Diploma of Diagnostic Ultrasound (DDU)
Syllabus

Critical Care
Diploma of Diagnostic Ultrasound (DDU)

DDU (Critical Care) Syllabus

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Introduction: Who is the DDU Critical Care for?

A DDU certified doctor is a specialist medical practitioner who has overall responsibility for ensuring the most accurate and valid information possible is obtained from the ultrasound examination. The DDU holder is then responsible for using the acquired information to meaningfully contribute to clinical patient management. The DDU holder would usually have diagnostic ultrasound as a major focus of their practice and accept referrals from a range of other medical practitioners as well as self-referrals.

The DDU holder has detailed specialist level knowledge and skill in all aspects of the diagnostic ultrasound process. When applicable, this knowledge and skill may also apply to therapeutic interventions/processes.

Candidates for the DDU (Critical Care) would usually be specialists working in emergency medicine, intensive care, operating rooms and/or be involved in undertaking emergency retrievals. Candidates for the DDU (Critical Care) would be expected to have a significant component of their practice involved in the use of ultrasound for the diagnosis, assessment and intervention of acute medical problems leading to timely determination of further clinical management. The DDU candidate is expected to achieve the recommended advanced level of critical care sonography as outlined in the International Expert Statement on Training Standards for Critical Care Ultrasonography: published in Intensive Care Medicine 2011;37:1077-1083.

The DDU (Critical Care) candidate would also be expected to be involved in teaching and mentoring of less experienced practitioners, research and development of innovative clinical ultrasound techniques.
MODULE 1: Foundations of Ultrasound Practice

MODULE 1 consists of three (3) parts as follows:

Part A: Physics and instrumentation (70%)
Part B: Principles of image/data collection and optimisation (15%)
Part C: Professional, ethical and legal issues (15%)

Part A: Physics and Instrumentation (70% weighting)

Rationale

To perform and interpret ultrasound competently users need to understand the physics of ultrasound and its interactions with tissue. They must also understand the technical principles of the equipment and how to select appropriate equipment for a specific application and optimise the settings. An understanding of the capabilities and limitations of ultrasound is also essential. In particular, it is important to be able to recognise major image artifacts and know how to minimise them.

Aim

For the candidate to demonstrate a sound knowledge and understanding of the fundamental physical principles and the instrumentation used in diagnostic ultrasound and how they relate to the quality and accuracy of information obtained in the examination.

Learning Objectives

Physical Principles of Ultrasound

Candidates will be able to describe:

• the wave nature of ultrasound and its propagation through tissue;
• the reflection and scattering of ultrasound and how these relate to acoustic impedance;
• the concept of attenuation, its mechanisms and factors affecting it;
• refraction of ultrasound and critical angle of incidence;
• the concept of pulsed ultrasound.

Transducer and Beamforming Concepts

Candidates will be able to describe the:

• purpose and function of a transducer and the construction of a typical probe;
• concept of an ultrasound beam and the importance of controlling beam width;
• methods used to focus the beam, including electronic focussing with array transducers;
• major probe types and the mechanisms used by each to scan the beam;
• concept of slice thickness.

Candidates will be able to:

• define beam sidelobes;
• explain the factors affecting the choice of transducer for a specific application.
Imaging Principles and Technology

Candidates will be able to describe the:

- pulse-echo principle and how it is used in B-mode and M-mode ultrasound;
- basic processing components of an ultrasound imaging machine and their purpose;
- controls associated with each component and their effect on the image;
- methods used to make measurements from images;
- methods available to record images.

Candidates will be able to:

- define the major aspects of image quality;
- recognise the principal image artifacts and describe how they occur and how they can be identified and reduced or eliminated;
- describe the main factors affecting the accuracy of measurements.

Doppler Principles and Instrumentation

Candidates will be able to describe the:

- principle of operation and components of continuous wave and pulsed Doppler instrumentation;
- elements of the Doppler spectral display and how it is used to make measurements;
- factors affecting accuracy of measurements, importance of keeping Doppler angle below 60°;
- principle of operation and components of colour Doppler;
- colour Doppler instrumentation, including power (amplitude) mode.

Candidates will be able to:

- explain the Doppler effect and describe how it is used in ultrasound diagnosis;
- recognise the principal Doppler artifacts and describe how they are produced and how they can be identified and/or eliminated.

Bioeffects and Safety

Candidates will be able to:

- demonstrate an understanding of the potential for bioeffects and biohazards;
- define the parameters used to characterise patient exposure.

Candidates will be able to explain:

- the known thermal and mechanical bioeffects and the relative likelihood of these occurring with different modes of examination;
- practical approaches to reducing risk and the relevant ASUM policies.

New and Evolving Techniques

Candidates will be able to discuss briefly the principles involved in a range of new technologies including:
• extended field of view (panoramic imaging);
• contrast agents;
• tissue and contrast harmonic imaging;
• spatial compound imaging;
• three dimensional (and 4D) imaging;
• elastography;
• Doppler tissue imaging;
• strain imaging and speckle tracking.

Suggested Topics To Review

Note that a number of equations are listed in this section. Candidates should ensure that they understand the underlying concepts that these equations express.

Physical Principles of Ultrasound

Describe:
• frequency, wavelength
• propagation speed
• amplitude, energy, power, intensity
• attenuation, relationship between frequency and penetration
• acoustic impedance
• reflection, scattering
• refraction, critical angle
• pulsed ultrasound, pulse repetition frequency, pulse duration

Relevant equations:
• Relationship between propagation speed \( c \), frequency \( f \) and wavelength \( \lambda \):
  \[
  c = f \times \lambda
  \]
• Definition of intensity:
  \[
  \text{intensity} = \frac{\text{power}}{\text{area}}
  \]
• Attenuation as a function of tissue attenuation coefficient \( \alpha \), distance travelled by the ultrasound \( d \) and frequency \( f \):
  \[
  \text{attenuation} = \alpha \times d \times f
  \]
• Reflection coefficient:
  \[
  R = \frac{(z_1 - z_2)^2}{(z_1 + z_2)^2} \times 100\%
  \]
• Refraction (Snell’s Law):
Transducer and Beamforming Concepts

Describe:

- piezoelectric effect
- transducer construction, backing and matching, coupling gel
- focussed transducer beam pattern
- electronic focusing using array transducers
- electronic beam steering
- sidelobes, slice thickness
- variation of intensity with depth and across width of beam
- major probe types - linear, curved and phased arrays
- scan patterns of major probe types
- matrix array transducers
- factors affecting choice of transducer for given application

Relevant equations:

- Near zone length (transition distance) as function of aperture \((A)\) and wavelength \((\lambda)\):
  \[
  NZL = \frac{A^2}{4 \times \lambda}
  \]

- Diffraction limit divergence angle \((\theta)\) as function of aperture \((A)\) and wavelength \((\lambda)\):
  \[
  \theta = \sin^{-1}\left(\frac{1.22 \times \lambda}{A}\right)
  \]

- Beamwidth \((w)\) at focus as function of aperture \((A)\) and wavelength \((\lambda)\) and depth of focus \((F)\):
  \[
  w = \frac{2.44 \times \lambda \times F}{A}
  \]

Imaging Principles and Technology

Describe:

- pulse echo concept (relationship between echo arrival time and depth)
- image formation, B and M-mode
- function, purpose and associated controls of:
  - transmitter
– beamformer
– amplifier, TGC
– dynamic range compression
– scan converter
– pre-processing
– image memory
– post-processing
– display

• meaning of term ‘artifact’ and reasons why artifacts occur
• mechanism of production and typical appearance of:
  – shadowing
  – enhancement
  – edge shadowing
  – reverberation
  – comet-tail
  – ringdown
  – propagation speed artifact
  – beamwidth artifact
  – sidelobe artifact
  – slice thickness artifact
  – refraction
  – mirror image
  – artifacts due to equipment failure and electrical interference

• use of some artifacts as diagnostic signs
• distance and area measurement
• limitations on accuracy of measurements
• image storage and recording techniques

Relevant equations:
• Relationship between echo arrival time \((t)\) and depth \((d)\):

\[ d = \frac{c \times t}{2} \]

• Relationship between depth of penetration \((P)\), beams per image \((N)\) and frame rate \((FR)\):
Defining Equipment Performance

Describe:

• axial resolution
• lateral resolution
• contrast resolution, improvement through reduction of artifacts
• temporal resolution, factors affecting it and methods to improve

Relevant equations:

• Relationship between axial resolution and pulse duration ($\tau$):
  \[
  \text{axial resolution} = \frac{c \times \tau}{2}
  \]

Doppler Principles and Instrumentation

Describe:

• The Doppler effect
• the Doppler angle and its implications
• principles and controls of:
  – continuous wave Doppler
  – pulsed Doppler
  – Doppler spectral display
  – colour Doppler, including power mode colour Doppler
• limitations of each Doppler modality
• Doppler artifacts, including:
  – frequency aliasing and ways to reduce or eliminate it
  – range ambiguity
  – intrinsic spectral broadening
  – spectral mirror artifact
  – wall thump
  – twinkle artifact
  – colour Doppler dropout
• standard Doppler measurements:
  – velocity

\[
P \times N \times FR = \frac{c}{2} = 77000 \text{ cm/sec}
\]
– spectral broadening, relationship to turbulent flow
– Resistance Index and other commonly used indices

Relevant equations:
• Doppler shift ($f_D$) as function of ultrasound frequency ($f$), blood velocity ($v$), Doppler angle ($\theta$) and ultrasound propagation speed ($c$):

$$f_D = \frac{2 \times f \times v \times \cos \theta}{c}$$

**Bioeffects and Safety**

Describe:
• importance of bioeffects and safety
• current knowledge based on epidemiology and clinical experience
• difference between bioeffects and biohazards
• known mechanisms and factors affecting them:
  – thermal effects
  – cavitation
  – other mechanical effects
• parameters used to characterise exposure:
  – pressure, power and intensity
  – spatial and temporal variation of intensity
• comparison of exposure levels associated with different operating modes: 2D imaging, M-mode, cw and pulsed Doppler etc
• Thermal and Mechanical Indexes - purpose and interpretation
• practical approaches to minimising risk
• ALARA principle
• ASUM policy statements and guidelines

**New and Evolving Techniques**

Describe:
• principles, advantages and limitations of:
  – extended field of view (panoramic imaging);
  – contrast agents;
  – tissue and contrast harmonic imaging;
  – spatial compound imaging;
  – three dimensional (and 4D) imaging;
  – elastography;
– Doppler tissue imaging;
– strain imaging and speckle tracking.

Part B: Principles of Image/Data Collection and Optimisation (15% Weighting)

Rationale

The aim of any ultrasound examination is to produce accurate, valid and clinically useful information. In achieving this aim all professionals involved in the ultrasound examination must have adequate underpinning knowledge and skill in: ultrasound physics and instrumentation (Part A of this syllabus); the major techniques used, principles applied and potential pitfalls encountered in producing an examination; the standard terminology and principles of reporting information used to describe ultrasound appearances and the care and maintenance of the equipment to ensure safe and accurate use.

Aim

For the candidate to demonstrate knowledge and application of the principles underpinning the production of an accurate and valid ultrasound examination that can be used as foundational knowledge for ongoing practice in the field of diagnostic ultrasound.

Learning Support

A specifically designed on-line tutorial is available to candidates on the myASUM site. Please refer to your enrolment information on how to access this resource.

The on-line tutorial is designed to cover the foundational knowledge required of any practitioner of ultrasound and the Learning Objectives as detailed in this Module 1 Part B syllabus.

Understanding of the material presented in this tutorial should, in most cases, allow a candidate to adequately demonstrate a foundational level of knowledge in this area and provide adequate preparation for the relevant ultrasound certification program examination.

Candidates are encouraged to read more broadly though on topics relevant to their own practice. You may wish to access some of the suggested materials and the readings and website links provided in the on-line tutorial.

Learning Objectives

1. Describe a range of techniques that can be used to ensure the best quality examination is obtained including: patient positioning and breathing; thorough systematic scanning throughout relevant organs/structures.

2. Describe and apply a range of probe manipulation techniques to produce an accurate, valid and efficient examination.

3. Define and recognise standard scan planes, image orientation and associated terminology used in general ultrasound applications and recognise where there may be variations used in particular fields (for example, intracavity scanning and cardiac ultrasound).

4. Describe the principles of adequate documentation of ultrasound images and data including labelling of images/data, and recording and archiving methods.

5. Define and accurately apply standard terminology used to describe ultrasound appearances.

6. Describe the use of, and apply, equipment controls to optimise the quality of the images/data produced including: time gain compensation (TGC); power; gain; focus; depth and zoom; principles of measurement to enhance accuracy.

7. Describe the general principles of ultrasound guidance for interventional procedures.
8. Describe general principles of care and maintenance of equipment.
9. Describe and apply principles of infection control in the use of ultrasound and its associated equipment.

Part C: Professional, Ethical and Legal Issues (15% weighting)

Rationale

The effective use of ultrasound examinations and procedures to contribute to clinical management of patients includes many aspects of the process. All professionals using ultrasound techniques are responsible for ensuring they have adequate and up-to-date knowledge of all aspects of the ultrasound examination process and associated legal and ethical requirements. Where other professionals are involved in the performance of any aspect of the ultrasound examination process it is a professional obligation of the responsible clinician to be aware of the role, functions, capabilities and responsibilities of all members of the contributing team.

Aim

For the candidate to demonstrate knowledge of the broad professional, ethical and legal principles and requirements that are particularly applicable to ultrasound practice as foundational knowledge for ongoing practice in the field of diagnostic ultrasound.

Learning Support

A specifically designed on-line tutorial for Parts B and C is available to candidates on the myASUM site. Please refer to your enrolment information on how to access this resource.

The on-line tutorial is designed to cover the foundational knowledge required of any practitioner of ultrasound and the Learning Objectives as detailed in this Module 1 Part C syllabus.

Understanding of the material presented in this tutorial should, in most cases, allow a candidate to adequately demonstrate a foundational level of knowledge in this area and provide adequate preparation for the relevant ultrasound certification program examination.

Candidates are encouraged to read more broadly though on topics relevant to their own practice. You may wish to access some of the suggested materials, and the readings and website links provided in the on-line tutorial.

Learning Objectives

1. Describe, in broad terms, the principles, importance and applicability of legal issues and requirements relevant to ultrasound practice including:
   a. Professional indemnity insurance;
   b. Vicarious liability, particularly as relevant to other staff, for example sonographers;
   c. Issues of negligence, including malpractice and misdiagnosis;
   d. Report writing standards and requirements;
   e. Data record keeping and archiving requirements;
   f. Electronic transmission and storage of data including Picture Archiving and Communication Systems (PACS), telemedicine and other means of data transfer;
   g. Privacy and confidentiality issues, including those related to electronic transmission of data;
   h. Legislative requirements for Medicare rebatable examinations including equipment requirements and practice standards.
2. Describe, in broad terms, the principles, importance and applicability of ethical considerations relevant to ultrasound practice including:
   a. Principles of biomedical ethics;
   b. Informed consent, particularly for "screening" procedures and invasive examinations;
   c. Communication, including limitations of the examination/procedure;
   d. Privacy and confidentiality issues.

3. Describe, in broad terms, the principles, importance and applicability of issues and requirements of health professional regulation and other professional issues relevant to ultrasound practice including:
   a. Registration and continuing professional development (CPD) for doctors;
   b. Registration and continuing professional development (CPD) for sonographers and other relevant staff;
   c. Sources of published standards of practice and relevant professional organisations;
   d. Incident reporting obligations, both mandatory and voluntary;
   e. Occupational health and safety issues;
   f. Quality control and processes for auditing of all aspects of ultrasound practice.

MODULE 1: Suggested Reading and Resources List

Part A: Ultrasound Physics and Instrumentation

Essential Reading


Supplementary Reading


ASUM Online Physics Tutorial (to access please refer to your confirmation of enrolment).

Part B: Principles of Image/Data Collection and Optimisation

ASUM Online Part B Tutorial  (To access please refer to your confirmation of enrolment)

American Institute of Ultrasound in Medicine (AIUM) Practice Guideline for Documentation of an Ultrasound Examination, 2014 version (Please refer to the AIUM Website www.aium.org)

American Institute of Ultrasound in Medicine (2011): Recommended Ultrasound Terminology, Third Edition (Please refer to the AIUM Website www.aium.org)


ASUM Policies and Statements (Please refer to the ASUM Website www.asum.com.au)

Part C: Professional, Ethical and Legal Issues

ASUM Online Part C Tutorial  (To access please refer to your confirmation of enrolment)


Australasian Sonographer Accreditation Registry (ASAR) at www.asar.com.au

Australian Health Practitioner Regulation Agency (AHPRA) at  www.ahpra.gov.au


Please refer to the Australasian Legal Information Institute(AustLII) website www.austlii.edu.au (database of Australian legal cases where full details of negligence and other cases before tribunals, courts etc can be found. Can search for cases using "ultrasound": (For interest and information only).
MODULE 2: Clinical Competence

Module 2 Clinical Competence is designed to assess the overall clinical ultrasound competence of the DDU candidate in the workplace/clinical setting and includes assessment of a wide range of required knowledge, skills and abilities as defined by the relevant specialty syllabus for Module 3. Candidates must familiarise themselves with the specific learning objectives, required abilities and major topic areas covered Module 3.

Assessment for Module 2 Clinical Competence is achieved via a variety of techniques to enable an accurate assessment of the candidate’s overall clinical ultrasound competence. The assessment methods used offer a balance between adequate assessment of knowledge, skills and abilities, and practicality and feasibility.

To assess Clinical Competence the following Module 2 assessments will be used:

i. Two (2) formative Case Studies

ii. Two (2) formative Clinical Supervisor Assessments

iii. Three (3) summative Case Studies

iv. Three (3) summative Clinical Supervisor Assessments

v. A Logbook with specified numbers and types of scans to be completed

vi. The completion of two (2) years diagnostic ultrasound experience

Logbook Requirements

All studies should be undertaken with appropriate supervision by the approved Primary Clinical Supervisor. The Primary Clinical Supervisor may delegate supervision to the approved Associate Clinical Supervisor where appropriate.

<table>
<thead>
<tr>
<th>DDU(Critical Care) Examination</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Echocardiographs</strong> (a minimum of 150 must be on haemodynamic evaluation):</td>
<td></td>
</tr>
<tr>
<td>- Transthoracic (performed and reported)</td>
<td>300</td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>- Transthoracic (reported)</td>
<td>150</td>
</tr>
<tr>
<td>- Transoesophageal (performed)</td>
<td>25</td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>- Transoesophageal (Observed/assisted)</td>
<td>25</td>
</tr>
<tr>
<td>Lung ultrasound</td>
<td>50</td>
</tr>
<tr>
<td>Abdominal rapid scan</td>
<td>50</td>
</tr>
<tr>
<td>Vascular</td>
<td>50</td>
</tr>
<tr>
<td>Line insertion</td>
<td>50</td>
</tr>
<tr>
<td>Ultrasound guided procedures</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>725</strong></td>
</tr>
</tbody>
</table>
MODULE 3: Advanced Ultrasound Practice

Learning objectives

In order to successfully complete the DDU (Critical Care) candidates are expected to be able to demonstrate, in relation to the list of major clinical areas as listed under “Major Topics”, the following:

- Ability to obtain a detailed, relevant clinical history as far as possible in the clinical circumstance.
- Ability to conduct the ultrasound examination in a timely and effective manner taking into consideration the clinical circumstance, environment, and the patient's privacy, cultural and religious needs.
- Understanding of, and skills involved in, producing and recognising an accurate and valid ultrasound examination and resultant data, including normal ranges of standard measurements and measurement protocols.
- Detailed knowledge of relevant anatomy, physiology and pathology.
- Ability to determine the need for further information such as: extension of the ultrasound examination; other tests; further clinical information; follow-up examinations.
- Competence in the recognition of sonographic appearances and relevant information including: normal anatomy; normal variants; artifacts; abnormalities.
- Competence in determining appropriate provisional diagnosis/diagnoses as a result of the ultrasound examination and in conjunction with other available clinical information as relevant.
- Detailed knowledge of the effect of surgery on cardio-thoracic and vascular anatomy and function and appreciation of the ultrasound protocols and possible findings in both normal and abnormal post-surgical states.
- Appreciation of the more rarely seen/uncommon pathologies which may be associated with an organ or organ system and ability to recognise the relevance to the presenting clinical circumstance.
- Ability to perform and/or be able to interpret advanced ultrasound techniques, such as contrast studies, as and when required to aid in the diagnosis.
- Recognition of any limitations of the ultrasound examination, including technical limitations, and the effect of these on diagnosis and clinical management.
- Ability to prepare a report/record of the examination including information on: findings/diagnoses; any limitations of the examination; correlation of findings with other relevant information; clinical decision as a result of the examination; requirements/suggestions for further testing or follow-up examinations.
- Ability to communicate effectively with the patient/client and/or their accompanying persons in a manner that is timely, relevant and appropriate to the circumstances.
- Ability to identify and act appropriately to ensure timely medical review/intervention where an urgent finding is made.

Major topics

Introduction:

The DDU Critical Care candidate is expected to have a deep level of knowledge across a select range of clinical applications of diagnostic ultrasound.

Candidates are expected to read widely and seek a range of learning opportunities including those focussed on theoretical and clinical learning, and practical skills development in order to be able to demonstrate competence across the syllabus. Practical requirements include the performance of at least 300 transthoracic echocardiographic studies, performing/observing at least 50 transoesophageal studies, and 200 lung, pleural, basic abdominal and venous/arterial line insertion
studies. Candidates are advised to the syllabus for Module 2 Clinical Competence and Logbook proforma for further details of the requirements for clinical experience.

A candidate is expected to be able to competently perform and interpret ultrasound examinations, including at least the following abilities:

1. Use of any combination of techniques for M-mode, B-mode (including trans-oesophageal) and Doppler (continuous wave and pulsed spectral, colour, amplitude or "power", tissue Doppler imaging) as required by the presenting circumstances.

2. All required measurements and calculations demonstrating a detailed knowledge of the principles, applications and limitations of all commonly used measurements/calculations and diagnostic criteria (as described by published standards and protocols).

3. Haemodynamic spectral analysis and interpretation of other Doppler modes demonstrating a detailed knowledge of the principles, applications and limitations of all commonly used calculations/indices and diagnostic criteria (as described by published standards and protocols) as required.

4. Interventional techniques as and when required by the presenting circumstances.

The candidate is expected to demonstrate understanding of, and be able to discuss, the following potential findings as integrated with the patient's clinical status:

**Cardiac Ultrasound:**

The major emphasis in the DDU (Critical Care) Syllabus is on the application of echocardiography in the management of the haemodynamically unstable patient, unexplained dyspnoea, or shocked patients.

1. Significant pericardial effusion and tamponade.

2. Left ventricular assessment.

3. Right ventricular assessment including acute pulmonale.

4. Haemodynamic evaluation
   - Cardiac output measurement
   - Intravascular volume status
   - Assessment for fluid responsiveness.

5. Evaluation of intracardiac pressures
   - RAP
   - RVEDP
   - Pulmonary artery pressures
   - Left atrial pressures
   - Left ventricular diastolic pressure.

6. Other
   - Valvular lesions
   - Intracardiac shunt
   - Thoracic aorta pathology
     - Atheromatous disease
     - Dissection
Aneurysm
  • Intracardiac masses.

Lung/Pleural Ultrasound
1. Pneumothorax.
2. Acute pulmonary oedema.
3. Lung consolidation.
4. Pleural effusion.

Vascular Ultrasound
1. Venous/arterial line insertion guidance.
2. Recognition of limb deep venous thrombosis.

Abdominal Ultrasound
1. FAST Examination.
2. Renal tract in evaluation of acute/chronic renal failure and/or obstruction.
3. Abdominal aortic aneurysm.
4. Gallbladder and bile duct evaluation.
5. Ascites.

Other applications of ultrasound and ultrasound guided interventions:
The principal processes and potential complications of ultrasound guided procedures such as:
• management of CPR
• cardiac pacing
• thrombolysis (AMI and PE)
• ventilatory changes, including lung recruitment (eg ARDS)
• volume resuscitation
• adjustment of pharmacologic and circulatory supports
• fluid drainage in all body cavities including the pericardium
• vascular access procedures including both arterial and venous for:
  • drug administration
  • invasive haemodynamic monitoring
  • intravascular circulatory supports (eg IABP, ECMO).
MODULE 3: Recommended Reading List


https://www.caeiccu.com/ (for internet CriticalCare ultrasound resources).