dr. Simon Ray, this indispensable guide provides a valuable insight into how echocardiography accreditation exams are structured.

Crucially, to support students with the more challenging video section of the exam, a companion website provides video cases, and with clear and concisely-structured explanations to all questions, this is an essential tool for anyone preparing to sit an echocardiography examination.

This book is accompanied by a companion website: www.accreditationechocardiography.com
The website includes:
- 89 interactive Multiple-Choice Questions
- 193 Videoclips

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Successful Accreditation in Echocardiography
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The website includes:

- 89 interactive Multiple-Choice Questions
- 193 Videoclips
Successful Accreditation in Echocardiography

A Self-Assessment Guide

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Endorsed by the British Society of Echocardiography
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COMPANION WEBSITE

This book is accompanied by a companion website:

www.accreditationechocardiography.com

The website includes:

- 89 interactive Multiple-Choice Questions
- 193 Videoclips
Echocardiography is a mainstay of cardiac diagnostics and remains by far the most commonly performed imaging examination in cardiology practice. The development of easily portable and hand held machines has enhanced its use in bedside diagnosis and emergency assessment while real time 3-D imaging, tissue Doppler and speckle tracking provide a sophisticated insight into myocardial structure and function. In tandem with the development of technology has come the recognition that echocardiography is only as good as the individual performing the examination and that the training, accreditation and continuing education of echocardiographers is essential to the effective functioning of a clinical service. Moreover there is an increasing drive for the accreditation of echocardiography laboratories and individual accreditation of echocardiographers is a central part of this process.

Sitting an accreditation examination is a daunting prospect for many trainee echocardiographers. There are numerous textbooks on echocardiography covering the range from basic to advanced imaging but few that provide specific preparation for examinations. In this book Sanjay Banypersad, Keith Pearce and their colleagues have set out to provide a revision aid based broadly on the current syllabus of the British Society for Echocardiography. Writing unambiguous multiple choice questions and selecting video cases relevant to clinical practice is far from easy and the authors and text reviewers have made strenuous efforts to ensure the accuracy and relevance of the content.

No book of this type is sufficient on its own to provide all the information required for individual accreditation but used in conjunction with one of the comprehensive echocardiography texts available it should be very useful to those preparing for examinations or simply wanting to refresh their knowledge.

Simon Ray, BSc, MD, FRCP, FACC, FESC
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Honorary Professor of Cardiology
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Manchester Academic Health Sciences Centre
Manchester, UK
Preface

There has been a vast expansion in the field of cardiac imaging in recent years. Coronary CT is now part of NICE guidance for low-risk ischaemic heart disease and cardiac MRI is increasingly favoured for certain pathologies. Echocardiography remains however of paramount importance in the cardiological assessment of patients. Its fundamental advantage lies in being widely available, cost-effective and easily portable without any appreciable reduction in picture quality. This has meant not only an increase in the number of studies being performed per year, but also in the specialty of the operator performing the studies. Emergency physicians and anaesthetists are now well versed in the application of echocardiography to critically ill patients in the resuscitation department, ICU or operating theatres.

It is important therefore that adherence to a quality standard is safeguarded to ensure that the patient receives a uniformly high standard of examination. There are a number of accreditation processes worldwide and this book is designed to broadly mimic the layout of the British Society of Echocardiography Transthoracic accreditation process, which currently comprises a written MCQ paper and a video section. This book has 8 chapters derived from the current syllabus and each chapter consists of 20 MCQ style questions each with 5 ‘True/False’ stems, except the LV Assessment chapter which has 30 questions. Chapter 9 is comprised of 20 video cases each consisting of 4 or 5 questions with the option to pick one ‘best-fit’ answer from the given stems.

It is my hope that all candidates sitting a board exam or accreditation will find this book an invaluable revision aid and that those not sitting for accreditation will still nevertheless find it useful for their continued professional development.

Sanjay M. Banypersad
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Dr Bruce Irwin, SpR in Cardiology, University Hospitals South Manchester NHS Foundation Trust, Wythenshawe Hospital, Southmoor Road, Manchester, UK.

We are also grateful to all the echocardiographers and technicians in the echocardiography department at Wythenshawe Hospital and to the University Hospitals South Manchester NHS Foundation Trust for their permission to use the images and video files.

Sanjay M. Banypersad would also like to add a final vote of thanks to his parents and younger brother, Vishal, for their constant words of support and encouragement throughout.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>5-HT</td>
<td>5-Hydroxytryptamine</td>
</tr>
<tr>
<td>ACC</td>
<td>American College of Cardiology</td>
</tr>
<tr>
<td>ACHD</td>
<td>adult congenital heart disease</td>
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<tr>
<td>AHA</td>
<td>American Heart Association</td>
</tr>
<tr>
<td>AF</td>
<td>atrial fibrillation</td>
</tr>
<tr>
<td>AR</td>
<td>aortic regurgitation</td>
</tr>
<tr>
<td>ARVC</td>
<td>arrhythmogenic right ventricular cardiomyopathy</td>
</tr>
<tr>
<td>AS</td>
<td>aortic stenosis</td>
</tr>
<tr>
<td>ASD</td>
<td>atrial septal defect</td>
</tr>
<tr>
<td>AV</td>
<td>aortic valve</td>
</tr>
<tr>
<td>AVR</td>
<td>aortic valve replacement</td>
</tr>
<tr>
<td>AVSD</td>
<td>atrioventricular septal defects</td>
</tr>
<tr>
<td>BP</td>
<td>blood pressure</td>
</tr>
<tr>
<td>BSA</td>
<td>body surface area</td>
</tr>
<tr>
<td>BSE</td>
<td>British Society of Echocardiography</td>
</tr>
<tr>
<td>CAD</td>
<td>coronary artery disease</td>
</tr>
<tr>
<td>CRT</td>
<td>cardiac resynchronisation therapy</td>
</tr>
<tr>
<td>CSA</td>
<td>cross-sectional area</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>CW</td>
<td>continuous wave</td>
</tr>
<tr>
<td>dB</td>
<td>decibel</td>
</tr>
<tr>
<td>DCM</td>
<td>dilated cardiomyopathy</td>
</tr>
<tr>
<td>dP</td>
<td>change in pressure</td>
</tr>
<tr>
<td>DSE</td>
<td>dobutamine stress echocardiogram</td>
</tr>
<tr>
<td>dT</td>
<td>change in time</td>
</tr>
<tr>
<td>dV</td>
<td>change in volume</td>
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<tr>
<td>ECG</td>
<td>electrocardiogram</td>
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<tr>
<td>E–F</td>
<td>not strictly an abbreviation – refers to anterior mitral leaflet movement on M-mode in the active and passive phase of transmirtal flow</td>
</tr>
<tr>
<td>EF</td>
<td>ejection fraction</td>
</tr>
<tr>
<td>EPSS</td>
<td>E-point septal separation</td>
</tr>
<tr>
<td>ESC</td>
<td>European Society of Cardiology</td>
</tr>
<tr>
<td>HCM</td>
<td>hypertrophic cardiomyopathy</td>
</tr>
<tr>
<td>HOCM</td>
<td>hypertrophic obstructive cardiomyopathy</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>HR</td>
<td>Heart rate</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>IVC</td>
<td>Inferior vena cava</td>
</tr>
<tr>
<td>IVCT</td>
<td>Isovolumetric contraction time</td>
</tr>
<tr>
<td>IVRT</td>
<td>Isovolumetric relaxation time</td>
</tr>
<tr>
<td>IVSd</td>
<td>Interventricular septum in diastole</td>
</tr>
<tr>
<td>JVP</td>
<td>Jugular venous pressure</td>
</tr>
<tr>
<td>LA</td>
<td>Left atrium</td>
</tr>
<tr>
<td>LAD</td>
<td>Left anterior descending</td>
</tr>
<tr>
<td>LBBB</td>
<td>Left bundle branch block</td>
</tr>
<tr>
<td>LV</td>
<td>Left ventricle</td>
</tr>
<tr>
<td>LVAD</td>
<td>Left ventricular assist device</td>
</tr>
<tr>
<td>LVEDD</td>
<td>Left ventricular end-diastolic dimension</td>
</tr>
<tr>
<td>LVEDP</td>
<td>Left ventricular end-diastolic pressure</td>
</tr>
<tr>
<td>LVESD</td>
<td>Left ventricular end-systolic dimension</td>
</tr>
<tr>
<td>LVH</td>
<td>Left ventricular hypertrophy</td>
</tr>
<tr>
<td>LVIT</td>
<td>Left ventricular inflow tract</td>
</tr>
<tr>
<td>LVOT</td>
<td>Left ventricular outflow tract</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>MS</td>
<td>Mitral stenosis</td>
</tr>
<tr>
<td>MR</td>
<td>Mitral regurgitation</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>MV</td>
<td>Mitral valve</td>
</tr>
<tr>
<td>MVP</td>
<td>Mitral valve prolapse</td>
</tr>
<tr>
<td>MVR</td>
<td>Mitral valve replacement</td>
</tr>
<tr>
<td>NICE</td>
<td>National Institute for Health and Clinical Excellence</td>
</tr>
<tr>
<td>PA</td>
<td>Pulmonary artery</td>
</tr>
<tr>
<td>PDA</td>
<td>Patent ductus arteriosus</td>
</tr>
<tr>
<td>PE</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td>PFO</td>
<td>Patent foramen ovale</td>
</tr>
<tr>
<td>PISA</td>
<td>Proximal isovelocity surface area</td>
</tr>
<tr>
<td>PPM</td>
<td>Permanent pacemaker</td>
</tr>
<tr>
<td>PR</td>
<td>Pulmonary regurgitation</td>
</tr>
<tr>
<td>PRF</td>
<td>Pulse-resonance frequency</td>
</tr>
<tr>
<td>PS</td>
<td>Pulmonary stenosis</td>
</tr>
<tr>
<td>PV</td>
<td>Pulmonary valve</td>
</tr>
<tr>
<td>PW</td>
<td>Pulsed wave</td>
</tr>
<tr>
<td>RA</td>
<td>Right atrium</td>
</tr>
<tr>
<td>RBBB</td>
<td>Right bundle branch block</td>
</tr>
<tr>
<td>RCA</td>
<td>Right coronary artery</td>
</tr>
<tr>
<td>RCM</td>
<td>Restrictive cardiomyopathy</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
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</tr>
<tr>
<td>ROA</td>
<td>regurgitant orifice area</td>
</tr>
<tr>
<td>RV</td>
<td>right ventricle</td>
</tr>
<tr>
<td>RVH</td>
<td>right ventricular hypertrophy</td>
</tr>
<tr>
<td>RVOT</td>
<td>right ventricular outflow tract</td>
</tr>
<tr>
<td>RWMA</td>
<td>regional wall motion abnormality</td>
</tr>
<tr>
<td>SLE</td>
<td>systemic lupus erythematosus</td>
</tr>
<tr>
<td>SV</td>
<td>stroke volume</td>
</tr>
<tr>
<td>SVC</td>
<td>superior vena cava</td>
</tr>
<tr>
<td>SVR</td>
<td>systemic vascular resistance</td>
</tr>
<tr>
<td>TAPSE</td>
<td>tricuspid annular plane systolic excursion</td>
</tr>
<tr>
<td>TB</td>
<td>tuberculosis</td>
</tr>
<tr>
<td>TOE</td>
<td>transoesophageal echocardiography</td>
</tr>
<tr>
<td>TR</td>
<td>tricuspid regurgitation</td>
</tr>
<tr>
<td>TTE</td>
<td>transthoracic echocardiography</td>
</tr>
<tr>
<td>TV</td>
<td>tricuspid valve</td>
</tr>
<tr>
<td>V</td>
<td>velocity</td>
</tr>
<tr>
<td>VSD</td>
<td>ventricular septal defect</td>
</tr>
<tr>
<td>VTI</td>
<td>velocity time integral</td>
</tr>
</tbody>
</table>
1 Basic Physics and Anatomy

QUESTIONS

For each question below, decide whether the answers provided are true or false.

1 The following is true of ultrasound waves:
   a. Propagate through medium like light
   b. Are part of the electromagnetic spectrum
   c. Loudness is measured in decibels
   d. The decibel scale shows a linear relationship with amplitude ratio
   e. Can be reflected but not refracted

2 The following are true of ultrasound waves during 2D echo:
   a. The optimal image is formed when the medium is perpendicular to the ultrasound beam
   b. The narrowest part of the beam (the focal zone) can be varied
   c. Side lobes are artefacts only found with phased-array transducers
   d. Structures smaller in diameter than the wavelength of the ultrasound beam may cause scattering of the beam
   e. Travel faster in blood than in bone

3 During standard TTE:
   a. Dropout occurs when there is parallel alignment of the beam with the tissue
   b. At a higher frequency, the ultrasound beam has a higher penetration depth
   c. Doppler studies are based on scattering of the ultrasound beam by red blood cells

BASIC PHYSICS AND ANATOMY: QUESTIONS

d. The transmitted ultrasound waves are attenuated with increasing mismatch in acoustic impedance
e. Axial resolution degrades more than lateral resolution when the depth is increased

4 The following are true of image resolution and artefacts:
   a. M-mode has excellent temporal resolution
   b. Prosthetic valves cause acoustic shadowing as well as reverberations
   c. Tissue harmonic imaging improves endocardial border definition but has no effect on valves
   d. High PRF can cause uncertainty due to range ambiguity
   e. Low aliasing velocities with colour Doppler can overestimate regurgitation

5 During echocardiography, the following can be changed by the operator:
   a. Impedance
   b. Focus
   c. Amplitude
   d. Wavelength
   e. PRF

6 Regarding the use of tissue Doppler imaging:
   a. It can be used to calculate myocardial tissue velocities
   b. It can give information on segmental LV function
   c. Unlike transmitral E and A velocities are, tissue Doppler imaging-derived E' and A' waves are not preload dependent
   d. Gives a more accurate assessment of IVRT than transmitral Doppler
   e. The heart’s movement in the chest cavity can be a limitation of the technique

7 When using M-mode to assess LV ejection fraction:
   a. May be inaccurate if the beam is oblique
   b. Results may not be indicative of overall function in ischaemic heart disease
   c. End-systolic dimensions are usually measured on the R wave of the ECG
   d. A fractional shortening of 30% can be normal
   e. The result is more accurate than EF derived using the Simpson’s method
8 Regarding PW Doppler, the following are true:
   a. Is subject to the Nyquist limit
   b. Has two dedicated crystals for sending and receiving
   c. Can measure velocities at varying depth
   d. Is used in tissue Doppler imaging
   e. More than one sample volume can be assessed at a time

9 Regarding continuous-wave Doppler, the following are true:
   a. Transmits and receives an impulse in sequence.
   b. Is useful in assessing mid-cavity step-ups in gradient
   c. Often aliases at high velocities
   d. Is limited in that it cannot separate individual velocities
      along the length of a beam
   e. Is useful when assessing peak aortic velocity

10 For a 5 MHz transducer at an angle of 60° to blood flow, the
Doppler frequency shift is 10 kHz. The following are true:
   a. The wavelength is approximately 0.3 mm
   b. The maximum depth is 2–3 cm
   c. The blood velocity is approximately 3 m/s
   d. Lowering the transducer frequency to 1 MHz increases
      maximum depth to 20 cm
   e. Optimal accuracy occurs with the Doppler cursor
      perpendicular to the direction of flow

11 In standard 2D echocardiography of a patient lying in the left
lateral position:
   a. The atrial septum is best visualised in the apical 4-chamber
      view
   b. In the apical 4-chamber view, tilting the ultrasound beam
      posteriorly reveals the 5-chamber view
   c. In the parasternal long-axis view, tilting the beam infero-
      medially reveals the RV inflow
   d. In the parasternal long axis view, the normal LA is ≤4.5 cm
      in men
   e. Coronary arteries can sometimes be seen in the parasternal
      short-axis view

12 Regarding the parasternal short-axis view:
   a. The most posterior of the aortic valve cusps is the
      non-coronary cusp
   b. The mitral valve leaflets are clearly seen
BASIC PHYSICS AND ANATOMY: QUESTIONS

c. It is a useful view for detecting PV abnormalities
d. It is a useful view for calculating PA pressure
e. Eccentric jets of regurgitant aortic or mitral valves can be clearly demonstrated

13 In the apical 4-chamber view:
\( a. \) The right ventricular wall is thinner than that of the LV
\( b. \) A septal ‘knuckle’ is often seen in elderly people
\( c. \) The Chiari network may be seen in the LA
\( d. \) Rotating to the apical 3-chamber view reveals the inferior wall
\( e. \) Rotating to the apical 2-chamber view shows the aortic valve

14 Regarding spectral Doppler signals:
\( a. \) The normal mitral E wave is greater than the A wave in young people
\( b. \) Peak aortic velocity of \( >2 \text{ m/s} \) can be normal with some prosthetic valves
\( c. \) In AF, an average of at least five consecutive signals should be taken
\( d. \) CW Doppler is usually needed for high velocities to avoid aliasing
\( e. \) A fast sweep-speed is required to assess for respiratory variation

15 The following relationships between structures is true in the parasternal long axis:
\( a. \) The left coronary cusp of the aortic valve is anterior
\( b. \) A fibrous band separates the anterior mitral valve leaflet and the aortic root
\( c. \) In the RV inflow view, the anterior and posterior tricuspid valve leaflets are seen
\( d. \) The moderator band can be seen in the RV
\( e. \) The nodules of Arantius are features of the mitral valve

16 The following parameters would not affect frame rate:
\( a. \) Increasing the depth
\( b. \) Increasing the sector size
\( c. \) Increasing the line density
\( d. \) Increasing the transmit frequency
\( e. \) Decreasing the sector size
17 The type of filter used for tissue Doppler imaging is a:
   a. High-pass filter
   b. Band-pass filter
   c. Low-pass filter
   d. Reject filter
   e. Notch filter

18 Dobutamine stress echo:
   a. Cannot be used to detect myocardial viability
   b. Can be used to diagnose CAD
   c. Is more sensitive and specific than exercise stress testing
   d. Can be used to predict anaesthetic risk for major surgery
   e. Is usually performed using agitated saline contrast

19 Harmonic imaging:
   a. Was developed to improve endocardial definition
   b. Uses a transmit frequency equal to the receive frequency
   c. Enhances the detection of transpulmonary contrast
   d. Makes valvular structures appear thicker
   e. Should not be used when making Doppler recordings

20 The following statements are true:
   a. Absorption is the transfer of ultrasound energy to the tissue during propagation
   b. Acoustic impedance is the product of tissue density and the propagation velocity through it
   c. Shifting the zero velocity baseline may eliminate aliasing in the pulsed-wave Doppler mode
   d. Shadowing results in the presence of echoes directly behind a strong echo reflector
   e. A longitudinal wave is a cyclic disturbance in which the energy propagation is parallel to the direction of particle motion
Visible light is part of the electromagnetic spectrum and is propagated as a transverse waves. Sound is not part of the electromagnetic spectrum and is propagated as longitudinal waves, with oscillations parallel to the direction of propagation. Loudness is measured in decibels and the scale shows a logarithmic relationship to amplitude ratio i.e. $\text{dB} = 20 \log \left( \frac{V}{R} \right)$ (where $V$ represents acoustic pressure and $R$ is a reference value). Ultrasound waves can be both reflected and refracted, the latter being responsible for false images in aberrant locations.

Reflection of ultrasound waves (and therefore imaging) is optimal when the tissue interface is perpendicular with the ultrasound beam. The normal ultrasound beam from a transducer of diameter $D$, travels through an aperture and has an initial columnar near zone; beyond this, there is divergence of the beam, according to $\sin \theta = 1.22 \frac{\lambda}{D}$, which causes image degradation. However, the transducer face can be altered to become, for example, more concave, changing the position of the narrowest point of the beam so that image resolution is greater – this is the focal zone and it is variable. Side lobes are beams dispersed laterally to the main beam leading to image artefact and are common to all transducers; grating lobes are specific to phased-array transducers. Scattering is caused by
structures smaller than the wavelength of the ultrasound beam. Structures larger in wavelength cause reflection or refraction. The propagation velocity in bone is double that of blood.

3 a. T
   b. F
   c. T
   d. T
   e. F

Parallel alignment causes very little of the ultrasound beam to be reflected back to the transducer, causing image dropout; this is typically seen of the atrial septum in apical 4-chamber view. A higher frequency produces higher image resolution but decreases penetration depth. The wavelength of ultrasound is 0.2–1 mm, whereas that of a red cell is about 7–10 $\mu$m, hence as stated above, red blood cells are effective scatterers and form the principle of Doppler flow studies. Air has high acoustic impedance, so any air between the transducer and the body causes a significant acoustic impedance mismatch and therefore attenuation of the transmitted beam; attenuation can also affect the reflected beam. Axial resolution is relatively unchanged with increasing depth because the beam remains parallel to the tissues. However, lateral resolution decreases because beam width increases due to divergence.

4 a. T
   b. T
   c. F
   d. T
   e. T

M-mode does have excellent temporal resolution and is often used to assess high-speed motion such as mitral valve leaflet fluttering. Prosthetic valves can cause reverberation and acoustic shadowing beyond the valve image. Harmonics improve border definition but also make valves appear thicker, thus standard imaging should always be used in conjunction with harmonics. High PRF is useful to detect very high velocities, but range ambiguity means that the depth at which that velocity occurs could be located at any one of several points along the insonating beam. Low aliasing velocities cause distinct colour changes at lower velocities than normal, making the degree of regurgitation seem higher than it actually is.
5  a. F  
b. T  
c. T  
d. F  
e. T  

Impedance is a property of the tissue itself. Wavelength is usually fixed, and since velocity is constant through a given medium, PRF can be altered to produce varying depth. Amplitude is altered through gain and the focus can be varied as explained above (see answer to Question 4)

6  a. T  
b. T  
c. T  
d. F  
e. T  

Tissue Doppler imaging can assess myocardial tissue velocities and indeed, the myocardial velocity gradient between 2 positions on the ventricle; it can therefore be very useful for assessing segmental motion and function. Because myocardial velocities rather than blood flow velocities are measured, they are less preload dependent. However, IVRT is best measured with conventional PW Doppler as myocardial movement does not necessarily correlate with valve opening and closure.

7  a. T  
b. T  
c. F  
d. T  
e. F  

M-mode has excellent time resolution and endocardial border motion is well imaged. A very oblique beam will overestimate cavity size and underestimate function as displacement is at an angle to the insonating beam. Maximal displacement measurement will occur when the beam is perpendicular to the chamber. Regional wall motion abnormalities are common in ischaemic heart disease and a large apical infarct with preserved basal segments would overestimate LV function with M-mode. End-diastolic dimensions are measured on the R wave and the normal range for fractional shortening is 25–45%. Simpson’s method is a more accurate measure of EF as a number of segments across the LV cavity are included.

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