• Handheld Echocardiography – It Depends Whose Hands are Holding it: Educational? Diagnostic? Overshadowing the Physical Examination?

Martin E. Goldman MD
Arthur Master MD Professor of Medicine
Mount Sinai Heart
Icahn School of Medicine, Mount Sinai NYC
Handheld Echocardiography – It Depends Whose Hands are Holding it: Educational? Diagnostic? Overshadowing the Physical Examination?

Martin E. Goldman MD
Arthur Master MD Professor of Medicine
Mount Sinai Heart
Icahn School of Medicine, Mount Sinai NYC
Point –of Care Ultrasound

• Define problem
• Define terms
• Equipment
• Who does the imaging?
• Education
• Adoption & Application
Case:

- 49 yr old woman
- h/o breast cancer
- Rx’d : Adriamycin
- Presents with dyspnea
- tachycardia and mildly hypotensive
• Normal vs Abnormal:
• Outside – In : any fluid?
• Chambers Normal Size:
• LV Wall Motion
• Valves Moving normally?
• Abnormal Mass:
FCU is a focused examination of the cardiovascular system performed by a physician by using ultrasound as an adjunct to the physical examination to recognize specific ultrasonic signs that represent a narrow list of potential diagnoses in specific clinical settings.

Synonyms

- Hand-held cardiac ultrasound
- Point-of-care cardiac ultrasound
- Ultrasound stethoscope
- Hand-carried cardiac ultrasound
- Bedside cardiac ultrasound
- Quick look cardiac ultrasound

Handheld Echocardiography – It Depends Whose Hands are Holding it: Educational? Diagnostic? Overshadowing the Physical Examination?

- Educational? **YES**
- Diagnostic? **YES**
- Overshadow the Physical Exam? **NO**

- ADJUNCT
- STRENGTHEN
- MODERNIZE
Physical Exam Is A Lost Art!

“Some doctors don’t even carry a stethoscope anymore.”
As the “teaching attending,” I discover very few people are paying real attention. Most are staring at their screens, ticking boxes and checking data. Occasionally, the presenter will slip up and say something outrageous — “The potassium was 29,” instead of 2.9 — and no one will react. To me it feels empty.
The 200th anniversary of the stethoscope: Can this low-tech device survive in the high-tech 21st century?

Ivan Bank¹,², Hubert W. Vliegen³, and Albert V.G. Bruschke⁴

Feb 2016

without new initiatives to improve proficiency in auscultation the stethoscope may soon be degraded from a valuable diagnostic instrument to a chain of honor worn around the neck by a next generation of doctors and allied health professionals.
The stethoscope can help us dx and teach but above all ties us to our pts. A hand-held echo device may one day displace the stethoscope.
In my view, practically and economically, echo systems are not—and will never be—poised to totally eradicate the stethoscope, as it is not possible for every clinician to possess a handheld echo. Thus, we cannot discontinue the important training that takes place during physical examination.
FoCUS: the point-of-care cardiac US exam, adds to the physical examination, by an operator not necessarily fully trained in echo but appropriately trained in FoCUS, usually responsible for immediate decision-making and/or treatment.

FoCUS examination provides sufficient information for mostly qualitative gross assessment of cardiac morphology and function, reported as ‘absent/present’, or ‘yes/no’.

Neskovic European Heart Journal – Cardiovascular Imaging (2014) 15, 956–960
# Point-of-Care Ultrasonography

Christopher L. Moore, M.D., and Joshua A. Copel, M.D.

## Table 1. Selected Applications of Point-of-Care Ultrasonography, According to Medical Specialty.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Ultrasound Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia</td>
<td>Guidance for vascular access, regional anesthesia, intraoperative monitoring of fluid status and cardiac function</td>
</tr>
<tr>
<td>Cardiology</td>
<td>Echocardiography, intracardiac assessment</td>
</tr>
<tr>
<td>Critical care medicine</td>
<td>Procedural guidance, pulmonary assessment, focused echocardiography</td>
</tr>
<tr>
<td>Obstetrics and maternal-fetal medicine</td>
<td>Assessment of the placenta, fetal heart, and amniotic fluid</td>
</tr>
<tr>
<td>Emergency medicine</td>
<td>FAST, focused emergency assessment, procedural guidance</td>
</tr>
<tr>
<td>Endocrinology and endocrine surgery</td>
<td>Assessment of thyroid and parathyroid, procedural guidance</td>
</tr>
<tr>
<td>General surgery</td>
<td>Ultrasonography of the breast, procedural guidance, intraoperative assessment</td>
</tr>
<tr>
<td>Gynecology</td>
<td>Assessment of cervix, uterus, and adnexa; procedural guidance</td>
</tr>
<tr>
<td>Obstetrics and maternal-fetal medicine</td>
<td>Assessment of pregnancy, detection of fetal abnormalities, procedural guidance</td>
</tr>
<tr>
<td>Neonatology</td>
<td>Cranial and pulmonary assessments</td>
</tr>
<tr>
<td>Nephrology</td>
<td>Vascular access for dialysis</td>
</tr>
<tr>
<td>Neurology</td>
<td>Transcranial Doppler, peripheral-nerve evaluation</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>Corneal and retinal assessment</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>Musculoskeletal applications</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>Assessment of thyroid, parathyroid, and neck masses; procedural guidance</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>Assessment of bladder, procedural guidance</td>
</tr>
<tr>
<td>Pulmonary medicine</td>
<td>Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance</td>
</tr>
<tr>
<td>Radiology and interventional radiology</td>
<td>Ultrasonography taken to the patient with interpretation at the bedside, procedural guidance</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>Monitoring of synovitis, procedural guidance</td>
</tr>
<tr>
<td>Trauma surgery</td>
<td>FAST, procedural guidance</td>
</tr>
<tr>
<td>Urology</td>
<td>Renal, bladder, and prostate assessment; procedural guidance</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>Carotid, arterial, and venous assessment; procedural assessment</td>
</tr>
</tbody>
</table>

FAST denotes focused assessment with sonography for trauma.
Point of Care – Focused Echo Exam

Definition
• Bedside
• Goal-directed
• Problem oriented
• Qualitative
• Rapid
• Store for review or
• Transmit for review

Examine
• LV size and function
• RV size and function
• Valve Motion
• Pericardial Effusion/Tamponade
• Cardiac Masses
• IVC: Volume status
Point of Care US – Quick Scan

Box 1. Clinical benefits of the quick-scan.

- Risk stratification
- Timely diagnosis
- Improving clinical diagnosis
- Cardiac arrest
- Extension of physical examination
- Differentiating between competing diagnoses
- Patient expectations
- Increasing access to echo
- Guidance of invasive procedures

<table>
<thead>
<tr>
<th>Indication</th>
<th>Specific areas to assess with a quick-scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute dyspnoea</td>
<td>Left ventricle</td>
</tr>
<tr>
<td>Acute chest pain</td>
<td>Right ventricle, Valve disease, Pericardium, Left ventricular function</td>
</tr>
<tr>
<td>Hypotension</td>
<td>Right ventricle, Inferior vena cava, Critical aortic stenosis, Severe mitral stenosis, Hypertrophic cardiomyopathy, Left ventricular size and/or systolic function</td>
</tr>
<tr>
<td>Syncope</td>
<td>Right ventricle, Inferior vena cava, Critical aortic stenosis, Severe mitral stenosis, Hypertrophic cardiomyopathy</td>
</tr>
<tr>
<td>Ventricular arrhythmia</td>
<td>Left ventricle size and systolic function: possible evidence of ischaemia and/or infarct, or of impaired function?</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>Right ventricle, Pericardium, Hypovolaemia, Pulmonary embolus, Distinguishing PEA (cardiac standstill) from pseudo-PEA (left ventricle contraction visible)</td>
</tr>
<tr>
<td>Procedural guidance</td>
<td>Guidance of pericardial aspiration and/or drainage</td>
</tr>
</tbody>
</table>
Point of Care Echo/US

- **Advantages**
  - Adds to Bedside Physical Exam
  - Fast
  - Provides immediate information
  - Low cost
  - Modernizes the “tenuous Tether”
  - Demonstration / Teaching / Murmur
  - Rapid Dx and Rx

- **Disadvantages**
  - Operator dependent
  - Errors in acquisition
  - Errors in interpretation
  - Equipment cost
  - Training
  - Supervision
Point –of Care Ultrasound

- Define problem
- Define terms
- **Equipment**
- Who does the imaging?
- Education
- Adoption & Application
HCU is not new: Ligtvoet constructed in 1978, Roelandt as part of physical in ’78-80
The use of pocket-size imaging devices: a position statement of the European Association of Echocardiography

Table 1  Classification of currently available echo machines according to their size and functions

<table>
<thead>
<tr>
<th>Echo machines</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary high-end systems</td>
<td>Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE), and advances modalities (3D, contrast)</td>
</tr>
<tr>
<td>Mobile (smaller machines on wheels, middle range technology)</td>
<td>Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE)</td>
</tr>
<tr>
<td>Portable (small machines that can be carried by a person)</td>
<td>Basic, standard echo modalities and measurements (MM, 2D, PW, CW, Colour)</td>
</tr>
<tr>
<td>Hand-held or pocket-size imaging devices</td>
<td>Limited functions (2D, Colour) and measurement package</td>
</tr>
</tbody>
</table>
# Pocket-sized focused cardiac ultrasound: Strengths and limitations

## Table 2
Summary of the technical characteristics of the four commercially available pocket-echo devices for FCU.

<table>
<thead>
<tr>
<th></th>
<th>Acuson P10™</th>
<th>Vscan V1.2</th>
<th>MobiUS™ SP1</th>
<th>Signostics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company</strong></td>
<td>Siemens</td>
<td>GE Healthcare</td>
<td>MobiSante</td>
<td>Signostics</td>
</tr>
<tr>
<td><strong>Size (cm)</strong></td>
<td>5.4 x 9.7 x 14.2</td>
<td>13.5 x 7.3 x 2.8</td>
<td>13 x 7 x 0.99</td>
<td>11.5 x 15 x 6</td>
</tr>
<tr>
<td><strong>Total weight (g)</strong></td>
<td>725</td>
<td>390</td>
<td>329</td>
<td>304</td>
</tr>
<tr>
<td><strong>Transducer (MHz)</strong></td>
<td>2–4</td>
<td>1.7–3.8</td>
<td>3.5–5.0</td>
<td>3.0–5.0</td>
</tr>
<tr>
<td><strong>Screen dimension (cm)</strong></td>
<td>9.4</td>
<td>8.9</td>
<td>8.0</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>Image resolution (pixels)</strong></td>
<td>640 x 480</td>
<td>240 x 320</td>
<td>480 x 480</td>
<td>250 (M-Mode)</td>
</tr>
<tr>
<td><strong>Grey scale</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Colour Doppler</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Measurements</strong></td>
<td>Distance, area</td>
<td>Distance</td>
<td>Distance, patient ID</td>
<td>Distance, area, circumference, volume</td>
</tr>
<tr>
<td><strong>Digital storage</strong></td>
<td>Still frames</td>
<td>Still frames, loop, voice recording</td>
<td>Loop</td>
<td>Still frames, patient ID</td>
</tr>
<tr>
<td><strong>Means to download to a PC</strong></td>
<td>Specific software</td>
<td>4 GB microSD card</td>
<td>USB sync</td>
<td>4 GB microSD card</td>
</tr>
<tr>
<td><strong>M-Mode</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Continuous/pulsed Doppler</strong></td>
<td>No/No</td>
<td>No/No</td>
<td>No/Yes</td>
<td>No/Yes</td>
</tr>
<tr>
<td><strong>Battery, scanning time (min)</strong></td>
<td>60</td>
<td>90</td>
<td>60–330</td>
<td>48</td>
</tr>
<tr>
<td><strong>Price (USD/€)</strong></td>
<td>8100/6508</td>
<td>8410/6760</td>
<td>—</td>
<td>7995/—</td>
</tr>
</tbody>
</table>

**FCU**: focused cardiac ultrasound; **ID**: Identification; **PC**: personal computer; **SD**: secure digital; **USB**: universal serial bus; **USD**: United States dollars.

*a* Includes the largest size of each component, as ultrasound probe, display unit or touch screen if available.

*b* The commercial prices of MobiUS™ SP1 and Signostics devices are not available in the European zone. The Signostics price is available in the US.
Relative Costs

$8,000
Point –of Care Ultrasound

• Define problem
• Define terms
• Equipment
• **Who does the imaging?**
• Education
• Adoption & Application
<table>
<thead>
<tr>
<th>Study</th>
<th>No.</th>
<th>Operators</th>
<th>Clinical setting</th>
<th>Type of training</th>
<th>Type of assessment</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galderisi et al.</td>
<td>304</td>
<td>Expert operators (102 studies), nurses (202 studies)</td>
<td>Outpatient cardiology clinic</td>
<td>15 hr of teaching and 3 months experience in handling and visual interpretation</td>
<td>LV dilation, hypertrophy, and function, RV dilation, valvular calcification, pericardial/pleural effusions</td>
<td>Additional diagnostic power 31.5% compared to physical examination. Concordance with stTTE was good</td>
</tr>
<tr>
<td>Panoulias et al.</td>
<td>122</td>
<td>5 final year medical students, 3 junior doctors</td>
<td>Emergency department, cardiology ward</td>
<td>2 hr bedside tutorial</td>
<td>LV function, RV function, valvular abnormalities</td>
<td>Improvement in diagnostic accuracy for LV dysfunction and valvular disease</td>
</tr>
<tr>
<td>Canlim et al.</td>
<td>189</td>
<td>6 cardiologists</td>
<td>Outpatient cardiology clinic</td>
<td>Pocket-size echo added to clinical examination</td>
<td>Pocket-size echo added to clinical examination</td>
<td>Increase in number of diagnostic, reduction in referrals for stTTE, facilitating discharges from cardiology clinic</td>
</tr>
<tr>
<td>Brennan et al.</td>
<td>40</td>
<td>4 internal medicine residents</td>
<td>Inpatients, &lt; 1 hr after right sided catheterisation</td>
<td>4 hr didactic teaching and 20 studies</td>
<td>Assessment of right atrial pressure</td>
<td>Diagnostic accuracy for RA pressure &gt; 10 mm Hg was higher compared to physical examination</td>
</tr>
<tr>
<td>Koiblo et al.</td>
<td>61</td>
<td>2 medical students</td>
<td>Inpatients,</td>
<td>18 hr of training in cardiac US</td>
<td>Assessment of valvular heart disease, LV function/ hypertrophy</td>
<td>Student's assessment with ICU resulted in higher diagnostic accuracy than that of cardiologists performing a physical examination</td>
</tr>
<tr>
<td>Spencer et al.</td>
<td>36</td>
<td>4 cardiologists</td>
<td>Outpatient</td>
<td>Experienced cardiologists who had performed 10–15 studies using the hand-held device</td>
<td>LV dysfunction, valvular heart disease, HCM, VSD</td>
<td>Improvement in diagnostic accuracy. Cardiac examination failed to identify 79% of findings, and this was reduced to 29% when portable echo was used</td>
</tr>
<tr>
<td>Martin et al.</td>
<td>354</td>
<td>10 hospitalists</td>
<td>Inpatients,</td>
<td>3 training studies</td>
<td>LV function, myocardial infarction, valvular disease, pericardial effusion</td>
<td>Improvement in diagnostic accuracy for LV function, cardiomegaly and pericardial effusion. No improvement in assessment of AR, AS, MR</td>
</tr>
</tbody>
</table>

**Pocket-Sized Echocardiography Devices: One Stop Shop Service?**
<table>
<thead>
<tr>
<th>Study Type</th>
<th>No.</th>
<th>Study Group</th>
<th>Methodology</th>
<th>Hypothesis</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrospective</td>
<td>360</td>
<td>Expert radiologist &amp; clinical assistant</td>
<td>Echocardiography</td>
<td>Comparison of diagnostic accuracy in diagnosing SLE</td>
<td>Level 4</td>
</tr>
</tbody>
</table>

**Table 2: Table comparing the diagnostic accuracy of pocket-sized echo doppler with ECHO showing operator, clinical setting, and operator experience.**

<table>
<thead>
<tr>
<th>Study</th>
<th>No.</th>
<th>Group</th>
<th>Methodology</th>
<th>Hypothesis</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert radiologist &amp; clinical assistant</td>
<td>360</td>
<td>Pocket-sized echo doppler</td>
<td>Echocardiography</td>
<td>Comparison of diagnostic accuracy in diagnosing SLE</td>
<td>Level 4</td>
</tr>
</tbody>
</table>
4 Med Students trained to perform brief, “focused” exam following a week of training.

Med students performed “limited” echo’s on consecutive subjects in the ER and the ICU who consented to an IRB protocol.

A total of the 235 “limited” independent echo’s

Dx changes: 29%
Rx changes: 27%
• HCU: Mt. Sinai Medical Residents Outpt Medical Clinic

❤️ 4 medical residents imaged 73 pts with HCU (Optigo™) as part of their routine clinic visit
❤️ Their study reviewed by expert immediately post
❤️ Mean echo time: 4.3 min (3-7)

Croft, Goldman. ACC 2003
A Pilot Study of the Clinical Impact of Hand-Carried Cardiac Ultrasound in the Medical Clinic

Lori B. Croft, M.D., W. Lane Duvall, M.D., and Martin E. Goldman, M.D.
The Zena and Michael A. Wiener Cardiovascular Institute and The Marie-Josée and Henry R. Kravis Center for Cardiovascular Health, Mount Sinai Medical Center, New York, NY

Figure 1. Diagnostic characteristics for LV function and valvular disease by history and physical examination compared to the addition of HCU limited echo.

Figure 2. Impact of the residents’ HCU limited echo on clinical management.
Pocket echo produced images that were accurate for LVEF and but not all cardiac structures compared with standard echo. MD’s with less experience disagreed more often about what the mobile images showed than did MD’s with more experience.
Nurse Practitioners: HCU Echo to Screen 50 Pts Having Nuclear Stress

Croft, Duvall, Goldman. 2004
Handheld echocardiographic screening for rheumatic heart disease by non-experts

- Non-expert, Ugandan nurses with handheld echo Vscan screened for RHD in Africa
- Sensitivity 74.4% and a spec of 78.8% for (borderline or definite) RHD
- Sens 90.9% for definite RHD.

Ploutz Heart 2016 102 35
Hand-held cardiac echo screening by family doctors with remote support interpretation

- Prospective, 1312 consecutive pts seen in primary care by Family MDs.
- Training: 7hr/day x 4 days
- Vscan (GE) via Studycast

Evangelista A; Heart 2016;102: 376-382
# Pocket-sized focused cardiac ultrasound: Strengths and limitations

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Accuracy¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left ventricular size</td>
<td>Good [11,15–19]</td>
</tr>
<tr>
<td>Left ventricular systolic function</td>
<td>Good [4,6,10–18]</td>
</tr>
<tr>
<td>Regional wall motion abnormalities</td>
<td>Good [10,19]</td>
</tr>
<tr>
<td>Ultrasound lung comet</td>
<td>Good [21,22]</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>Good [23]</td>
</tr>
<tr>
<td>Inferior vena cava</td>
<td>Variable [4,11,13,15,27]</td>
</tr>
<tr>
<td>Left atrial size</td>
<td>Fair [28]</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>Excellent [4,5,10,11,15–19]</td>
</tr>
<tr>
<td>Aortic valve disease presence/severity</td>
<td>Fair [10,13,16,30]</td>
</tr>
<tr>
<td>Mitral valve disease presence/severity</td>
<td>Fair [10,13,16,30]</td>
</tr>
<tr>
<td>Abdominal aortic aneurysm</td>
<td>Good [10,32,33]</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>Variable [4–6,10,16]</td>
</tr>
</tbody>
</table>

¹ Accuracy is defined as a compromise between sensitivity and specificity. Excellent: sensitivity ≥ 90%, specificity ≥ 95%, including by non-experts. Good: sensitivity > 90%, specificity > 90% by experts. Fair: sensitivity ≈ 80%, specificity ≈ 80%. Variable: figures vary across studies.
Screening athletes for sudden death

Procedure is costly, but it can identify cardiomyopathy, a rare heart disorder

By Robert Davis
USA TODAY

Chad Butrum dropped dead during a league football game without ever taking a hit.

The 26-year-old was the picture of health when he died in 1984 on the California field. His body was fit, but his heart was not.

Like many victims of cardiomyopathy — a silent disease that can strike fatally during exercise — Butrum died without any warning. After a huddle, he walked to the line of scrimmage, where he fell.

“Nobody hit him or anything,” says Butrum’s mother, a New York actress who goes by the name Arista.

Chad became one of an estimated 200 young victims of cardiomyopathy who die suddenly on athletic fields each year. Like the others, his heart — which had become enlarged by the disease — could not handle the stress of physical activity.

The silent disease is one known cause of sudden cardiac death in young athletes.

Since his death, Chad’s mother has been on a crusade to screen others for the disease.

“We want to raise enough awareness to let every parent know that their kids need this,” she says.

But for the initial test that detects the rare disorder is so costly — an echocardiogram, which is typically done in a hospital’s cardiac center, costs more than $1,000 — the medical community has been slow to support the idea of screening every young athlete for the condition.
Limits on Residents’ Hours Worry Teaching Hospitals

By REED ABERLE

Many of the nation’s teaching hospitals, already under financial pressures, are raising concerns about the effect of new rules that will limit the number of hours worked by medical residents.

“Four academic medical centers, the impact is going to be profound,” said Dr. Peter Herbert, the chief of staff for Yale-New Haven Hospital, a teaching affiliate of the Yale School of Medicine, who estimates that the cost for some hospitals could run into the millions of dollars.

The rules, which are being imposed by the group that accredits teaching hospitals, will limit the average workweek to 80 hours and restrict a resident’s duty to no more than 24 hours at a time.

Some hospitals consider residents an inexpensive source of labor. Some residents say they work 100 hours or with a loss of accreditation because of the long hours residents worked, is hiring 12 physician associates to reduce their residents’ workloads.

“With a huge financial hit,” said Dr. Jon Cohen, the chief medical officer for the North Shore-Long Island Jewish Health System, which, like other New York hospitals, has had to adapt to a law that already limits residents’ hours.

The cost of two to three physician assistants can run as high as $200,000 a year, compared with $50,000 to pay a medical resident, Dr. Cohen said. “No one knows what that money is going to come from,” he said.

Many hospitals acknowledge that the new rules will require significant changes in how they do things and how they view residents.

“The big cultural change is the institutions have to recognize and some residents, no students

Echo by Resident in ER
Point –of Care Ultrasound

• Define problem
• Define terms
• Equipment
• Who does the imaging?
• Education
• Adoption & Application
High Quality Echo IS NOT Automatic

Variables: 1. Body habitus
2. Image Acquisition skills
3. Equipment
4. Physician interpretation
5. Appropriate Application

ALL 5 REQUIRED FOR A GOOD ECHO STUDY!
When I went to medical school, the term 'digital' applied only to rectal exams.

– Eric Topol
The use of pocket-size imaging devices: a position statement of the European Association of Echocardiography

- pocket-size imaging devices do not provide a complete diagnostic echocardiographic examination.
- should be reported as part of the physical examination of the patient.
- Image data should be stored according to the applicable national rules for technical examinations.
- does not replace a complete echocardiogram.

Sicari European Journal of Echocardiography (2011) 12, 85–87
As part of the hands-on aspect of the echo training program, *experience with HCU devices is desirable.*

*These devices extend the clinical utility of echo by allowing the operator to offer a “visual physical examination” in a manner that can be applied practically in the clinical setting.*

HCU devices offer capabilities similar to but less robust than their standard echo counterparts.
The use of pocket-size imaging devices: a position statement of the European Association of Echocardiography

**Table 2** Summary of indications for pocket-size devices

1. Complement to a physical examination in the coronary and intensive care unit
2. Tool for a fast initial screening in an emergency setting
3. Cardiologic counselling in- or outside health-care facilities and hospitals
4. First cardiac evaluation in ambulances
5. Screening programmes in schools, industry, and community activities
6. Triaging candidates for a complete echocardiographic examination
7. Teaching tool
8. Semi-quantification of extravascular lung water
The use of pocket-size imaging devices: a position statement of the European Association of Echocardiography

EAE recommendations on the use of pocket-size echo devices

Recommendation 1. Pocket-size imaging devices (category 4 of the present classification) do not provide a complete diagnostic echocardiographic examination. The range of indications for their use is therefore limited as specified in Table 2.

Recommendation 2. Imaging assessment with pocket-size imaging devices should be reported as part of the physical examination of the patient. Image data should be stored according to the applicable national rules for technical examinations.

Recommendation 3. With the exception of cardiologists who are certified for transthoracic echocardiography according to national legislation, specific training and certification is recommended for all users. The certification should be limited to the clinical questions that can potentially be answered by pocket-size devices.

Recommendation 4. The patient has to be informed that an examination with the current generation of pocket-size imaging devices does not replace a complete echocardiogram.
the triple aim of health care—
1. to improve the delivery and experience of care
2. to improve the health of populations
3. to reduce the per capita costs
we cannot resist the changes, or means, that are needed to achieve that end.
Value of Echo in Era Healthcare Reform

Echocardiography = Benefits / Cost

Benefits:
- Versatile (diverse diseases identified)
- Demonstrated diagnostic and prognostic utility
- Widely available

Echocardiography:
- Mature technology
- Immediate results without image processing
- Small, portable imaging systems (lower overhead)
- Relatively inexpensive technology
- Safer for patients compared to other imaging

Pellikka, P. Progress CV Dis 57; 1-3, 2014
Cardiac Exam: stethoscope or pocket echo: why not both?

- Introduced 1978; cost < $10k; no reimbursement
- Studies have shown neither modality perfect
- Can reduce unnecessary standard costly echo’s
- If I were a young physician beginning a career as a cardiologist, I would obtain a pocket echo and become an expert in its use!

James Dalen MD, MPH. AJM. 2016; 129: 650
"Some doctors don’t even carry a stethoscope anymore"...BUT THEY ARE ENTHUSIASTIC to CARRY A STETHOSCOPE and USE ULTRASOUND
A generation of physicians will need to be trained to view this technology as an extension of their senses, just as many generations have viewed the stethoscope. That development will require the medical education community to embrace and incorporate the technology throughout the curriculum.
“That it will ever come into general use, notwithstanding its value, is extremely doubtful; because its beneficial application requires much time and gives a good bit of trouble both to the patient and the practitioner; because its hue and character are foreign and opposed to all our habits and associations.”

London Times, 1834
• Handheld Echocardiography – It Depends Whose Hands are Holding it: Educational? Diagnostic? Overshadowing the Physical Examination?

• Educational? YES
• Diagnostic? YES
• Overshadow the Physical Exam? NO

• ADJUNCT
• STRENGTHEN
• MODERNIZE
Handheld echocardiographic screening for rheumatic heart disease by non-experts

- Non-experts Ugandan nurses with handheld echo Vscan: sens 74.4% and a spec of 78.8% for (borderline or definite) RHD; Sens 90.9% for definite RHD. Ploutz Heart 2016 102 35
Point of Care US – Quick Scan

- H-US in trained hands adds value to the physical exam
- Ideal for acute care
- Rapid at the point of care improves diagnosis, decision-making.
- Another potential revolution in clinical exam

Hothi SS Clin Med 2014 14 608-11
Cardiology Imaging

Nuclear: $250-500k
CT: $1.4 million
MRI: $2 million
PET: $2.8 million
Cardiac Related Applications

- Cardiac
  - LV Size & Function
  - RV Size & Function
  - Peric Effusion
  - Volume Status
  - Source of Murmur
  - Wall Thickness – Hi BP
  - Hypotension Etiology
  - Correlate Abn ECG (ER)

- Volume Status
  - IVC fill
  - Pulm: effusion, PTX
  - Abd Aortic Aneurysm
  - Bladder volume?
Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.
—Albert Einstein (1)
Ultrasound-Guided Internal Jugular Vein Cannulation
Rafael Ortega, M.D., Michael Song, M.D., Christopher J. Hansen, M.A., and Paul Barash, M.D.

Emergency Pericardiocentesis
Michael T. Fitch, M.D., Ph.D., Bret A. Nicks, M.D., Manoj Pariyadath, M.D., Henderson D. McGinnis, M.D., and David E. Manthey, M.D.
# Pocket-sized focused cardiac ultrasound: Strengths and limitations

Table 1  Accuracy of parameters assessed by pocket-echo.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Accuracy&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left ventricular size</td>
<td>Good [11,15–19]</td>
</tr>
<tr>
<td>Left ventricular systolic function</td>
<td>Good [4,6,10–18]</td>
</tr>
<tr>
<td>Regional wall motion abnormalities</td>
<td>Good [10,19]</td>
</tr>
<tr>
<td>Ultrasound lung comet</td>
<td>Good [21,22]</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>Good [23]</td>
</tr>
<tr>
<td>Inferior vena cava</td>
<td>Variable [4,11,13,15,27]</td>
</tr>
<tr>
<td>Left atrial size</td>
<td>Fair [28]</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>Excellent [4,5,10,11,15–19]</td>
</tr>
<tr>
<td>Aortic valve disease presence/severity</td>
<td>Fair [10,13,16,30]</td>
</tr>
<tr>
<td>Mitral valve disease presence/severity</td>
<td>Fair [10,13,16,30]</td>
</tr>
<tr>
<td>Abdominal aortic aneurysm</td>
<td>Good [10,32,33]</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>Variable [4–6,10,16]</td>
</tr>
</tbody>
</table>

<sup>a</sup> Accuracy is defined as a compromise between sensitivity and specificity. Excellent: sensitivity ≥ 90%, specificity ≥ 95%, including by non-experts. Good: sensitivity > 90%, specificity > 90% by experts. Fair: sensitivity ≈ 80%, specificity ≈ 80%. Variable: figures vary across studies.

Mirabel M . Arch CVD 2015:108; 197-205
Development and Evaluation of Methodologies for Teaching Focused Cardiac Ultrasound Skills to Medical Students

- 12 1st yr med students:
Is Pocket Mobile Echocardiography the Next-Generation Stethoscope? A Cross-sectional Comparison of Rapidly Acquired Images With Standard Transthoracic Echocardiography

Max J. Liebo, MD; Rachel L. Israel, MD; Elizabeth O. Lillie, PhD; Michael R. Smith, MD; David S. Rubenson, MD; Eric J. Topol,

Table 2. Visualizability, Accuracy, and Variability of Readings of Images Obtained by Using Pocket Mobile Echocardiography

<table>
<thead>
<tr>
<th>TTE Variable</th>
<th>Abnormal, %</th>
<th>Visualized, %</th>
<th>True-Positive Plus True-Negative Readings (Visualized/Total), %/% *</th>
<th>Variability (λ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Overall</td>
<td>Attendings</td>
<td>Fellows</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>14 (low)</td>
<td>95</td>
<td>93</td>
<td>97</td>
</tr>
<tr>
<td>WMA†</td>
<td>13</td>
<td>83</td>
<td>85</td>
<td>81</td>
</tr>
<tr>
<td>LVEDD</td>
<td>15 (enlarged)</td>
<td>95</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>0 (significant)</td>
<td>94</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Aortic valve</td>
<td>6</td>
<td>82</td>
<td>86</td>
<td>80</td>
</tr>
<tr>
<td>Mitral valve</td>
<td>7</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>IVC size‡</td>
<td>12 (dilated)</td>
<td>75</td>
<td>73</td>
<td>77</td>
</tr>
</tbody>
</table>
# Expert Consensus Statement

**Focused Cardiac Ultrasound: Recommendations from the American Society of Echocardiography**

## Table 3: Differences between limited echocardiography and FCU

<table>
<thead>
<tr>
<th></th>
<th>Limited echocardiogram</th>
<th>FCU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients</strong></td>
<td>Any adult patient</td>
<td>Defined scope of practice</td>
</tr>
<tr>
<td><strong>Location of imaging</strong></td>
<td>Any location</td>
<td>Defined scope of practice</td>
</tr>
<tr>
<td><strong>Image protocol</strong></td>
<td>Skill to perform any view, but only selected views may be required</td>
<td>Limited number of views</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>Full function (M-mode, 2D, color Doppler, spectral Doppler, TDI, contrast), EKG gated</td>
<td>2D minimum</td>
</tr>
<tr>
<td><strong>Transducers</strong></td>
<td>Multiple</td>
<td>Single</td>
</tr>
<tr>
<td><strong>Measurements</strong></td>
<td>Advanced quantification</td>
<td>None or linear measurement</td>
</tr>
<tr>
<td><strong>Acquisition</strong></td>
<td>Sonographer or level IV/IVI echocardiographer</td>
<td>Physician with FCU training</td>
</tr>
<tr>
<td><strong>Interpretation</strong></td>
<td>Echocardiographer; all pathology and normal structures within imaging view</td>
<td>Physician with FCU training defined, limited scope</td>
</tr>
<tr>
<td><strong>Image storage</strong></td>
<td>DICOM format, archived for easy retrieval and review</td>
<td>Only for select indications (see text)</td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
<td>Formal report meeting ICAEL standards</td>
<td>Documentation as brief report or as part of PE depending on indication</td>
</tr>
<tr>
<td><strong>Billing</strong></td>
<td>93308</td>
<td>None</td>
</tr>
</tbody>
</table>

*TDI, Tissue Doppler imaging; ICAEL, Intersocietal Commission for the Accreditation of Echocardiography Laboratories; PE, physical examination.*

---

FCU is a focused examination of the cardiovascular system performed by a physician by using ultrasound as an adjunct to the physical examination to recognize specific ultrasonic signs that represent a narrow list of potential diagnoses in specific clinical settings.

- Hand-held cardiac ultrasound
- Point-of-care cardiac ultrasound
- Ultrasound stethoscope
- Hand-carried cardiac ultrasound
- Bedside cardiac ultrasound
- Quick look cardiac ultrasound

# A Summary of the American Society of Echocardiography Foundation Value-Based Healthcare: Summit 2014

## Comparison of imaging modalities

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Echocardiography</th>
<th>CMR</th>
<th>CT</th>
<th>Nuclear scintigraphy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>++++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Portability</td>
<td>++++</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Cost (relative value units)</td>
<td>9.11†</td>
<td>22.51‡</td>
<td>14.39§</td>
<td>13.59</td>
</tr>
<tr>
<td>Radiation risk</td>
<td>—</td>
<td>—</td>
<td>++++</td>
<td>++++</td>
</tr>
</tbody>
</table>

*CMR, Cardiovascular magnetic resonance; CPT, Current Procedural Terminology; CT, computed tomography.*
In summary, pocket ultrasound devices provide high quality diagnostic images of the heart in real time. These devices are relatively easy to use and far more accurate than the stethoscope. Their use can potentially decrease additional expensive tests. These devices bring us into the present and propel us into the future. It is time to discard the inaccurate albeit iconic stethoscope and join the rest of mankind in the technology revolution!

Kaul S. Echo Research & Practice. Dec 2014
Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.

—Albert Einstein (1)
The use of pocket-size imaging devices: a position statement of the European Association of Echocardiography

<table>
<thead>
<tr>
<th>Echo machines</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary high-end systems</td>
<td>Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE), and advances modalities (3D, contrast)</td>
</tr>
<tr>
<td>Mobile (smaller machines on wheels, middle range technology)</td>
<td>Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE)</td>
</tr>
<tr>
<td>Portable (small machines that can be carried by a person)</td>
<td>Basic, standard echo modalities and measurements (MM, 2D, PW, CW, Colour)</td>
</tr>
<tr>
<td>Hand-held or pocket-size imaging devices</td>
<td>Limited functions (2D, Colour) and measurement package</td>
</tr>
</tbody>
</table>
Evolution of Echo Technology
Cardiology Imaging

Nuclear
CT
MRI
PET

$250-500k
$1.4 million
$2 million
$2.8 million
Echocardiography

Sustained Innovation...

Pearlman JASE 8/10
AIUM : Compact US Conference 2004

Point of care vs. referral based
1. Adjunct to Physical Exam
2. Guidance for Procedures:
   - vessel finder
   - pericardiocentesis
3. Diagnostic: Focused Exams
   - ER
   - Screening
4. Diagnostic: comprehensive Exam
   - Greenbaum LD, Benson CB J Ultrasound Med 2004; 23:1249-1254
A Pilot Study of the Clinical Impact of Hand-Carried Cardiac Ultrasound in the Medical Clinic

Lori B. Croft, M.D., W. Lane Duvall, M.D., and Martin E. Goldman, M.D.

The Zona and Michael A. Wiener Cardiovascular Institute and The Marie-Josée and Henry R. Kravis Center for Cardiovascular Health, Mount Sinai Medical Center, New York, NY

Figure 1. Diagnostic characteristics for LV function and valvular disease by history and physical examination compared to the addition of HCU limited echo.

Figure 2. Impact of the residents' HCU limited echo on clinical management.
Miniaturization of Ultrasound equipment is inevitable, as with smaller phones and computers.

All US units vary in capability, resolution and functionality.

Greenbaum LD, Benson CB J Ultrasound Med 2004; 23:1249-1254
A generation of physicians will need to be trained to view this technology as an extension of their senses, just as many generations have viewed the stethoscope. That development will require the medical education community to embrace and incorporate the technology throughout the curriculum.
Point-of-Care Ultrasound in Medical Education — Stop Listening and Look

- The risk of misdiagnosis is high when diagnostic US is used by inexperienced practitioners.
- The amount of training required to perform a competent US examination is not trivial...Although medical students trained in US may be able to make relatively crude diagnoses—determining whether ventricular function is normal or reduced, assessing vena cava size, or detecting gallstones—more sophisticated anatomical assessment will require substantially more training.
- In addition, false positive findings may lead to additional and often unnecessary testing, and false negatives may provide unwarranted reassurance and result in underdx leading to unnecessary costs to the health care system.
- these “devices can distract students from the core principles of physical diagnosis, especially if introduced early in training, and will interpose another layer of technology between doctor and patient”

Scott D. Solomon, M.D.
POC US can decrease medical errors, provide more efficient real time diagnosis, may be cost effective, replace more expensive imaging.

However, ultrasonography is a user-dependent technology, and as usage spreads, there is a need to ensure competence, define the benefits of appropriate use, and limit unnecessary imaging and its consequences.

NEJM 2011 364;8; 749-756
# Current Concepts

## Point-of-Care Ultrasonography

Christopher L. Moore, M.D., and Joshua A. Copel, M.D.

## Table 1. Selected Applications of Point-of-Care Ultrasonography, According to Medical Specialty.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Ultrasound Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia</td>
<td>Guidance for vascular access, regional anesthesia, intraoperative monitoring of fluid status and cardiac function</td>
</tr>
<tr>
<td>Cardiology</td>
<td>Echocardiography, intracardiac assessment</td>
</tr>
<tr>
<td>Critical care medicine</td>
<td>Procedural guidance, pulmonary assessment; focused echocardiography</td>
</tr>
<tr>
<td>Dermatology</td>
<td>Assessment of skin lesions and tumors</td>
</tr>
<tr>
<td>Emergency medicine</td>
<td>FAST, focused emergency assessment, procedural guidance</td>
</tr>
<tr>
<td>Endocrinology and endocrine surgery</td>
<td>Assessment of thyroid and parathyroid, procedural guidance</td>
</tr>
<tr>
<td>General surgery</td>
<td>Ultrasonography of the breast, procedural guidance, intraoperative assessment</td>
</tr>
<tr>
<td>Gynecology</td>
<td>Assessment of cervix, uterus, and adnexa; procedural guidance</td>
</tr>
<tr>
<td>Obstetrics and maternal-fetal medicine</td>
<td>Assessment of pregnancy, detection of fetal abnormalities, procedural guidance</td>
</tr>
<tr>
<td>Neonatology</td>
<td>Cranial and pulmonary assessments</td>
</tr>
<tr>
<td>Nephrology</td>
<td>Vascular access for dialysis</td>
</tr>
<tr>
<td>Neurology</td>
<td>Transcranial Doppler, peripheral-nerve evaluation</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>Corneal and retinal assessment</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>Musculoskeletal applications</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>Assessment of thyroid, parathyroid, and neck masses; procedural guidance</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>Assessment of bladder, procedural guidance</td>
</tr>
<tr>
<td>Pulmonary medicine</td>
<td>Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance</td>
</tr>
<tr>
<td>Radiology and interventional radiology</td>
<td>Ultrasonography taken to the patient with interpretation at the bedside, procedural guidance</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>Monitoring of synovitis, procedural guidance</td>
</tr>
<tr>
<td>Trauma surgery</td>
<td>FAST, procedural guidance</td>
</tr>
<tr>
<td>Urology</td>
<td>Renal, bladder, and prostate assessment; procedural guidance</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>Carotid, arterial, and venous assessment; procedural assessment</td>
</tr>
</tbody>
</table>

FAST denotes focused assessment with sonography for trauma.
In my view, practically and economically, echo systems are not—and will never be—poised to totally eradicate the stethoscope, as it is not possible for every clinician to possess a handheld echo. Thus, we cannot discontinue the important training that takes place during physical examination.
Definitions

- **Point of Care US**: performed in real time at pt bedside to correlate with signs and symptoms for immediate Dx and Rx
- **Procedural /Diagnostic / Screening**
- **Agency Healthcare Research & Quality**: use of real time US guidance during central line insertion to prevent complications is 1/12 most highly rated pt safety practices
Point of Care Echo/US

- **Advantages**
  - Adds to Physical Exam
  - Fast, low cost
  - Modernizes the “tenuous Tether”
  - Demonstrate
  - Immediate
  - Eliminates delay for formal exam

- **Disadvantages**
  - Operator dependent
  - Initial cost