USC School of Medicine – Primary Care Ultrasound Fellowship Curriculum

Introduction

The ultrasound fellowship in Primary Care was established in July 2011 to provide primary care physicians an opportunity to promote interest of primary care physicians in diagnostic ultrasound and provide those interested an opportunity to master the skill of point of care (POC) ultrasound. The fellowship was created from a long-term commitment to POC ultrasound by the USC School of Medicine (USCSOM), the USC Ultrasound Institute and Palmetto Health Richland (PHR). USCSOM was also the first medical school in the US to incorporate ultrasound as part of medical education in all four years of the medical education curriculum.

The USCSOM first started the ultrasound program for the medical students in 2006. The program was made possible by a generous loan by GE Healthcare of GE LOGIQe laptop size ultrasound systems. The small size ultrasound systems rival closely the capability of the larger ultrasound units. Each system comes with three different ultrasound transducers which provide the users the tools to perform a variety of ultrasound procedures ranging from basic echocardiography to assessment of abdominal organs, blood vessels and other structures using conventional B-mode imaging, M-mode, color Doppler and Spectral Doppler. The ultrasound systems are based on a digital platform and have the ability to generate, store and transmit standard DICOM images as well as jpegs and avi (video) files. USCSOM has also invested in remote media storage servers as well as a dedicated ultrasound image storage server on the internet cloud for students and physicians to be able to transmit and store ultrasound images and video clips of ultrasound studies performed.

The fellowship training at USCSOM utilizes a broad approach to train the fellow to become a true expert in point of care ultrasound. The fellowship curriculum is comprised of comprehensive diagnostic ultrasound techniques, rigorous teaching and medical student image assessment responsibilities, scientific investigation and research as per availability and general administrative responsibilities. It is expected that the fellow will have a deeper and clearer understanding of the technology on completion of the program.

Training and Experience

The ultrasound fellow will spend 70 - 80 percent of his/her time in the use of diagnostic ultrasound in a clinical environment or academic center. Activities during this time would also include teaching medical students and residents, as well as some scholarly activity related to ultrasound research and publications. During the course of the fellowship the ultrasound fellow is expected to attend and or perform 300-500 full studies under the direct supervision of an ARDMS registered sonographer and/or ultrasound trained physician. It is strongly recommended that the fellow maintains a complete log of all studies performed which should include but not limited to the date, time, amount of time spent, indication, findings and final impression/diagnosis including initials of the supervising physician or sonographer. This would be of great value when the fellow pursues some form of accreditation or certification offered by ultrasound organizations like AIUM and ARDMS. This can be accomplished during their scheduled clinical rotations. The fellowship director ensures compliance with this policy by periodically monitoring the fellow's progress through the ultrasound database. During these sessions the fellow will receive feedback regarding the accuracy, image quality, and technique of their scanning skills.

The fellowship director will review these ultrasound studies either at the patient bedside or during the review sessions. The fellow will also attend each of the morning meetings held every Tuesday morning to report on the progress as well as to keep in touch with other departmental activities. Additionally, the fellow will learn how to integrate the findings of their ultrasound into the clinical management of their patient.

The ultrasound fellow will also have access to a laptop size portable ultrasound system with three transducers and a small handheld (pocket size) ultrasound device. Other teaching resources would be online educational material, educational videos, ultrasound text books, ultrasound phantoms, and 3D anatomy software and lab handouts.

The fellows will cover the following topics/applications of bedside ultrasound during the course of their fellowship. If an ultrasound fellow has interest in a specific area of ultrasound, it may be possible to arrange more intensive training in that specialty depending upon availability.

Ultrasound Instrumentation and Physics

Instrumentation / Knobology

- Selecting and attaching appropriate transducer
- Turning ultrasound system on
- Role of ultrasound gel, acoustic standoff or water bath
- Preset selection
- Frequency
- Gain
- Time gain compensation (TGC/DGC)
- Focus and focal point(s)
- Depth
- Dynamic range
- Color map
- Frame rate
- Acoustic output
- X-beam
- Harmonics
- Beam adjustment
- Zoom
- Freeze image
- Store image
- Annotation
- Body markers
- Clear annotation and calculations
- Split screen mode
- Distance measurement (linear and circumference/trace)
- Area measurement calipers
- Volumetric measurement calipers
- Heart rate calculation
- Using ultrasound reporting package (inbuilt)
- Saving images on internal hard drive

- Saving images on USB flash drive
- Transmitting DICOM images to remote server and cloud
- Printing and transmitting images to DICOM server

Modes of ultrasound

- A-mode
- B-mode
- Color Doppler
- Power Doppler
- Spectral Doppler
    - Spectral waveform
    - Understanding arterial waveform
    - Significance of Doppler angle
    - Sample volume (SV)
    - PRF (Pulse Repetition Frequency)
    - Pitfalls
    - Peak systolic (PS) and end diastolic (ED) velocity measurement
    - Understanding spectral Doppler terms like envelope, spectral window
    - High and low resistance arterial waveform (examples)
    - Laminar flow
    - Turbulent flow
    - Monophasic, biphasic and triphasic flow
    - Calculating resistive indices, A/B ratio or S/D ratio
    - Acceleration time
    - Tardus parvus waveform
    - Peak systolic and end diastolic velocity measurement
    - Venous waveform
    - Normal phasic venous flow
    - Abnormal non-phasic cenous flow and significance
    - Absent venous flow
- M-mode
    - M-mode in echocardiography (basic)
    - M-mode in fetal heart rate determination (FHR)
    - M-mode in IVC assessment
    - M-mode in lung assessment
- E-mode (basic concept and possible uses)
- 3D & 4D mode (basic concept and possible uses)
- CW Doppler (basic)

Artifacts

- Understanding ultrasound artifacts (basics – why they occur)
- Mirror image artifact
- Reverberation
- Refraction errors
- Posterior acoustic enhancement
- Acoustic shadow
- Doppler ultrasound artifacts

- Significance of artifacts
- How to eliminate or reduce artifacts
- Useful artifacts

Resolution

- Axial resolution
- Lateral resolution
- Temporal resolution

Transducer types and different applications

- Single element transducer
- *Multiple element transducers*
    - Linear
    - Convex/curvilinear
    - Cardiac/sector
    - Transvaginal ultrasound (concept)
    - Hockey-stick (high frequency)
    - 3D /4D

Bioeffects

- ALARA principle
- Thermal effect
- Cavitation
- Thermal index (TI)
- Mechanical index (MI)
- FDA requirements for ultrasound imaging devices
- Fetal ultrasound (safety concerns)

Clinical / Diagnostic Ultrasound

Liver and gallbladder

- Liver and gallbladder (normal appearance)
    - Views of the liver
    - Lobes of the liver (Left, right and caudate)
    - Liver echotexture
    - Liver echogenecity
    - Intrahepatic portal vein, hepatic vein, intrahepatic biliary radicals
    - Diaphragm
    - Porta hepatis
    - Mirror image of liver and significance
    - Liver span assessment (right lobe)
    - Liver as acoustic window
    - Hepatorenal fossa (Morison's pouch)
    - Normal direction of flow in portal vein
    - Liver echogenecity comparison with kidney parenchyma and echogenecity scale

- Normal gallbladder appearance
- Gallbladder wall thickness measurement
- Cholelithiasis
- Acute and chronic cholecystitis
- Gallbladder mass, polyp, cholesterosis (twinkle artifact)
- Sludge in gallbladder
- Calculus impacted in neck of gall bladder and demonstrating mobility

- Liver and gallbladder (pathology)
    - Liver echogenecity comparison with kidney parenchyma and echogenecity scale
    - Fatty liver
    - Hepatomegaly
    - Cirrhosis of liver
    - Hemangioma
    - Liver mass or SOL
    - Cyst in liver
    - Metastases
    - Biliary obstruction
    - Longitudinal and transverse views of gallbladder
    - Gallbladder wall thickness measurement
    - Acute cholecystitis
    - Ultrasound Murphy's sign
    - Chronic cholecystitis
    - Mucocele gallbladder
    - Gallstones and acoustic shadow
    - Assessment of free mobile or impacted gallstone
    - Polyp in gallbladder
    - Gallbladder carcinoma
    - Ascaris in gallbladder
    - Sludge in gallbladder (layering)
    - Cholesterosis and twinkle artifact
    - Necrosis or gangrenous gallbladder

- Limitations of ultrasound of the liver and gallbladder
    - Air in second portion of duodenum masquerading as gallstones
    - Wall echo shadow (**WES**) sign and clinical significance
    - Inadequate gallbladder study due to patient not fasting
    - Patient positioning for proper gallbladder scan

Pancreas

- Pancreas (normal appearance)
    - Long and short axis views of pancreas
    - Pancreatic duct
    - Various parts of the pancreas
    - Relationship to stomach and splenic vein
    - Comparison of pancreas echogenecity to normal liver

- *Limitations of ultrasound of pancreas*
    - Limitations of pancreas ultrasound in acute pancreatitis (regional ileus)
    - Obesity

- *Pancreatic pathology*
    - Pancreatic mass
    - Acute and chronic pancreatitis
    - Pseudocyst of pancreas
    - Carcinoma of head of pancreas

Kidneys

- Kidneys (normal appearance)
    - Kidney views – longitudinal and transverse views
    - Dromedory hump
    - Renal agenesis (concept)
    - Ectopic kidney
    - Horseshoe kidney

- Limitations
    - Bowel gas shadows obscuring view of entire kidney
    - Large renal calculus obscuring view of the kidney parenchyma

- Diagnostic capabilities
    - Renal mass
    - Renal cyst
    - Renal size and normalcy assessment
    - Renal stones/calculus
    - Renal echotexture
    - Hydronephrosis
    - Renal cell carcinoma
    - Atrophic kidney
    - Chronic renal failure

Appendix and bowel

- Appendix ultrasound for appendicitis
    - Graded compression technique

- Limitations
    - Obesity
    - Uncooperative patient

- Diagnostic capabilities
    - Appendicitis
    - Appendicular abscess
    - Bowel mass/thickened bowel wall (concept)

Abdominal Aorta

- Abdominal Aorta (normal appearance)
    - Longitudinal and transverse views of abdominal aorta down to bifurcation
    - Celiac axis and branches and "Seagull sign"
    - Superior mesenteric artery in longitudinal and transverse views
    - Renal arteries
    - Left renal vein
    - Abdominal aorta bifurcation and left and right common iliac arteries

- Limitations
    - Bowel gas obscuring abdominal aorta or part of it
    - Dense calcification obscuring view
    - Thrombus in aneurysm
    - Techniques of working around bowel gas

- Diagnostic capabilities
    - Ectasia
    - Abdominal aortic aneurysm
    - Impeding rupture and leaking aneurysm
    - Saccular versus fusiform aortic aneurysm
    - Common iliac artery and or popliteal artery aneurysm and significance
    - Atheromatous plaques
    - Dissection of abdominal aorta

IVC

- IVC general concept and scan techniques
    - *Normal IVC views*
    - *IVC diameter and relation to respiration*
    - *IVC thrombus*
    - *IVC diameter as guide for central venous pressure and hydration status*
    - *IVC / Aorta ratio and relation to dehydration as well as response to IV fluids*
    - *Normal venous waveform pattern*
    - *CVP assessment and limitations*

Female Pelvic Ultrasound

- Female Pelvic anatomy (normal appearance)
    - Transabdominal - sagittal and transverse views
    - Pouch of Douglas
    - Version and flexion (concept)
    - Cervix
    - Uterus and endometrium
    - Ovaries
    - Internal iliac artery and vein
    - Fallopian tubes

- Limitations
    - Significant fetal biometry error in third trimester
    - Transabdominal approach limitation in first trimester
    - Fetal anomalies- needing significant user experience

- *Diagnostic capabilities*
    - Identify normal pelvic anatomy
    - Measure uterus and ovaries
    - Detect intrauterine pregnancy
    - Live intrauterine pregnancy
    - Multiple gestation
    - Basic obstetrical ultrasound including fetal biometry
    - Placenta assessment including placenta grading and placenta previa
    - Amniotic fluid assessment
    - Concept of uterine anomalies and role of 3D ultrasound to diagnose
    - Missed and threatened abortion
    - Extrauterine/ectopic pregnancy
    - Pelvic mass with pregnancy
    - Ovarian cyst – Physiological and pathological
    - Free fluid in the Pouch of Douglas
    - Ovarian torsion
    - Tubo-ovarian abscess

Heart (echocardiography-TTE)

- Cardiac views (TTE)
    - Parasternal long axis view (PLAX)
    - Parasternal short
    - Apical 4 chamber, 3 chamber, 2 chamber and 5 chamber views
    - Subcostal view
    - Suprasternal notch view

- *Limitations of TTE*
    - Inadequate patient position
    - Effect of respiration on cardiac windows
    - Effect of underlying disorders like emphysema and COPD

- *Diagnostic capabilities*
    - Global heart function
    - Left ventricular hypertrophy
    - Poor contractility of heart
    - Pericardial effusion and tamponade
    - Pericardial effusion differentiation from pleural effusion
    - Gross /obvious septal defect
    - Cardiac mass like atrial myxoma
    - Obvious valvular pathology or regurgitation
    - Right ventricular stress

Lower Extremity Arterial and Venous Doppler

- Normal findings on B-mode, color Doppler and Spectral Doppler
    - Lower extremity venous compression
    - Identify the deep venous system in lower extremity
    - Sapheno-femoral junction and Mickey Mouse sign
    - Aberrant vessels
    - Venous flow augmentation
    - Normal venous phasic variation in Spectral Doppler
    - Color Doppler technique and two-zone compression technique to detect clots
    - Normal arterial waveform and velocities (what to expect)

- Limitations of lower extremity arterial and venous Doppler
    - False positive due to inadequate compression
    - Difficulty viewing deep veins in adductor canal and obese patients
    - Limitations of B-mode and Color Doppler
    - Inability to see blood clot in deep veins consistently

Ultrasound guided procedures

- Central venous cannulation / access
- Venous wire guidance in long axis
- Pericardiocentesis under ultrasound guidance
- Thoracentesis under ultrasound guidance
- Paracentesis under ultrasound guidance
- Ultrasound guided biopsy
- Subcostal view of right ventricle with pace maker wire in place

- *Associated artifact recognition*
    - Reverberation artifact from needle and echo-tip needle
    - Wood /glass /metal foreign body artifacts

Musculoskeletal and soft tissue ultrasound

- Basics of MSK ultrasound
- Anisotropy
- Differentiation of cellulitis vs abscess
- Foreign body or subcutaneous implant detection
- Tendinitis detection with Power Doppler
- Tendon rupture (partial and total/complete tear)
- Knee joint
- Baker's cyst
- Shoulder joint
- Detection of joint effusion
- Needle localization in knee and shoulder joint injection
- Fracture – long bone
- Achilles tendon
- Carpal tunnel

Ocular ultrasound (concept)

- *Ocular ultrasound and common indications for eye ultrasound*
    - Views
    - Anterior chamber
    - Optic nerve
    - Posterior chamber
    - Retina
    - Hemorrhage
    - Lens dislocation
    - Foreign body in eyeball
    - Optic nerve sheath diameter measurement and significance
    - Retinal detachment
    - Understanding of equipment approved by FDA for ophthalmology applications

Renal Vascular ultrasound

- Basic concept of renal artery hemodynamics
- Evaluation of renal artery
- Renal artery stenosis
- Transplant kidney
- Renal vein evaluation and anatomical relation
- Renal vein assessment for thrombosis or renal tumor invasion and progression to IVC

Testicular ultrasound

- Normal testicular ultrasound and common pathologies
    - Sagittal and transverse and coronal views
    - Epididymis and rete testes
    - Epididymitits
    - Orchitis
    - Microlithiasis and significance
    - Testicular torsion
    - Varicoceole
    - Hydroceole
    - Spermatoceole
    - Testicular mass
    - Undescended testis

Emergency Medicine Ultrasound (Trauma)

- *eFAST exam (views and how to perform)*
    - Hepatorenal including the right lower chest (costophrenic angle)
    - Splenorenal , parasplenic including the left lower chest (costophrenic angle)
    - Subcostal and parasternal views
    - Suprapubic (transabdominal)
    - Chest ultrasound (to rule out pneumothorax)
    - RUSH protocol for undifferentiated hypotension

- *Limitations of diagnostic ultrasound in trauma setting*
    - Inadequate patient preparation/bowel gas
    - Inadequate lighting condition, probe selection and or probe position
    - Uncooperative patient or inadequate patient position
    - Limitation of eFAST in detecting low volume of intraperitoneal fluid
    - Not very reliable for solid organ damage detection
    - Variable appearance of blood in the peritoneal cavity

Diagnostic capabilities

- Free fluid in the peritoneal cavity
- Pericardial effusion
- Free fluid in the chest cavity
- Pneumothorax (limitations and comparison with X-ray and CT)
- Solid organ injury
- Vascular injury- extremities
- Long bone fracture determination with ultrasound
- Role of ultrasound in assessing ocular injury/ foreign body

Lung Ultrasound

- *Lung ultrasound exam*
    - Lung ultrasound anatomy
    - Lung ultrasound scan zones
    - Bat sign
    - A lines
    - B lines
    - E lines
    - Z lines
    - V lines
    - Lung sliding
    - Lung Point
    - Quad sign
    - Sinusoidal sign
    - Role in pleural effusion
    - Lung consolidation and abscess
    - Static and dynamic air bronchogram
    - Pneumonia diagnosis
    - Pulmonary embolism
    - US guided thoracentesis
    -

Miscellaneous

- *RUSH protocol*
- *BLUE protocol*
- *CLUE*

Teaching Responsibilities

The ultrasound fellow is responsible for assisting with teaching the medical students and running the ultrasound labs, ultrasound open labs and ultrasound OSCEs for the medical students. The fellow will also be evaluating the ultrasound image assignments submitted by the medical students during their lab sessions. Teaching the internal medicine, family practice and pediatrics residents and faculty is the second priority. Each month approximately 200 medical students (M1 + M2) perform ultrasound exams during their ultrasound exam labs and submit ultrasound images and videos directly to the online server via Ethernet cable which are connected to the ultrasound systems. During the lab session, the fellow provides bedside instruction on scanning skills and image interpretation to the medical students. The medical students at USCSOM have bedside ultrasound incorporated in all four years of their training program. The ultrasound fellow will be required to present. This involves lecture presentation and significant hands-on technique instruction over a two-day period.

Scientific / academic publication

Publication of original research is expected. Therefore, research will be a significant activity of the fellow's non-clinical hours. A minimum of one IRB approved research projects are required by completion of the fellowship. These projects may be retrospective or prospective in design and must be related to ultrasound. Case reports, case series, expert opinions, letters to the editor, textbook chapters etc. are not eligible to satisfy this requirement but are desirable as additional projects.

Credentials

The fellow will be expected to graduate with the skills to successfully guide a group of primary care physicians or medical students or medical residents through a teaching program in POC ultrasound. The following items may or will be part of the process.

- QA - The fellow will be monitored for progress report which may be filled by the attending physician in the respective departments at the end of each rotation if possible.
- Credentialing - The fellow will be required to contact the AIUM and ARDMS to assess what steps would be necessary for her/him to accomplish their academic goals.
- The fellow will be expected to be familiar with documents such as AIUM ultrasound practice guidelines and ultrasound protocols.
- Documentation - The fellow will learn the various methods of documenting his/her ultrasound findings.
- There may be a possible separate credential available from ARDMS or AIUM in the near future for POC ultrasound