Use of Ultrasound in Anesthesia/Critical Care: Technology, Applications and Training

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The application of ultrasound as a near routine part of diagnostic and interventional/therapeutic management of patients managed by anesthesiologists in the operating room, pain clinic, and critical care units has truly exploded over the past decade. Steady technical improvement in commercially available ultrasound units in several key areas necessary for widespread clinical use have facilitated this growth. Thus, improvement in transducer technology with higher resolution probes with the proper configuration for specific anatomic applications, improvement in digital processing and display of the signal, a progressive decrease in the all important "footprint" of the ultrasound unit with new all purpose units capable of even transesophageal imaging decreasing to the size of a laptop computer as well as interface and storage enhancements necessary for storage and documentation/billing are all pushing ultrasound imaging into the mainstream of anesthetic, pain and critical care practice.

Although much of the initial attention was focused on cardiac or vascular surgery TEE imaging for diagnostic and hemodynamic management and vascular imaging for central venous access, there is rampant enthusiasm in use for adult peripheral nerve blocks (and pediatric central blocks) as evidenced by multiple courses at national meetings, review articles and textbooks, etc. on the topic. The more mundane and currently less well accepted uses for placing arterial catheters and peripheral venous access is perhaps of equal importance given all the time that is wasted in the average O.R. and ICU struggling to place these lines.

However, it is also apparent to me and others that the level of sophistication of the "average" clinician with regards to the optimal use of ultrasound is still surprisingly low. Clearly, any commercially available ultrasound unit still requires what I would consider an "intermediate" level of familiarity with a fair array of ultrasound methodology, very little of which is taught in a truly integrated fashion in standard anesthesia texts or even in residency. There are of course bona fide concerns about expense of these units and despite price dropping into ranges not dreamed about 10 years ago even a 10 – 15K unit may be too high for many anesthesia groups or O.R. budgets. The introduction of 3Dimensional imaging comes at a steep price that although good for stockholders, will likely take many years to come down to most of our daily budgets. The recent defeat in San Diego this October (at least temporarily) of the proposed ASA Practice Guidelines for Central Venous Access at the hands of the House of Delegates, which in large part appears to be attributed to the strength of that documents enthusiasm for the routine use of ultrasound (among a few other controversial factors related to infection control) does highlight that there is still skepticism and perhaps some real concerns about its limitations and the ability of the average clinician to properly use it to warrant delay of its acceptance by the ASA (albeit at a potential price to the ASA's reputation as a "leader in patient safety" so prominently

displayed on its new website and in its various promotional material). Despite this seemingly overly conservative approach by one part of the ASA, another part is quite interested in promotion of the new and as of yet poorly publicized program for Basic TEE certification now open to all clinicians (of which this lecturer is involved in program development for).

However, resistance to ultrasound is rapidly changing and both educators and companies are clearly realizing that standardized training and equipment that is usable right out of the box without being an trained ultrasound technician is necessary for universal penetration of ultrasound into clinical practice. Although it will (and should) be the very rare clinician who will be as well educated as a cardiologist/radiologist/ultrasonographer and the highly trained certified technicians who perform complex diagnostic exams, even the busiest clinicians should be able to learn enough solid basics of ultrasound imaging to accomplish a multitude of clinical tasks (and also appreciate the limitations of their training and when to consult with a better trained specialist). The payoff for such an investment of time is in my opinion is absolutely tremendous in terms of increasing one's productivity and decreasing the level of stress associated with the rigors of daily clinical practice. It is also immensely stimulating to literally "see" new things hidden beneath the surface of the body that one didn't appreciate before and can learn so much about both in terms of anatomy and physiology.

Although it is impossible in a 30 minute time frame to give more than a whirlwind tour of the emerging field of perioperative ultrasound, I will attempt to present a very brief introduction to the major physical principles of diagnostic ultrasound and transducer technology, follow that with a quick look at major clinical applications and what the literature has to say about their efficacy (including at least a few meta-analyses that have been recently published) and finish with a look at training, simulation and certification issues germane to this arena. Included are a number of references that I have found to be particularly important and easily accessible via pubmed and our common specialty/subspecialty journals.

I. Technologic Aspects

a. Physical Principles of Diagnostic Ultrasound (1) (2)
b. Transducer Technology (Basic and Advanced)
c. Imaging and Non-imaging Modalities (3,4)
d. Ultrasound Artifacts (5)
e. Safety issues (6)

II. Clinical Applications of Ultrasound (Doppler and 2D technologies)

a. Anatomic Assessment: Vascular
    a. Central Venous access (7,8) (9)
    b. Arterial cannulation (10)
    c. Peripheral venous access
b. Anatomic Assessment: Cardiac
    a. Systolic/Diastolic function (11)

b. Chamber assessment
c. Valve Function
d. Aortic Arch (12)
e. Pericardium
f. Device assessment
g. 3D Cardiac Imaging (13)

c. Hemodynamic monitoring
   a. Stroke volume assessment (4)
   b. Filling pressures (14,15)
d. Anatomic Assessment: Nervous system (16,17) (18)
e. Anatomic Assessment: Thoracic/Pulmonary (19)

III. Assessing the Efficacy of Ultrasound Guided Interventions
   a. Central Venous Cannulation (20) (21)
   b. Arterial Cannulation (22)
   c. Point of Care TEE/TTE Noncardiac Surgery (23) (24)
   d. Regional Anesthesia (25) (26)
   e. ICU Uses (27)

IV. Training/Simulation/Certification/Guidelines/Consensus Statements
   a. Internal Jugular Access (28)
   b. ICU Medicine (29-31) (32) (33)
   c. ASA TEE Guidelines (2010) (34)
   d. TEE Training and Competency (35,36)

V. Internet Links
   a. Educational Sites
      -Toronto General Hospital Virtual TEE Simulator
      http://pie.med.utoronto.ca/TEE/
      -Univ Washington Anesthesia TEE Cases
      http://depts.washington.edu/anesth/education/resources/tee/index.shtml
      -Ultrasound for Regional Anesthesia Toronto http://www.usra.ca/
      -NY School of Regional Anesthesia http://www.nysora.com/

   b. Professional Societies
      i. National Board of Echocardiography
      -Advanced Certification http://www.echoboards.org/content/advanced-pteexam
      -Basic Certification http://www.echoboards.org/content/basic-pte
      ii. American Society of Echocardiography
      -Free Guidelines and Standards documents
      http://www.asecho.org/i4a/pages/index.cfm?pageid=3317
      iii. American Society of Regional Anesthesia
      http://www.asra.com/
      iv. American Board of Anesthesiology

c. Selected Commercial vendors

i. Philips http://www.healthcare.philips.com/in/products/ultrasound/
ii. Siemens http://www.medical.siemens.com
iii. General Electric
http://www.gehealthcare.com/euen/ultrasound/index.html
iv. Sonosite http://www.sonosite.com/
v. Biosound Esaote http://www.biosound.com/default.asp
vi. Imacor http://www.imacormonitoring.com/
vii. Ultrasonix http://www.ultrasonix.com/
viii. Heartworks TEE simulator
http://www.heartworks.me.uk/index.php?page=home&lang=us
ix. CAE Vimedix TEE simulator
http://www.cae.com/en/healthcare/imaging.solutions.asp
x. Deltex CardioQ esophageal Doppler
http://www.deltexmedical.com/Deltex_Website_USA/index.html

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