IECCUS
Introduction to Emergency & Critical Care Ultrasound

The Peter M. Winter Institute for Simulation, Education, and Research

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CHAPTER 1

Welcome

Thanks for joining us.

Critical care, point of care, bedside, emergency ultrasound—lots of names for the same thing. Physicians and other practitioners using an ultrasound machine (outside the radiology suite) to answer clinical questions, guide therapy, and make invasive procedures safer.

We have a lot to cover in this introductory course. We want to maximize learning by student and instructor interaction.
In the course, you will be presented with some material to review beforehand, so we will spend as little time as possible on didactics and maximize scanning and discussion.

At the end of our two days together we hope you will have the a firm foundation for incorporating US into your practice, and starting your journey to achieve ultrasound competence and expertise.

**Course Goals:**

**Cardiac US**
- Acquire quality images: PSLA, PSSA, Apical 4, subcostal and IVC views
- Identify: LV dysfunction, LV dilation, pericardial effusion, RV dysfunction, RV dilation, hyper dynamic contractility
  - Incorporate findings into clinical decision making for the patient with shock or dyspnea.

**Lung US**
- Obtain images of lung sliding, diaphragms, artifact analysis
  - Identify: A-lines, B-lines, Consolidation, Pleural fluid, pleural loculations

**Abdominal US**
- Obtain images of: the hepatorenal and splenorenal spaces, kidneys, bladder, aorta, and gall bladder
  - Identify: ascites, abdominal fluid, aortic dilation, aortic dissection, cholelithiasis, gall bladder thickening

**Vascular US**
- Obtain images of the proximal lower extremity veins and perform compression ultrasound to rule out DVT
  - Review techniques and optimize techniques for central venous catheterization and peripheral IV insertion

So, scan as much as possible, participate in the cases, and ask lots of questions.
Yours in scanning,

Phil Lamberty and Marek Radomski

Course directors
The American College of Emergency Medicine (ACEP) has created an US practice management resource where they have collected important documents outlining their consensus on the scope of US practice for EM, requirements for images, and paths to competency.

Critical care ultrasound (CCUS), the practice of point of care of US in the ICU setting, in comparison to the field of EM, has not developed and adopted formal training guidelines and standards. We have been told from various experts in the American College of Chest Physicians (ACCP) that board certification in advanced critical care ultrasound may be forthcoming. It is expected that CCUS with basic cardiac ultrasound will be incorporated into CCM fellowship training.

In 2009, the ACCP and SRLF published a consensus statement describing the scope of CCUS, outlining via expert opinion, what is basic and advanced critical care US and all the skills that should be mastered for competency.

Currently, there does not exist a path for recognized competence in CCUS provided by any of the critical care societies. Privileges for performing CCUS are hospital specific, and will vary depending on local department preferences.

All manner of physicians practice point-of-care ultrasonography. Only a few professional societies have tackled the issues of training, competence and credentialing.
Therefore, attaining CCUS competency carries controversy, as no clear standards (eg. number of scans etc) have been developed by any critical care professional society.

Practically, if you want to achieve competence in CCUS, we strongly advise the following:

- scan as much as possible and record images to improve acquisition quality
- review your images with an “expert” — a radiologist, cardiologist, an ultrasound technician, an US fellowship trained EM physician, or local CCUS proponent.
- take courses that offer scanning with lower scanner to actor ratios (ACCP, SCCM) and interaction with experts
- take advantage of Free Open Access Medical Education (FOAMED)— podcasts, ebooks, and image repositories.
Resources For US Education

A great format to learn ultrasonography.

Introduction to Bedside Ultrasound Volume 1
Introduction to Bedside Ultrasound Volume 2

Instructions, videos, links, you name it, by the Ultrasound Podcast gurus.

I bought them years ago, but they may be free now. If you have to pay, probably a good investment.

Cardiac and Critical Care Ultrasonography by Robert Thiele

this is free, need I say more. He does his own figures— you will know what I mean.

Practical Ultrasound Series: Deep Venous Thrombosis

An ACEP sponsored resources on point of care DVT scanning. Lots of video clips. Probably the best DVT resource around— did I mention its free?????

Essentials of Point-of-Care Ultrasound by Steve Socransky

Textbooks...NOT free!!!!

Ok...you are old school and need a hefty book on your shelf. You like to spend money. You are a high roller.

Textbook of Clinical Echocardiography, 5e (Echocardiography) 5th Edition
by Catherine M. Otto MD

If you want to take a deeper dive into echocardiography, take a swim here. You should get an electronic version with this, that is cool to look at echo clips on your browser or tablet. An iBook version exists.

Manual of Emergency and Critical Care Ultrasound 2nd Edition
by Noble and Nelson

Not free, but one of the original user friendly US resources. There is an iBook version, kindle, paperback.

Whole Body Ultrasonography in the Critically Ill 1st ed. 2010 Edition
by Daniel A. Lichtenstein

All things ultrasound written by the godfather. Its a rambling piece, but chock full of awesomeness.

Point of Care Ultrasound
by Soni, Arntfield, Kory

Another great resource by folk who teach CCM and EM folk nationally. Paperback, iBook, kindle versions.
Websites and Apps

Too many to list here.

Here are some great ones.

Echocardiographer.org

I used this site to hammer down the echo planes. Nice cartoons.

Works with flash, so video clips NOT good on an iPad.

Preoperative Interactive Education (PIE)

The PIE group, from Toronto, hosts a series of simulators and apps to learn among other things: lung ultrasound, focused cardiac ultrasound, trans-thoracic echo, and TEE.

You can access the material for FREE, but the apps cost a little bit. Another reason to pack things up and move north to Canada. Its all good.

To get started, I INSIST on you viewing the TTE Standard Views:

TTE standard view website (free!)

FOCUS cardiac ultrasound website (free as well!!)

UltrasoundPodcast

Video podcasts that can be quite entertaining. I watch them while I work out.

Stanford Echocardiography in the ICU

Great site that kicks tail. There is a mall on their campus.

Sonoaccess from Sonosite

Apps for iPad and android. All free.

PACCMUS

This is my site. I use it to teach on the wards. I plan to beef it up when I have the time.

ACEP Ultrasound

I am not a member, but you may be.
All practitioners of US should have a basic understanding of US physics. Modern point of care machines are very user friendly, but they won’t tell you if you viewing an artifact or real pathology. A working knowledge of US physics aids the novice US scanner in understanding artifacts.

**MUST KNOW FACTS:**

- High frequency probes are best used for superficial structures like muscles and soft tissue.
- Low-frequency probes, like your abdominal and cardiac probes, are best use for deeper structures.
  - AIR scatters ultrasound waves, and there's no getting around that.
  - So, you need something like gel that couples your probe to the skin surface (saline drips off the patient!)
  - Since air scatters ultra sound waves, anything deep to just a tiny sliver of air will appear on the screen as snow. Organs behind an air pocket, will be INVISIBLE.
  - Bowel gas = snow, lung air = snow, and stomach gas = snow.
- Subcutaneous air can scatter US beams. Tiny gas bubbles will reflect and can appear as dots and refract.
• Terminology:
  • ANECOIC- no echo— BLACK,
    • fluid transmits (blood, urine, ascites)
  • ECHOGENIC— bright—
    • US beams have been reflected.
    • structures that transmit AND reflect waves
    • soft tissue-- muscle, fat, vessel walls, nodes, masses

• Because bone has much higher IMPEDANCE than other human tissue, its a REFLECTOR- super bright.
  • There will be an ANECOIC region posterior to a bony surface: SHADOW
  • Big changes in Impedance lead to REFLECTION (AIR and Tissue)

• With all the waves bouncing, reflecting, scattering, and attenuating— sometimes the US machine plots information incorrectly on the screen. Like a 4 year old child, the machine will lie to you, but if you have an appreciation for ultrasound properties and knowledge of possible artifacts usually you can discern if an image is real.

For a deeper dive:

🌟View the US Physics slides by Marek

🌟Ultrasound Podcast Lecture a nice and mellow 17 minute US physics lecture

🌟Ultrasound Podcast- Tissue Harmonic Imaging/Vascular Doppler Techniques

Another 17 minute lecture
CHAPTER 5

Lung Ultrasonography

Remember….air reflects and scatters ultrasound waves. The lungs are full of air. Healthy lung—lots of snow. This snow has clinical meaning.

Indication: dyspnea, respiratory failure, shock, and sepsis.

With lung ultrasound (LUS) and add some cardiac US and DVT analysis, we can confidently diagnose and rule out:
**pneumonia** (consolidation, B-lines)

**atelectasis** (consolidation with shift of structures)

**pleural pathology** (effusions, empyema, loculations)

**pneumothorax** (lack of lung sliding)

**pulmonary edema** (B-lines, effusions)

**ARDS** (scattered B-lines)

**interstitial lung disease** (B-lines)

**diaphragmatic weakness and paralysis**

**pleural and lung neoplasms**

**large pulmonary embolism** (A-lines, RV dysfunction, leg clot)

**Asthma/COPD** (A-lines, wheezing)

No, not sure how its going to save you time. I can’t sell that. But when you are in the room scanning away, you can do this thing called take a history and examine the patient. If this chief complaint is shortness of breath, just bring in the US machine with you.

**MUST KNOW**

Ok, I’m a pulmonologist, but I think you should know this stuff.

Lung pathology OFTEN manifests at the lung surface.

Most of this work was pioneered by Daniel Lichtenstein, a French intensivist. Examine his work for an intense experience.

Here are his slides...I think he has given this talk a million times.
Start by framing rib space— in sectors— anterior, mid axillary, posterior

Place the probe over a rib space oriented cephalic to caudal

Aim probe for beam to hit the pleurae perpendicularly (lung surface not always parallel with the skin surface)

Display a rib space with meat in the middle framed by two ribs with shadow on the edges

Pleural Line and LUNG SLIDING

Lung sliding: when the parietal pleurae RUBS against the visceral pleurae

can only see sliding when there is lung movement (NOT APNEIC) AND no pneumothorax

Pneumothorax— just a sliver of air, will reflect/scatter US waves and make the visceral pleural INVISIBLE.

LACK OF LUNG SLIDING SUGGESTS PNEUMOTHORAX

PRESENCE OF LUNG SLIDING- NO PTX....AT THAT SPOT!!!!

Lung Point— you have found the edge of the PTX!

l lung point clip

Lung Pulse— no sliding, but pleurae is beating from the heart- NO PTX

Sometimes it gets tough to see SLIDING-- use the VASCULAR probe for high resolution.

M-Mode- Barcode- +PTX, Seashore- NORMAL
The A-line reverberation artifact (THINK A for AIR)

A-line: horizontal lines below and parallel to the pleural line, ~ equidistant from skin to pleural line.

Its an artifact- US waves bouncing back from pleurae (because of impedance mismatch) to probe— machine plots these lines as farther and farther away.

no A-lines, no B-lines— well someone published that- O-lines— same as an A-line

The B-line reverberation artifact (THINK B for BUSINESS TIME)

fluid-air ARTIFACT suggesting ENGORGED interlobular septae.

you are seeing the VISCERAL PLEURA- so, there is NO PTX at that spot!

Lichtenstein defines B-lines:

This is a comet-tail artifact.
It arises from the pleural line
It is well defined and laser-like— headlights in the fog.
It is hyperechoic- bright as the pleurae.
It is long, spreading out without fading to the edge of the screen.
It erases, or obliterates, the A-lines— it dominates.
It moves with lung sliding. (Lichtenstein, Whole Body Ultrasonography in the Critically Ill, 2010, p 152)

ABNORMAL when >3 B-lines to rib space— Alveolar Interstitial Syndrome

pneumonia, edema, infarct, inflammation, etc

not all comet tail artifacts are B-lines

Consolidation

tissue sign- devoid of air
shred sign - tissue sign interfacing with air filled lung

consolidation vs. atelectasis

subtle signs with atelectasis — the heart is no longer where it should be

**dynamic air bronchograms** - moving hyperechoic gas bubbles

**Pleural fluid** - **ANECHOIC** — **DARK**

dependent — so need to get UNDER the patient

adjust gain to image floating things - exudate

**spine sign** — see thoracic vertebrae

NO AIR from skins to bone - consolidation/fluid/tumor etc

Thoracentesis AND pleural drainage

FIRST define all structures — pleurae, organ below the pleurae, the lung flapping

use an abdominal/cardiac probe to see DEEP into chest

**Pleurae**

from underneath - through the liver or spleen - will move toward the probe (UP) with respiration

**measure and quantify excursion**

from the axilla - the pleurae will move toward the feet (away from the dot)

thickening (contraction) can be measured with the vascular probe
MORE LUNG ULTRASOUND

EM lecture by Vicki Noble on Lung Ultrasound  Part 1  Part 2

Thoracic Ultrasonography for the Pulmonary Specialist

Sonosite lecture on Pleural Fluid Scanning

CritCareSono  lung and pleural ultrasound lessons

Western Sono Lung Ultrasound  Part 2- Interpretation

PIE lung ultrasound module