Suggested Reading List and Syllabus

- The European Association of Echocardiography Education Committee will run a teaching course in October which will provide preparation for the exam.
- The syllabus is set by the Accreditation Committee of the European Association of Echocardiography and is presented as a guide to candidates.
- The reading list is provided by the Education Subcommittee of the European Association of Echocardiography.

There are many excellent books on echo and just some examples are listed below. In addition to those listed there are many small basic texts which are a useful introduction to the subject.

**Authoritative textbooks:**

A.E.Weyman, Principles and Practice of Echocardiography, 2nd ed. 1994 Lea & Febiger

H.Feigenbaum, Echocardiography, 5th ed. 1994 Lea & Febiger


Marwick TH. Stress Echocardiography: Its Role in the Diagnosis and Evaluation of Coronary Artery Disease (Book with CD-ROM) Kluwer 2003

**Useful review articles:**


Syllabus

GENERAL

General Concepts

The place of echocardiography
  Clinical role of echocardiography and Doppler
  • Information that echocardiography can, and cannot provide
  • ‘Ruling out’ pathology (sensitivity, specificity & Baye’s theorem)
  • Likelihood of findings influencing patient management
  • Undesirable outcomes: inaction while waiting for results, clinical ‘red herrings’
Indications for echocardiography
  Competing and complementary technology
  • Cardiac catheterisation
  • X-ray ventriculography and coronary angiography
  • contrast C-T
  • Magnetic resonance imaging
  • Nuclear Cardiology

Service Provision
  Advantages/disadvantages of technician-led versus physician-led service
  Costs: fixed and variable
  Provision and indication for specialised techniques, e.g. TOE. Stress echo, Contrast echo
  Availability and access
  Controlling workload
  Training & motivation of staff
  Audit, Quality Control, Clinical Governance

Relationship with patients
  Explaining the procedure in terms relevant to the particular patient
  Respect for patients’ dignity and cultural backgrounds
  Relationships with colleagues.
  Handling requests for information about the study findings

Reporting and Documentation
  Standard methods & terminology
  Distinction between Technical and Clinical reports
  Responsibility for reporting
  Medico-legal considerations (Data Protection Act)

Imaging Physics & Instrumentation

Concepts and Terminology
  Concept of compression waves
  Definitions: frequency, wavelength, propagation velocity
  Units of measurement: Hz and MHz, Decibel
  Comparison of Ultrasound with audible sound.

Propagation of ultrasound through tissues
  Speed of sound in different body tissues.
  Frequency range used for diagnostic imaging
  Distinction between specular reflection and backscatter
  Principles of attenuation and scattering
Ultrasound Transducers
Piezo-electric effect
General concepts of transducer construction
Characteristics of the ultrasound beam: Near (Fresnel) & Far (Fraunhofer) zones, side lobes
Beam steering methods: mechanical & electronic
Focusing methods, including multiple transmit focusing

Imaging physics
Factors affecting choice of imaging frequency: typical practical values for adults & children
Broad-band imaging
Harmonic imaging
B mode and M Mode methods.
Scanning speed limitations, relationships between pulse repetition frequency, frame rate, lines per frame, field of view, depth to be imaged.
Concept of Parallel Processing and its influence on frame rate and image quality
Effect on evaluation of rapid motion, temporal resolution.
Grey scale and dynamic range
Measurement and optimisation of Resolution: axial, azimuthal and elevation
Lateral resolution and grating artefacts
Reverberation artefacts
Limiting factors for detecting small targets

Echo Instrumentation
Function of machine controls: Transmit power; overall gain; time gain compensation; reject, logarithmic compression,
Signal processing, dynamic range, pre-processing; post processing
Optimisation of imaging parameters, including transducer frequency, scan angle, gamma correction, spatial and temporal smoothing

Optimising Images
Use of gel (infection risk from transducer, operator)
Positioning of the subject
Standard views: Parasternal, apical (4, 5 and 2-chamber), subcostal, suprasternal, right parasternal), long and short axis
Use of non-standard views
Adapting for subjects with difficult windows, ventilated patients, ward-based echos

Storage and Display of Images
Basic concept of digital systems.
Scan converters and digital memories.
Display devices and controls, recording techniques

Doppler physics & fluid dynamics

Basic Fluid Dynamics
Fluid flow: significance of peak & mean velocities
Determination of volumetric flow
Continuity equation
Laminar & turbulent flow: Reynolds’ equation (qualitative)
Transition from Laminar to turbulent flow: inlet jet
Bernoulli equation
Basic Principles of Doppler
Interaction of ultrasound waves with moving blood: the Doppler effect
The Doppler equation: factors influencing magnitude of Doppler shift
Spectral analysis: fast Fourier transform (qualitative)
The spectral Doppler display: determination of mean, modal and peak velocities
Limitation of CW Doppler caused by lack of depth discrimination
Audible range of Doppler shift frequencies
The effect of beam angle errors on Doppler velocities
Aliasing: how it is caused and how it manifests in practice: the Nyquist limit
Influence on aliasing of: transducer frequency; sample depth (range x velocity product); and beam angle
High pulse repetition frequency (extended range) PW Doppler
Relative advantages and disadvantages of CW, PW and HPRF modes
Concept of colour flow imaging as multi-sampled PW
Velocity estimation, by moving target indication and autocorrelation (qualitative)
Limitations of mean velocity: use of velocity variance to show high velocities/turbulence
Aliasing in colour Doppler
Packet size, colour mode and sector size and their effect on frame rate and aliasing

Doppler instrumentation

Spectral Doppler Instrumentation
Duplex Doppler using imaging transducers
The ‘Stand-alone’ Doppler probe
Features of the spectral display: positive & negative velocities; scale & baseline controls.
Effect of high- and low-pass filter and intensity threshold (‘reject’) settings
Pulsed Doppler sample volume: influence of gate length and distance (beam width)
Representation of signal strength by image intensity
How aliasing manifests on the spectral display

Colour Flow Instrumentation
The colour display: BART convention
Colour maps to show velocity scales
Image domination and additive colour modes
Basic principles of Tissue Doppler Imaging, including optimisation of filters for detecting tissue versus blood velocities
Difference between velocity and power (signal amplitude) displays

TOE Instrumentation
Transducer types: single plane, biplane, multiplane
Optimising machine settings for TOE
Patient monitoring for TOE and general safety considerations
Control of infection

Safety of ultrasound
Potential hazardous biological effects: heating, resonance and cavitation effects
Measurement of beam intensity (SPTA)
Practical precautions: power levels, use of colour and CW Doppler
Recording methods
Advantages/disadvantages of recording on: videotape, photographic or dye-transfer prints, thermal strip chart
Basic understanding of digital image processing and recording methods: pixel density, volume of data, concept of data compression, storage in RAM or magneto-optical disc format

Cardiac Anatomy and Physiology

Anatomy of the thorax
Thorax contained by rib cage & diaphragm
Lungs & pleura; heart & pericardium; mediastinum
Blood vessels within the thorax

Gross anatomy of the heart
Basic cardiac embryology
Nomenclature of chambers and valves
Major relationships of chambers, valves and blood vessels
Distinguishing features of valves and chambers as related to echocardiography
The pericardial sac

Cardiac anatomy and physiology as demonstrated by echocardiography
Detailed structural anatomy of the heart, great vessels and pericardium
Visualisation of normal cardiac anatomy and normal variants in standard echocardiographic planes
Normal valve function, normal Doppler parameters and normal variants

The Cardiac Cycle
Temporal relationships of the ECG, chamber pressures and valve movements
Typical values for intracardiac pressures
Relationship of valve movements to heart sounds

Cardiac functional parameters

Measurements and calculations
On-screen measurement of length, slope, area, volume and time interval, and their significance for 2-D images, M-mode and spectral Doppler displays
Standard M-mode measurements and calculations, both using machine software and manual methods
Derivation of Stroke Volume, Ejection Fraction and LV Mass
Methods of measuring LV volume, including biplane area, area-length and Simpson’s rule methods
Limitations of measurement and/or calculation validity in presence of poor quality and/or off-axis images

Doppler determination of cardiac output, ejection time and velocity acceleration
Methods of measuring diastolic dysfunction: E/A ratio, deceleration time, pulmonary venous flow patterns
Peak and Mean pressure gradient measurements by Doppler and their relationship to catheterisation data
Measurement of pulmonary pressures from tricuspid and pulmonary regurgitant flow velocities and assessment of inferior vena cava contraction
Contrast Studies
Significance of spontaneous echo contrast
Optimisation of machine control settings for detecting contrast
Indications for a bubble contrast study
Technique for performing a hand-agitated contrast study
Clinical precautions

Awareness of encapsulated contrast agents and techniques
Interaction of ultrasound with encapsulated agents
Generation of harmonic energy by bubble distortion and fracture
Doppler signals generated by bubbles (Power Mode)
Clinical application for LV opacification and Doppler enhancement

PATHOLOGY

Mitral Valve Disease

2D, M-mode and Doppler features of the normal mitral valve

Mitral Stenosis
Qualitative description of valve and sub-valve calcification and fibrosis
Measurement of orifice area by planimetry
Factors favouring successful balloon valvuloplasty
Doppler assessment of mean and end-diastolic gradient
Doppler assessment of area by ‘pressure half-time’: technique and limitations

Rheumatic mitral stenosis
Assessment of severity (see 2.1.2)

Mitral regurgitation
Assessment of severity by:
• Chamber sizes and volume overload
• CW Doppler
• PISA
• Pulmonary vein flow patterns
• Indirect effects

Aetiology and typical echocardiographic features of:
• rheumatic
• mitral annular calcification
• ‘Floppy MV’
• ischaemic
• functional
• infective endocarditis

Aortic Valve Disease

2D, M-mode and Doppler features of the normal aortic valve

Aortic Stenosis
Assessment by CW Doppler
• Peak and Mean gradients
• Apical, right parasternal and suprasternal positions
• Continuity equation
• Assessment of left ventricular hypertrophy and function

Aetiology and echocardiographic features:
• Rheumatic
• Bicuspid
• Senile degenerative
• Sub- and supra-valve obstruction

Aortic regurgitation
Aetologies and typical echocardiographic features of:
• rheumatic
• bicuspid valve
• aortic root disease
• infective endocarditis (including root abscesses)

Assessment of severity by:
• Chamber sizes/volume overload
• CW Doppler
• Colour Doppler
• Indirect effects
Role of TOE in assessing aetiology and severity

Tricuspid Valve Disease

2D, M-mode and Doppler features of the normal tricuspid valve

Rheumatic tricuspid valve stenosis
Echocardiographic features
Assessment of severity by imaging and Doppler

Tricuspid Regurgitation
Assessment of severity by:
• 2D imaging and M-mode
• CW Doppler
• Colour Doppler
• Indirect effects

Aetologies and echocardiographic features of:
• rheumatic
• prolapse
• congenital
• endocarditis
• carcinoid
• functional

Pulmonary Valve Disease

2D, M-mode and Doppler features of the normal pulmonary valve

Pulmonary Valve Stenosis
Echocardiographic features
Assessment of severity by spectral Doppler
Detection of infundibular obstruction by spectral Doppler

Pulmonary Regurgitation
Aetologies and echocardiographic features
Assessment of severity by
• CW Doppler
• Colour Doppler
• Indirect effects
Infective Endocarditis
Typical echocardiographic appearance of vegetations in bacterial and fungal endocarditis
Preferred locations for vegetations
‘Jet’ lesions
Endocarditis associated with congenital disease and HCM
Complications: abscess, fistula, perforation
Role of TOE in suspected endocarditis

Prosthetic Valves
2D, M-Mode and Doppler features of the main types of replacement valves
• Ball & cage
• Tilting Disc
• Bi-leaflet
• Stented Bioprostheses
Age-related deterioration of bioprostheses
Role of TOE in examining normal and malfunctioning prosthetic valves

Prosthetic valve stenosis
Assessment by 2D, M-mode and Doppler
Normal ranges
Use of Continuity Equation for aortic prostheses

Prosthetic valve regurgitation
Trans- versus para-valvar regurgitation
Normal versus abnormal regurgitation
Assessment by CW, PW and Colour Doppler
Colour artefacts from mechanical prostheses

Cardiomyopathies
Dilated Cardiomyopathy
2D, M-mode and Doppler features of dilated cardiomyopathy
Detection and assessment of associated lesions: Functional valve regurgitation
Thrombus in cardiac chambers
Pericardial effusions
Role of echocardiography in assessment and follow-up

Hypertrophic Cardiomyopathy
2D, M-mode and Doppler features of Hypertrophic Cardiomyopathy
Differentiation from other causes of hypertrophy, e.g. ‘athletic heart’
Techniques for measurement of left ventricular wall thickness, detection of intracavity flow acceleration
Assessment of right ventricular involvement
Associated abnormalities, e.g. mitral regurgitation

Intracardiac Masses
Typical locations for formation of intracardiac thrombus
Echocardiographic features of typical LA Myxoma
Differentiation of myxoma from other cardiac tumours
Features suggestive of malignancy
Role of TOE in assessment of intracardiac masses
Pericardial Disease

**Anatomy of the normal pericardium**
- Relationships of serous pericardium to heart and great vessels
- Transverse and oblique sinuses of the pericardium

**Echocardiographic features of pericardial fluid**
- Location of fluid in relation to patient position and fluid volume
- Differentiation from pleural effusion
- Assessment of volume of pericardial fluid
- Role of echocardiography in pericardiocentesis

**Features of tamponade**
- Collapse of RA and/or RV walls
- Effect on IVC
- Effect on A-V valve flow velocities

**Features of pericardial constriction**
- Effect on A-V valve flow velocities
- Effect of respiration
- SVC/hepatic vein flow
- Differentiation from restrictive cardiomyopathy

**Coronary Artery Disease and Systolic LV function**
- Anatomy & nomenclature of the major branches of the coronary arteries
- Relationship of coronary anatomy to standard echocardiographic imaging planes
- Nomenclature for describing myocardial segments (ASE convention)
- Analysis of segmental systolic myocardial function
- Diastolic dysfunction in coronary artery disease
- Global measures of LV function:
  - Ejection Fraction
  - Stroke Distance
  - Stroke Volume

**Myocardial Infarction and its sequelae**
- 2D, M-mode and Doppler features of:
  - post-infarction VSD
  - mitral papillary muscle rupture
  - tamponade
  - mural thrombus
  - myocardial scarring
  - Dressler’s syndrome
  - left ventricular aneurysm – true aneurysm vs pseudoaneurysm

**Pulmonary Hypertension**
- 2-D, M-mode and Doppler features of pulmonary hypertension
- Aetiologies: primary; post pulmonary embolism; secondary to left-sided lesions; lung disease

**Diseases of the Aorta**
- Technique for examining the ascending and descending thoracic aorta
- Echocardiographic features of the normal aortic root, sinuses of Valsalva, ascending aorta and aortic arch
- 2-D, M-mode and Doppler features of:
  - Marfan’s syndrome
  - sinus of Valsalva aneurysm
  - thoracic aortic aneurysm
  - aortic dissection
  - Additional features related to aortic dissection:
• aortic cusp prolapse
• aortic regurgitation
• fluid in pericardium

Role of transoesophageal echocardiography in the diagnosis of aortic dissection

Adult Congenital Heart Disease
Anatomy, pathophysiology and natural history of common congenital lesions present in adults:
2-D, M-mode and Doppler features of the following, pre-operatively and post-operatively, as seen in the older child or adult
• Ostium Secundum Atrial septal defects
• Perimembranous and muscular ventricular septal defects
• Partial and complete atrio-ventricular septal defects
• Persistent ductus arteriosus
• Bicuspid aortic valve
• Sub- and supra-valve aortic stenosis
• Aortic coarctation
• Pulmonary stenosis
• Ebstein’s anomaly
• Fallot’s tetralogy

Role of contrast echocardiography in evaluating shunts in adults
Calculation of shunts
Role of TOE in adult congenital disease

Likely echocardiographic findings for common clinical presentations:
Heart failure or breathlessness
Arrhythmia
Ejection systolic murmur
Hypertension
Collagen abnormalities
Renal failure
Stroke