Ultrasound in the NICU
What the Neonatologist wants to Know:

Point-of Care (POC) Ultrasound by the Neonatologist

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Conflict of Interest Disclosure

I have no financial relationships with any commercial entity producing healthcare-related products and/or services relevant to this presentation.
Portable bedside ultrasound: the visual stethoscope of the 21st century

Lawrence M Gillman\(^1\)\(^*\) and Andrew W Kirkpatrick\(^2\)

Abstract
Over the past decade technological advances in the realm of ultrasound have allowed what was once a cumbersome and large machine to become essentially hand-held. This coupled with a greater understanding of lung sonography has revolutionized our bedside assessment of patients. Using ultrasound not as a diagnostic test, but instead as a component of the physical exam, may allow it to become the stethoscope of the 21st century.

Keywords: Point of care ultrasound, Physical exam, Pleural rub
History/Demographics of Who

• Geographic differences in who performs diagnostic US in NICU
  – Europe: Peds vs. Rad
  – Institution specific histories
    • specialty that initially picked it up remains in control
    • local specialty staffing and resources differ

• Changes in equipment
  – Machines have become smaller and portable
  – Image quality has improved
  – Cost has dramatically declined making inexpensive units available

• Residency/Fellowship training
An ultrasound device barely bigger than a smartphone

Ultrasound machines can take images (echocardiograms) of the heart’s chambers, valves, and blood flow that rival CT and MRI scans for detail and clarity. But sometimes a more rapidly acquired echocardiogram serves a particular purpose better than one with all the “bells and whistles.”

New ultrasound devices that physicians can carry in a pocket now “compare favorably with the stethoscope as a tool to differentiate what’s normal from what’s not,” says Dr. Judy Mangion, associate director of the noninvasive cardiac laboratory at Harvard-affiliated Brigham and Women’s Hospital. They let doctors see on a flip screen what they previously could only hear and feel during a physical exam. And at about $8,000 each, a hospital conceivably could give 25 doctors their own pocket-sized ultrasound device for the same cost as a single high-end machine.

The device can deliver useful images when time is of the essence or in situations that don’t justify a full-fledged ultrasound. Dr. Mangion uses hers to see how much fluid a heart failure patient is retaining, how well a recently replaced heart valve is working, or how well the heart’s chambers are pumping, to name just three applications.

Limits of the technology

As handy as they are, the small units will not replace full-sized machines anytime soon. They can’t deliver fine-tuned analyses of heart function, and most aren’t suitable for taking pictures of structures close to the body’s surface, such as the neck’s carotid arteries. Images from these devices can’t yet be stored in the digital archiving systems that enable doctors to share and compare pictures, nor can they be entered into a patient’s electronic health record.

The Echocardiography Lab at Brigham and Women’s Hospital is planning a study to compare handheld units with higher-end ultrasound equipment. But while researchers investigate whether these devices truly improve the practice of medicine, don’t expect your cardiologist to pull one out from his or her lab coat as part of your next heart check-up.

And if you’re healthy, your doctor shouldn’t use one. The FDA has restricted handheld ultrasound devices for use in people showing specific signs of disease or to monitor and follow up those already diagnosed with a specific condition.
Lecturers
Prof. Michael Riccabona
Department of Paediatrics, Radiology
Graz University, Austria

Prof. Veronica Donoghue
Children’s University Hospital,
Dublin 1, Ireland

Prof. Alan Daneman
Department of Diagnostic Imaging
Hospital for Sick Children
University of Toronto, Canada

Prof. George A. Taylor
Department of Radiology,
Children’s Hospital, Boston, USA

Learning objectives of the Course
Ultrasound imaging of neonatal abdomen
• To understand limits and usefulness of gastrointestinal tract, liver, spleen and pancreas ultrasound imaging
• In the practical session, imaging tests will be made to help participants understand many practical issues of diagnosis

Ultrasound imaging of neonatal brain
• To become familiar with the different pathologic images of neonatal brain: morphology and hemodynamics
• In the practical session, imaging tests will be made to help participants understand many practical issues of diagnosis and the importance of ultrasound follow-up

Ultrasound imaging of neonatal urogenital tract
• To become familiar with the different pathologic images of neonatal urogenital tract and with renal hemodynamics
• In the practical session, imaging tests will be made to help participants understand many practical issues of diagnosis and the importance of ultrasound follow-up

Information
The theoretical-practical course is for paediatricians, neonatologists and paediatric radiologists and is limited to 47 participants. Practical sessions include tests for the participants and case discussions, without direct examination of a baby. The language of the course is English.

UEMS – European Union of Medical Specialists
UEMS credits will be applied for. They are valid all over Europe, the United States and Canada (reciprocal agreement with the American Medical Association).

Live educational activities occurring outside of Canada, recognized by the UEMS-ECME, are deemed to be Accredited Group Learning Activities (Section 1) as defined by the Maintenance of Certification Program of The Royal College of Physicians and Surgeons of Canada.

CME – Continuing Medical Education
(Foreign Participants only)
CME credits, requested to Ministry of Health, will be given to the participants of the course.

Registration fee
Registration received by 18 January 2013:
€ 795.00 (VAT included)
Registration received by 11 March 2013:
€ 840.00 (VAT included)
No on-site registration.
The fee includes course materials, a CD with the lessons, coffee break and lunch each day.

Accommodation
AIM negotiated preferential rates with Residence Palazzo Riccardi Hotel.
Double room double use € 150.00 per room per night, taxes and breakfast included.
Double room single use € 120.00 per room per night, taxes and breakfast included.

Information
Please be informed that, a City Tax (“Tassa di soggiorno”) has been applied for all Florentine hotels (but also to camping, guest houses, rooms for rent, residences, farm holidays with different taxation).

Hotel Palazzo Riccardi requires a fee of 4 Euros per person, per night, to be paid at the check-out directly to the hotel.

Make sure to have your reservation made by 18 January 2013: after this date rooms could not be guaranteed. A receipt will be sent as confirmation of your reservation.

Application
To make a registration and/or hotel reservation, please return the elected application form duly filled in to the Organizing Secretariat.

Cancellation
Cancellation must be sent in writing. You will receive a 75% refund of the participation fee in case of cancellation before 19 February 2013. After this date no refunds will be possible.

Course endorsed by EFUMB

Course venue
Palazzo Riccardi Polihotels
Via delle Mandorle, 2 - Florence, Italy

Organizing Secretariat
AIM Group International
Rivarolo Uffici
Via G. Marzoli, 70 - 50119 Florence, Italy
Tel. +39 055 233861 - Fax +39 055 2483246
www.aimgrourinternational.com
ultrasound2013@aimgrour.it

2013 Neonatal Ultrasound Course.
Why, how and when an ultrasound image?

Florence, 18-21 March 2013
Palazzo Riccardi Polihotels

PROGRAMME

DIRECTOR
Dr. Antonio La Torre
Neonatology Department,
AOU Careggi Hospital, Florence
Sonography in the NICU International

• In many countries, the limiting steps are:
  – Access to equipment
  – Access to a physician
  – Access to a Radiologist

• There are many scenarios under which sonography is performed, e.g.
  – Neonatologists have always done HUS
  – Machine stationed in NICU for fEcho by certified Neonatologist
Sonography in the NICU United States

- Most are in tertiary care setting with Radiologist supported services available
- Not all of these settings have Pediatric Radiologists
- Most of these settings would not be able to provide instantaneous service within minutes
- Most of these settings do not have equipment stationed in the NICU, and these patients are usually not mobile.
POC Sonography in Medicine

• Specialties that use non-Radiologist imagers:
  – Cardiology
  – OB
  – ER
  – ICU (central vascular access, A-lines)
  – Urology (hydronephrosis)
  – Orthopedics (joint injections)
  – Ophthalmology
  – Anesthesia

  – 21% increase in utilization rate of non-cardiac US
  – 41% of 2009 POC US studies done by non-radiologists
  – Radiologists’ US market share stable

J Am Coll Radiol 2011;8:772-775
AHRQ Recommended Patient Safety Practices (2001)

- RCT (n=201)
- recommended dynamic, real-time US guidance during, as opposed to static guidance before cannulation.
  - IJ cannulation: improved success rate with both static (82%) and dynamic ultrasound (98%) compared with landmark methods (64%)
  - Dynamic vs. static improved success rates (98% vs. 82%)
  - 1st attempt success rates (62% vs. 50%)
  - mean # attempts (2.3 vs. 2.9)
  - mean time to cannulation (109 vs. 126 secs)

Emerg Med J 2012; doi:10.1136/emermed-2012-201652
Common Problems in the NICU Evaluated with Sonography by the Radiologist

• Neuro
  – Screening for ICH and PVL
  – Monitoring evolution of ICH (including ICP)
  – Confirmation of prenatally suspected malformations or injuries
  – Evaluation for occult defects of the lower spine

• Renal/GU
  – Confirmation of prenatally suspected malformation, dysgenesis or obstruction
  – Assessment for obstruction of blood flow to or from the kidney in the setting of hypertension or hematuria
  – Suspicion for testicular torsion
  – Confirmation of bowel in inguinal hernia

• GI
  – Evaluation of biliary tree in the setting of cholestasis
Acute clinical issues that might be aided by POC US

- fECHO/TNE
  - PDA significance
  - Response to inotropic agents
- Umbilical line tip placement
  - Reduction in radiation exposure
- Bladder catheterization or tap
- Pleural effusion drainage
- PICC and PIV placement
- Increased ICH requiring LP
- ETT placement

Ultrasound Quarterly 2012;28:299-304
## Pros and Cons for Neonatologist

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<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
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<tr>
<td>• Knowledge of the patient’s clinical history and needs</td>
<td>• Lack of training in imaging</td>
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<td>• Rapid return of information that can inform acute management</td>
<td>• Lack of knowledge of anatomy</td>
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<td>• Access optimized for non-mobile patients (timing, portable)</td>
<td>• Lack of knowledge on physics of ultrasound</td>
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<td>• Lower radiation exposure for line, tube placement</td>
<td>• Lack of technical knowledge regarding the machine</td>
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<td>• Loss of control by Radiologist (QI, reporting, billing)</td>
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<tr>
<td></td>
<td>• Lack of access to machine</td>
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<td>• Lack of technical support/service</td>
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Potential Uses of POC US Proposed for the Neonatologist

1) Functional echocardiography (fECHO)/ Targeted Neonatal Echocardiography (TNE)

2) Localization of fluid collections for fluid withdrawal
   a. Bladder
   b. Pleural effusion
   c. Ascites

3) Localization of UA/UVC and PICC line tips

4) Assistance in placing PICC and peripheral A-lines

5) Progression of ICP by RI

6) Other: ETT placement, pneumothorax detection
Neonatologist vs. Cardiologist

• Neonatologist trained for 8 hours to perform POC US evaluation for presence of PDA
• 24 studies performed by Neonatologist prospectively read by Neonatologist and Pediatric Cardiologist.
• Readings compared to formal cardiac echo report

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<th>Sensitivity (%) (95% CI)</th>
<th>Specificity (%) (95% CI)</th>
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<tr>
<td>Neonatologist</td>
<td>69 (49 – 89)</td>
<td>88 (67 – 99)</td>
</tr>
<tr>
<td>Pediatric Cardiologist</td>
<td>87 (67 – 98)</td>
<td>71 (29 – 96)</td>
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Functional Echocardiography for the Neonatologist

fECHO

1. Bedside use of cardiac ultrasound allows to longitudinally follow changes in
   a) cardiac function
   b) systemic and pulmonary blood flow and
   c) clinically relevant organ perfusion

2. Hemodynamic data may provide clinical information that is different to the assumed underlying cardiovascular physiology

Kluckow M, Seri I, Evans N; Pediatr Cardiol, 2008
fECHO

• To fulfill fECHO potential
  – Must be available at all times in NICU
  – Neonatologist must be appropriately trained

• Major issues
  – Training and accreditation
  – Maintenance of skills
  – Potential for misdiagnosis

• Concluded that close collaboration with Cardiologist essential: all patients followed by fECHO require formal structural survey

Kluckow M, Seri I, Evans N; Pediatr Cardiol, 2008
Functional Echocardiography (fECHO) or Targeted Neonatal Echocardiography (TNE)

http://www.neonatalechoskills.com
Functional Echocardiography (fECHO) or Targeted Neonatal Echocardiography (TNE)

• Presence of physiologically significant PDA
• Ventricular function assessment regarding pressor use
• R -> L shunting: cardiac vs. pulmonary etiology of cyanosis

http://www.neonatalechoskills.com/index.html
http://www.asecho.org/files/NICU.pdf
Use of Targeted Neonatal Echocardiography to Prevent Postoperative Cardiorespiratory Instability after Patent Ductus Arteriosus Ligation

Amish Jain, MD1,2, Mohit Sahni, MD1, Afif El-Khuffash, MD1, Emad Khadawardi, MD1, Arvind Sehgal, MD1, and Patrick J. McNamara, MD1,2,3

• Retrospective
• 62 infants post-PDA ligation
• LV output < 200 ml/kg/min 1 hour post-op was highly predictive of need for inotropes
• Early inotrope use was associated with lower rate of ventilation failure (15% vs. 48%, p = 0.02)
Bladder Catheterization

• Setting: ER
• Imager: Pediatric ER Physicians
• Patients: Infants < 2 years
• Blind cath: 76% success on first attempt
• US directed: 96% success on first attempt
• Skill set allows for bladder tap
Thoracentesis and Paracentesis for Fluid Drainage

- Relatively little data in Peds and none in NICU
- In adults, lower complication rate with post-tap pneumothorax with US guidance (risk decreased by ~50%)
- Simulation centers have developed models to train critical care personnel for such US guided procedures
PICC/UAC/UVC Line Tip Placement

  - 31 preterm infants underwent umbilical line placement with tip localization documented by either POC US or radiography.
  - Mean time to final placement was 75 vs. 139 min in the US vs. X-ray groups (p <0.001).
  - No. of X-rays taken was 2.3 vs. 4.1 in the US vs. X-ray groups (p = 0.003)

  - 22 premature infants, mean GA 26.5 weeks (25.4 – 28.8)
  - Underwent both TNE radiography for PICC placement
  - Sensitivity of radiographs in determining malposition was 64% with a specificity of 55%
  - TNE was more accurate and reduced the need for a second radiograph by 41%, thus significantly reducing potential radiation exposure

- CONCLUSIONS: For PICC, UVC and UAC tip localization, POC US may be more accurate, faster and result in decreased radiation exposure
CVC/PICC placement

- Multiple organizations (e.g.)
  - NICE  www.nice.org.uk  NICE Technology Appraisal Guidance – No. 49

have developed standards and guidelines for US guided placement (Radiologist or Non-radiologist) of

- Internal Jugular (IJ)
- Subclavian
- Femoral
- Peripherally Inserted Central Catheters (PICC)
- Peripheral IVs: may decrease # sticks, time to placement, avoid PICC
Resistive Index (RI)

- Use POC US to determine change in RI as a reflection of change in intracranial pressure (ICP) in premature newborns with ICH and PHH
- ICP increase prompts LP decompression pending shunt placement
- Useful in infants too small for shunt placement; temporizing taps to keep ICP down for minimization of brain injury
- Same daily observer lends reliability to results

Taylor et al. Radiology 1994; 191;787-791
Training Resources for MDs
Training and Certification Requirements

• What would be exam for Neonatologist?
  – little currently exists for Neonatology except fECHO/TNE

• Organizations for training/certification
  – RPVI: M.D., 500 supervised studies, course, exam

• Organizations developing guidelines
  – AIUM, ASE, SCA,

• “Stethoscope”
  – don’t get certified, don’t charge, don’t document
  – use to gather info in clinical assessment
# Potential Imaging Combinations

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<th>Perform Study</th>
<th>Interpret Study</th>
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<td>• Technologist</td>
<td>• Radiologist</td>
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<td>• Technologist</td>
<td>• Neonatologist</td>
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<tr>
<td>• Technologist</td>
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<td>• Neonatologist/Radiologist</td>
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<td>➢ individual vs. group</td>
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SUMMARY

• Evolution of fECHO/TNE will pave the way for other uses of POC sonography in the NICU with equipment access.

• Needed:
  – Development of training and credentialing pathways
  – Development of NICU procedure standards jointly by Neonatologists, Subspecialists and Radiologists (similar to AIUM vascular access guidelines)

• With appropriate standards and training, NICU POC US may lead to lower procedure complication rates and lower radiation exposure in a high risk population.