HANDHELD ECHOCARDIOGRAPHY
POCKET ECHO
PORTABLE ECHO
SCREENING ECHO
COMPACT ECHO
POINT OF CARE ULTRASOUND

Anthony DeMaria
University of California, San Diego
Grantee or Consultant to DIA Inc, Bay Labs (CAPTION)
Uncompensated advisor to General Electrics

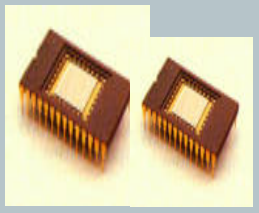
1

Miniaturization of Echo

1953

1983

1999



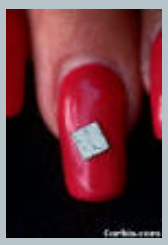


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Figure 2. Currently available pocket-sized devices. Top left, Vscan, 1.7–3.8-MHz phased array transducer (GE Healthcare, Wauwatosa, WI; approved 2009). Top right, Acuson P10, 2–4-MHz phased array transducer (Siemens Medical Solutions USA, Inc, Malvern, PA; approved 2007). Bottom left, Sonimage P3, 3–5-MHz mechanical interchangeable transducer (Signostics Ltd, Thebarton, South Australia, Australia; approved 2013). Bottom right, MobiUS SP1, 75–12-MHz mechanical interchangeable transducer, smartphone connected (Mobisante, Inc, Redmond, WA; approved 2011).

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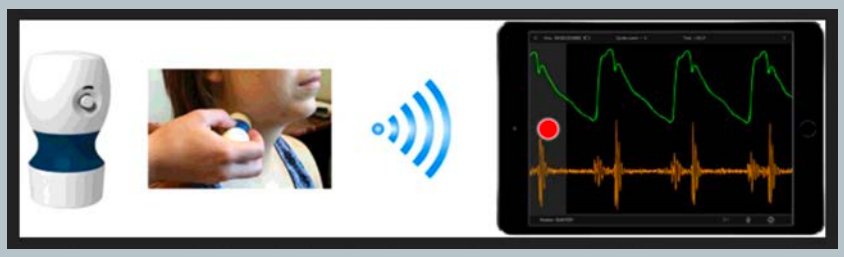
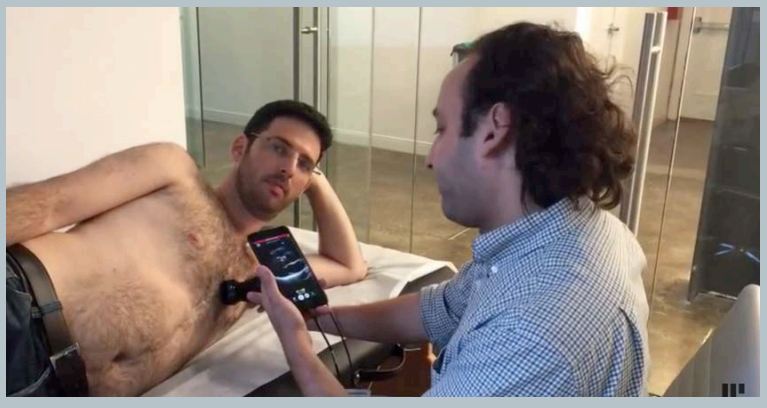


Accuracy of a Novel Handheld Wireless Platform for Detection of Cardiac Dysfunction in Anthracycline-Exposed Survivors of Childhood Cancer

Saro H. Armenian, Derek Rinderknecht, Kaylene Au, Lanie Lindenfeld, George Mills, Aida Siyahian, Claudia Herrera, Karla Wilson, Kalyanasundaram Venkataraman, Kristen Mascarenhas, Peyman Tavallali, Marianne Razavi, Niema Pahlevan, Jon Detterich, Smita Bhatia, and Morteza Gharib

5

Automated Intelligence. ECHO *GPS*



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LVIVO™ EF ON GE HEALTHCARE'S VSCAN EXTEND ULTRASOUND

,

DIA IMAGING ANALYSIS

7

7

Accuracy of left ventricular ejection fraction determined by automated analysis of handheld echocardiograms: A comparison of experienced and novice examiners

Omar M. Aldaas MD, Sachiyo Igata PhD, Ajit Raisinghani MD, Megan Kraushaar BA, Anthony N. DeMaria

Abstract

Background

Handheld ultrasound devices have been developed that facilitate imaging in new clinical settings. However, quantitative assessment has been difficult. Software algorithms have recently been developed with the aim of providing rapid measurements of left ventricular ejection fraction (LVEF) with minimal operator input.

Results

There was a positive correlation between the LVEFs obtained from the standard transthoracic echocardiogram and handheld device in the hands of a novice (r = 0.62; 95% CI 0.45-0.75) and experienced sonographer (r = 0.69; 95% CI 0.54-0.80). The sensitivity and specificity to detect a reduced LVEF (<50%) were 69% and 96% for the novice and 64% and 98% for the experienced sonographer. The sensitivity and specificity to detect a severely reduced LVEF (<35%) were 67% and 97% for the novice and 56% and 93% for the experienced sonographer, but when limited to recordings of at least adequate quality, improved to 100% and 100% for the novice and 100% and 98% for the experienced sonographer, respectively.

Conclusion

These data demonstrate that the handheld ultrasound device paired with novel software can provide a clinically useful estimate of LVEF when the images are of adequate quality and yield results by novice examiners that are similar to experienced sonographers.

These data demonstrate that the handheld ultrasound device paired with novel software can provide a clinically useful estimate of LVEF when the images are of adequate quality and yield results by novice examiners that are similar to experienced sonographers.

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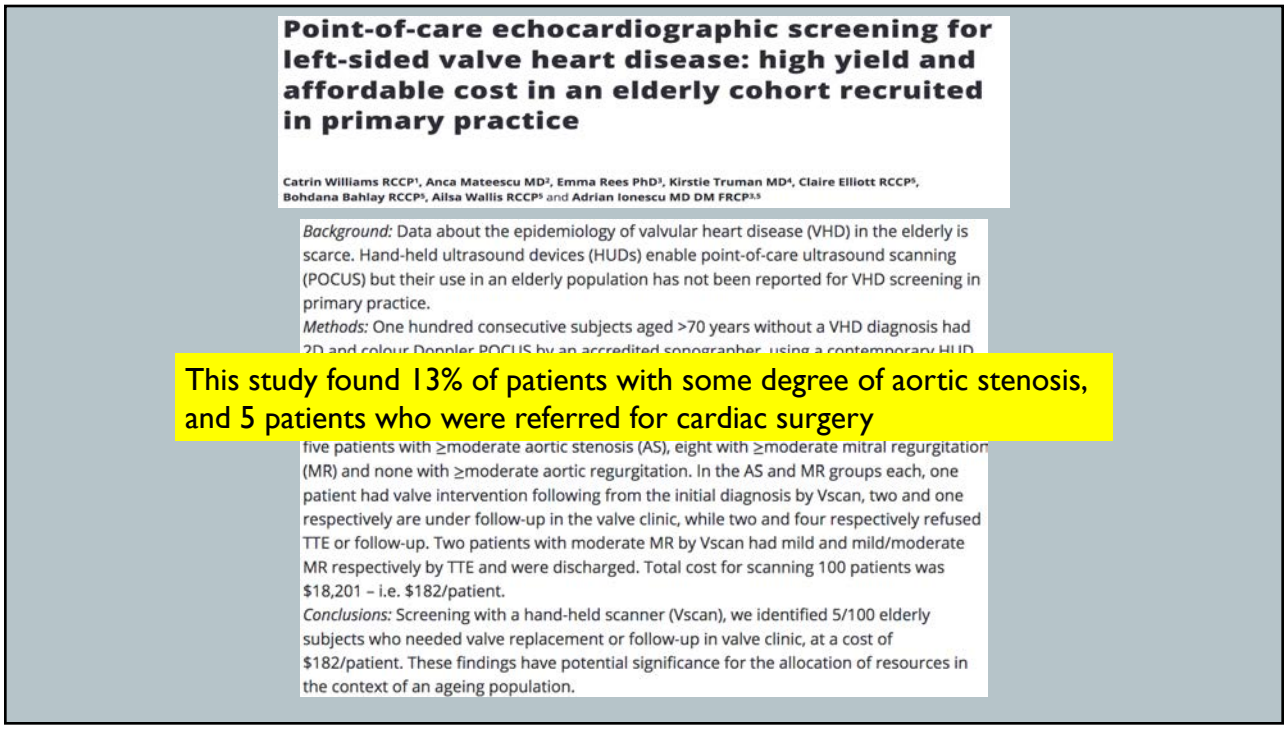
Point-of-care echocardiographic screening for left-sided valve heart disease: high yield and affordable cost in an elderly cohort recruited in primary practice
Catrin Williams RCCP[1], Anca Mateescu MD[2], Emma Rees PhD[3], Kirstie Truman MD[4], Claire Elliott RCCP[5], Bohdana Bahlay RCCP[5], Ailsa Wallis RCCP[5] and Adrian Ionescu MD DM FRCP[3,5]
Background: Data about the epidemiology of valvular heart disease (VHD) in the elderly is scarce. Hand-held ultrasound devices (HUDs) enable point-of-care ultrasound scanning (POCUS) but their use in an elderly population has not been reported for VHD screening in primary practice.
Methods: One hundred consecutive subjects aged >70 years without a VHD diagnosis had
This study found 13% of patients with some degree of aortic stenosis, and 5 patients who were referred for cardiac surgery
five patients with ≥moderate aortic stenosis (AS), eight with ≥moderate mitral regurgitation (MR) and none with ≥moderate aortic regurgitation. In the AS and MR groups each, one patient had valve intervention following from the initial diagnosis by Vscan, two and one respectively are under follow-up in the valve clinic, while two and four respectively refused TTE or follow-up. Two patients with moderate MR by Vscan had mild and mild/moderate MR respectively by TTE and were discharged. Total cost for scanning 100 patients was $18,201 – i.e. $182/patient.
Conclusions: Screening with a hand-held scanner (Vscan), we identified 5/100 elderly subjects who needed valve replacement or follow-up in valve clinic, at a cost of $182/patient. These findings have potential significance for the allocation of resources in the context of an ageing population.

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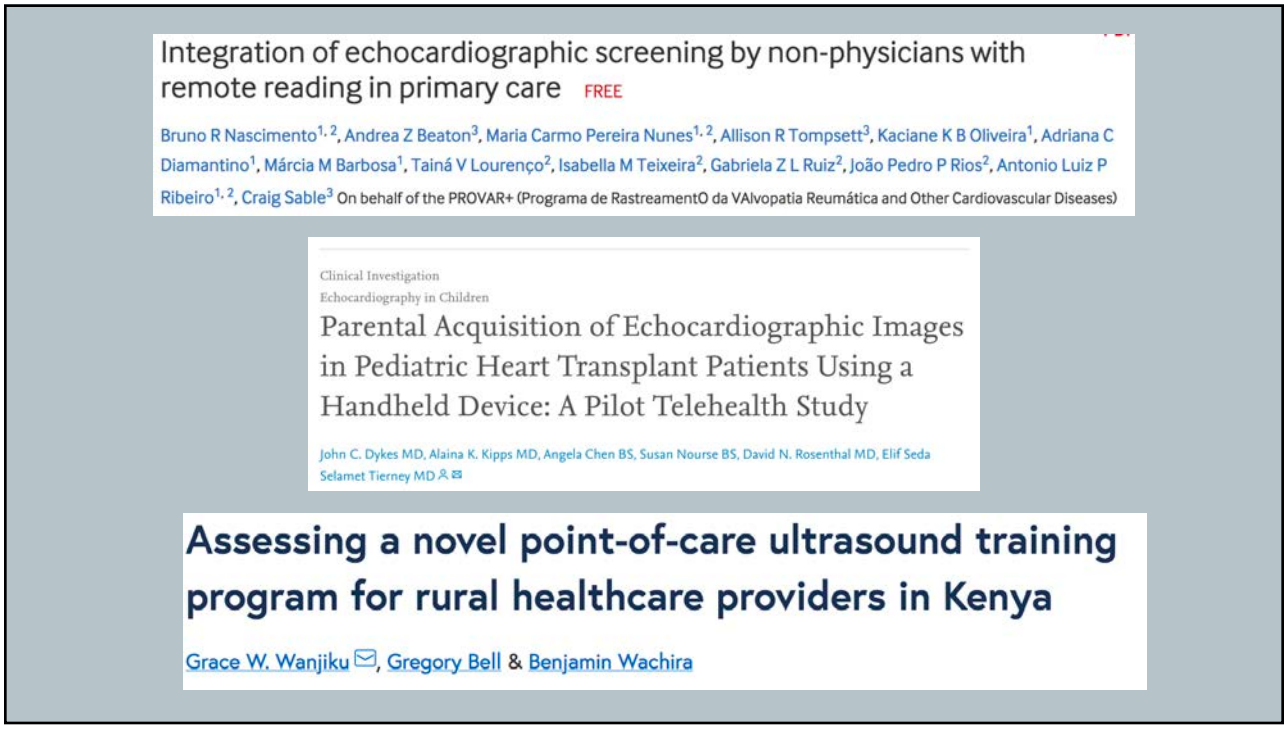
Integration of echocardiographic screening by non-physicians with remote reading in primary care FREE
Bruno R Nascimento[1,2], Andrea Z Beaton[3], Maria Carmo Pereira Nunes[1,2], Allison R Tompsett[3], Kaciane K B Oliveira[1], Adriana C Diamantino[1], Márcia M Barbosa[1], Tainá V Lourenço[2], Isabella M Teixeira[2], Gabriela Z L Ruiz[2], João Pedro P Rios[2], Antonio Luiz P Ribeiro[1,2], Craig Sable[3] On behalf of the PROVAR+ (Programa de RastreamentO da VAlvopatia Reumática and Other Cardiovascular Diseases)
Clinical Investigation
Echocardiography in Children
Parental Acquisition of Echocardiographic Images in Pediatric Heart Transplant Patients Using a Handheld Device: A Pilot Telehealth Study
John C. Dykes MD, Alaina K. Kipps MD, Angela Chen BS, Susan Nourse BS, David N. Rosenthal MD, Elif Seda Selamet Tierney MD
Assessing a novel point-of-care ultrasound training program for rural healthcare providers in Kenya
Grace W. Wanjiku, Gregory Bell & Benjamin Wachira

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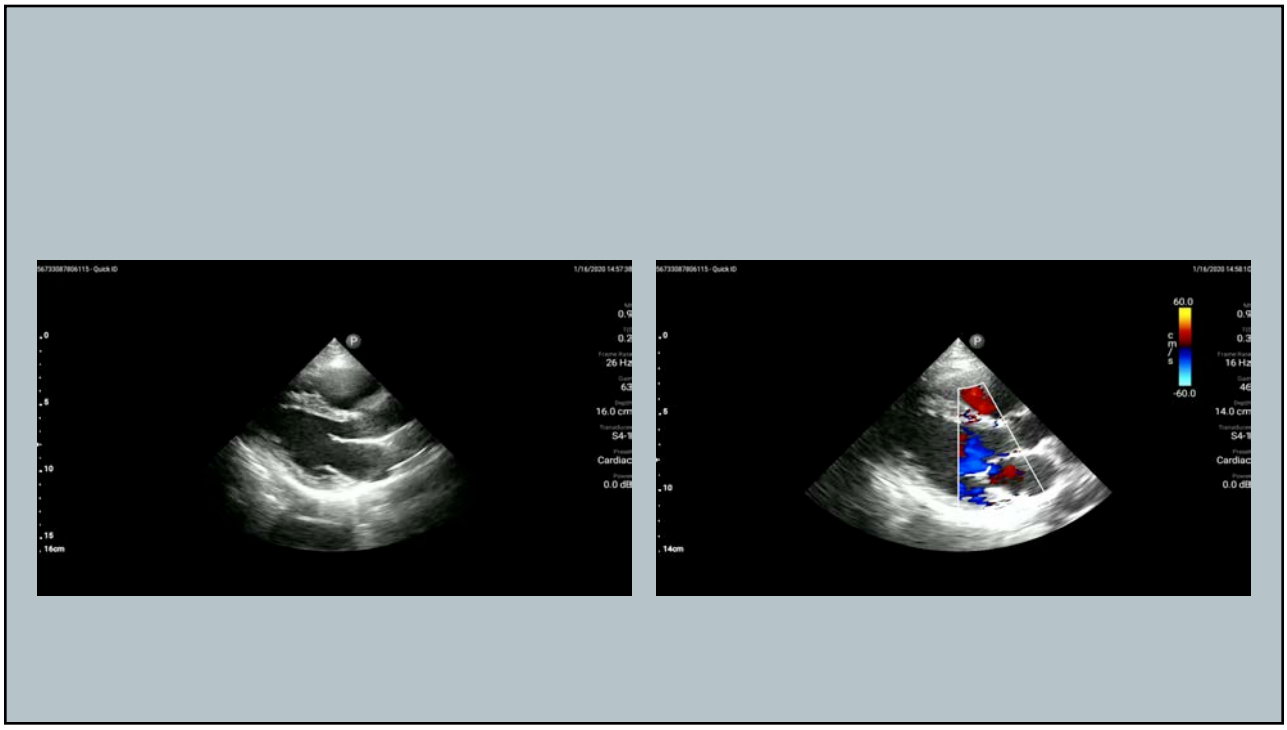

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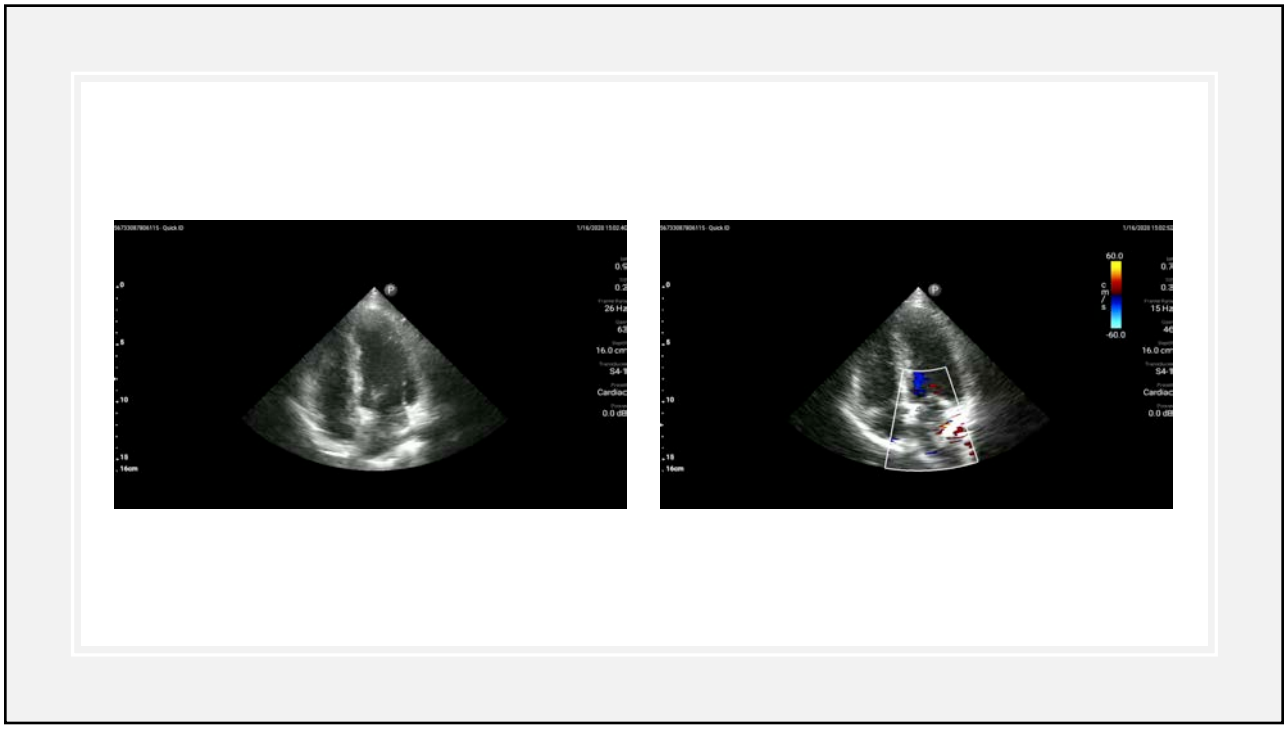

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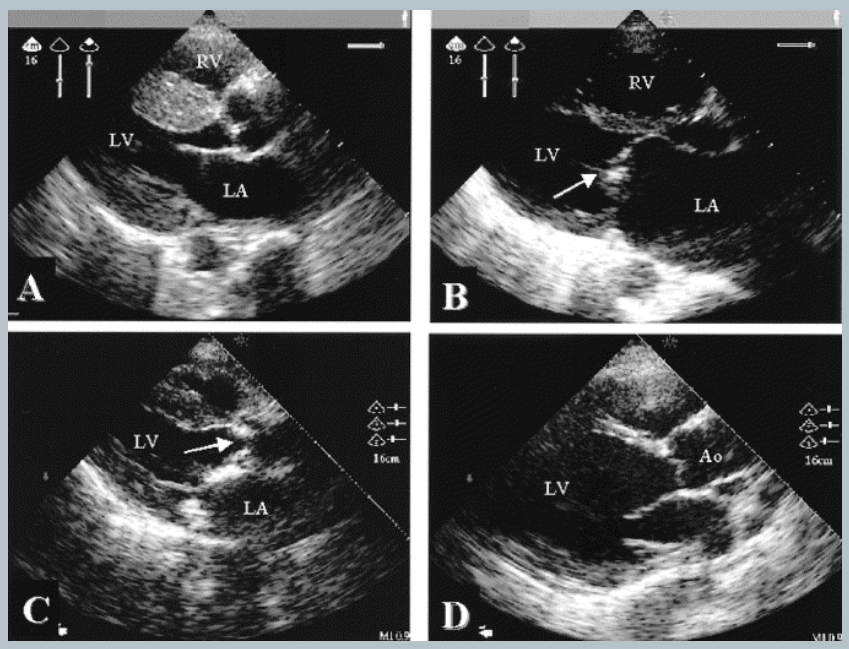
EXAM: 140
06/09/2010
4:41:44 PM
Cardiac
MI: 0.8
TI: 0.1
14cm
EXAM: 140
06/09/2010
4:42:31 PM
Cardiac
MI: 0.8
TI: 0.1
14cm
EXAM: 140
06/09/2010
4:43:54 PM
Cardiac
MI: 0.8
TI: 0.1
18cm

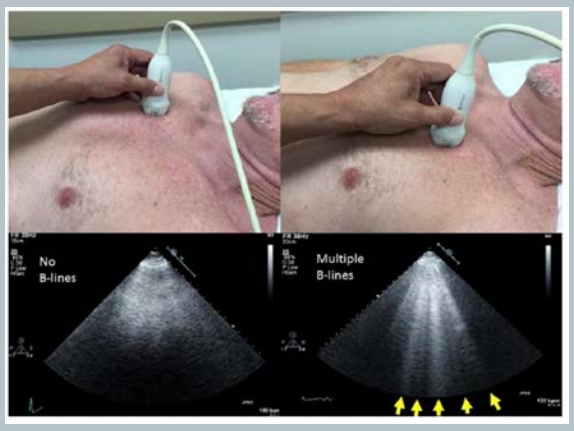
13


RV
LV
LA
A
RV
LV
LA
B
LV
LA
16cm
C
LV
Ao
16cm
D

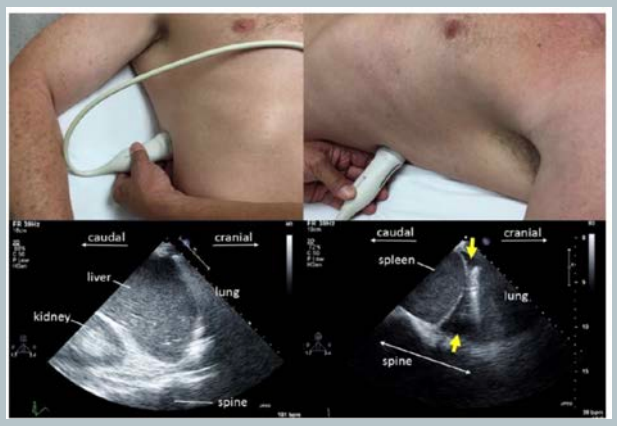
14

PULMONARY POCUS

”Lung Comets” – Pulmonary Congestion



Pleural Effusion



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APPLICATIONS OF HANDHELD ECHO

- Emergency imaging
- Limited exams
- Extended physical examination
  - the “ultrasonic stethoscope”

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HANDHELD ECHO: CARDIAC EMERGENCIES

- Pericardial effusion/tamponade
- Profound LV dysfunction
- Mechanical lesions
  - cardiac rupture
  - papillary muscle rupture
- Dissection

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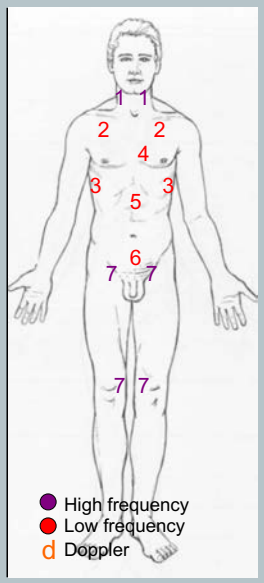
Specific Examinations: *Inpatient evaluation*

Seven Sites

…Simple
…Supported by literature
…Suitable for the inpatient



1. internal jugular
2. pneumothorax
3. pleural effusion
4. cardiac parasternal
5. cardiac subcostal
6. bladder
7. deep leg veins

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IS HANDHELD ECHOCARDIOGRAPHY SUPERIOR TO THE *PHYSICAL EXAM* IN CRITICAL CARE?

(Yes)

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POINT-OF-CARE ECHOCARDIOGRAPHY

- Spencer, Lang et al. JACC; 37, 2001
- Compare POC with PE ***by cardiologists***
- 36 pts; full echo was gold standard
- Abnormalities missed; PE=59%; POC=29%
- Major abnl missed; PE=43%; POC=21%
- Use of handheld by cardiologists is useful but not perfect

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IS HANDHELD ECHO EQUIVALENT TO *STANDARD ECHOCARDIOGRAPHY*?

(Not quite)

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Diagnostic Capability of Comprehensive Handheld vs Transthoracic Echocardiography

Michael W. Cullen, MD; Lori A. Blauwet, MD; Ori M. Vatury, MD; Sharon L. Mulvagh, MD; Thomas R. Behrenbeck, MD, PhD; Christopher G. Scott, MS; and Patricia A. Pellikka, MD

Abstract

Objective: To assess the diagnostic capability of handheld echocardiography (HHE) compared with transthoracic echocardiography (TTE) performed and evaluated by experienced sonographers and expert echocardiographers.

Patients and Methods: We conducted a prospective study of adult outpatients undergoing comprehensive TTE between July 9, 2012, and April 3, 2013. Experienced sonographers performed a detailed, standardized examination using a handheld ultrasound device that included 2-dimensional and color

Conclusion: In experienced hands, HHE shows moderate correlation with standard TTE, but discordant findings were present in 27% of patients. Even when performed and interpreted by experienced operators, HHE should not be used as a surrogate for standard TTE.

regional wall motion abnormalities, 0.73 for aortic stenosis, and 0.61 for mitral regurgitation. Lin concordance correlation coefficients ranged from 0.89 for LV end-systolic diameter to 0.78 for LV end-diastolic diameter. In 51 patients (27%), echocardiographic findings were discordant between HHE and standard TTE. The most common discordant finding was the presence vs absence of any regional wall motion abnormalities. In discordant cases, HHE tended to underestimate, rather than overestimate, the severity of abnormal findings.

Conclusion: In experienced hands, HHE shows moderate correlation with standard TTE, but discordant findings were present in 27% of patients. Even when performed and interpreted by experienced operators, HHE should not be used as a surrogate for standard TTE.

Trial Registration: clinicaltrials.gov Identifier: NCT01558518

 ■ Mayo Clin Proc. 2014;89(6):790-798

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THE LIMITED (FOCUSED) EXAM AND HANDHELD ECHO

- Instrument size not critical, but useful
- Focused exam to save time/cost
- Focused exam for specific conditions

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REQUIREMENTS FOR A FOCUSED EXAM

- **A focused exam can be defined**
- **The exam retains diagnostic accuracy**
- **The exam will not miss important findings**
- **The exam saves significant time/money**

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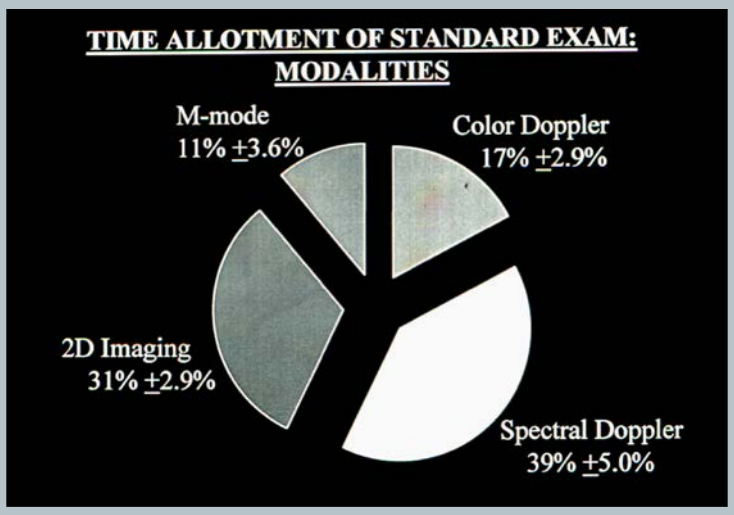

Echo exam = 30 min; 50% is Doppler

Kimura et al; JASE;2004

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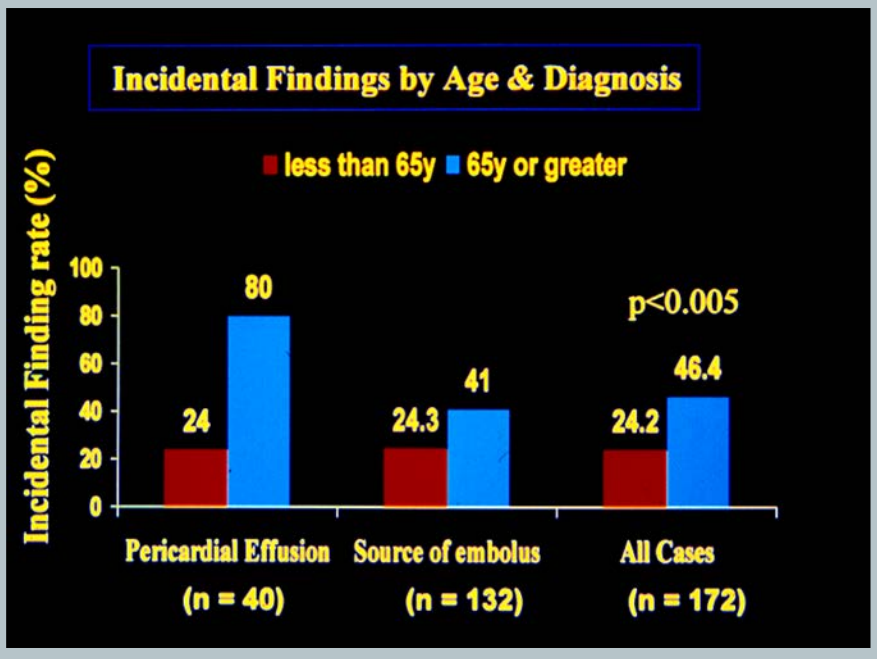

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HANDHELD ECHO WILL COMPLEMENT/REPLACE THE STETHESCOPE FOR PHYSICAL EXAM

- The PE is indirect, imprecise, limited
- Accuracy of performing PE is limited
- Handheld is comparable to standard echo
- Handheld is superior to PE (for all organs)
- Trainees can master basic handheld skills
- Handheld units will be smaller/cheaper

- A handheld exam will supplant the PE as the primary cost-effective cardiac ***screen***

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Laennec invented the stethoscope, the original employment of the instrument being his desire to save a young woman's modesty from the shock of having him listen directly to her chest.

30

ACCURACY OF CURRENT PE

- *St Clair* AnnIntMed 1992 63 res 50-60% error
  MR, AR, MS
- *Mangione* JAMA 1997 453 res 80% error
- *Roldan* AJC 1996 15 card 20% error } Functional murmurs
- *Jost* AmJMed 2000 20 card 21% error
- *March* MayoProc 2005 17 card 66% error
  All MDs had 76% error
- *Criley* ArchIntMed 2006 860 MDs 42% error
  Cards fellows best at 30% error
  No difference for intern to faculty

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Usefulness of a Hand-Held Ultrasound Device for Bedside Examination of Left Ventricular Function

Bruce J. Kimura, MD, Stan A. Amundson, MD, Casey L. Willis, RDCS, Elizabeth A. Gilpin, MS, and Anthony N. DeMaria, MD

The central role of physical examination in detecting cardiovascular disorders is attributable to its low cost and ease of application despite reported limitations in accuracy.[1–3] The recent development of inexpensive hand-held ultrasound devices will potentially allow the incorporation of ultrasound into the routine bedside examination and thereby improve diagnostic accuracy.[4] Patients with left ventricular (LV) systolic dysfunction represent a group who can benefit from early detection and treatment,[5,6] but in whom the condition may be asymptomatic[7,8] and elude physical diagnosis. The present study was undertaken to examine whether physicians who undergo brief training in the use of a hand-held ultrasound device can improve their capability to diagnose patients with significant LV dysfunction.

...

The study took place at an accredited teaching hospital using second- and third-year internal medicine residents (n = 13). All residents initially received a 1-hour review lecture on the use of physical examination techniques to detect impaired LV systolic function.[2] Within the same month, a 1-hour ultrasound training session was given including instruction on proper orientation of the parasternal long-axis view echocardiogram, review of videotaped examples of normal and abnormal systolic function, and a "hands-on" exercise for each resident to image and interpret findings on 5 normal volunteers using a 7-pound, hand-carried ultrasound device with a 2.5-MHz transducer probe (Op/t/Go, Philips Medical Systems, Andover, Massachusetts). Residents were instructed to evaluate impaired systolic function based upon 3 echocardiographic criteria: (1) presence of abnormal wall motion or thickening, (2) inability of the mitral valve to open fully and nearly touch the septum (i.e., the E-point septal separation distance of >1 cm), and (3) failure of the midventricle to become smaller than the base of the heart.

Six weeks later, residents were formally evaluated in their examination of 12 model patients for the presence of significant LV systolic dysfunction. Five volunteer patients with a history of an LV ejection fraction <50% and asymptomatic with medical therapy were age-matched to 7 patients or normal volunteers with ejection fractions ≥60%. No model had undergone thoracotomy, had significant valvular disease, had pacer or defibrillator placement, or was recently admitted to the hospital or had contact with any resident physician. All 12 models underwent measurement of ejection fraction by Simpson's rule,[9] performed by experienced sonographers using a standard echocardiographic instrument (Sonos 5500, Philips Medical Systems). An adequate-quality parasternal long-axis image was obtained for each patient and reviewed by a cardiologist (BJK) for the presence of the 3 echocardiographic criteria of LV dysfunction. Immediately after echo evaluation, a senior faculty internist (SAA), blinded to the results of the echocardiogram, physically examined each model.

Residents were initially given 5 minutes to perform a physical examination to detect LV dysfunction. No significant verbal communication was allowed. The physical diagnosis was then scored as: 1 = definitely normal, 2 = probably normal, 3 = equivocal, 4 = probably abnormal, and 5 = definitely abnormal. Immediately after the physical examination, the resident performed a 3-minute ultrasound examination. The quality of the best image obtained during the ultrasound examination was scored on a 4-point scale by the proctor: 0 = no image, 1 = only motion seen with visualization of any 1 of 3 landmarks of the parasternal long-axis view (the aortic valve, mitral valve, and LV long axis), 2 = any 2 of the 3 landmarks present, and 3 = all 3 landmarks present. An additional point was given if endocardial definition was near complete. A total quality score of 3 or 4 was considered an adequate study. After obtaining the ultrasound, the resident physician was given the opportunity to revise his/her diagnostic score based on all the data assimilated through physical and ultrasonic examination of the model. This was considered the final diagnostic score.

Initial diagnostic error (after physical examination), quantified as the absolute difference between the true status of the patient (1 = normal, 5 = abnormal) and the initial diagnostic score, was calculated for each resident for each patient. Similarly, the final diagnostic error (after ultrasound examination) was calculated from the final diagnostic score. The initial diagnostic error was then subtracted from the final diagnostic error so that a negative difference would indicate an improved, and a positive difference a worsened, diagnostic error. Patient evaluations showing improvement, no change, or worsening of the diagnostic error after the use of the hand-held ultrasound device were scored −1, 0, or +1, respectively.

From the Department of Cardiology, ScrippsMercy Medical Center, San Diego, and the Department of Cardiology, University of California, San Diego, San Diego, California. Dr. Kimura is supported in part by an unrestricted grant from Philips Medical Systems, Andover, Massachusetts. Dr. Kimura's address is: University of California, San Diego, ScrippsMercy Noninvasive Cardiology, 330 Prospect Place #250, Coronado, California 92118. Email: kimura.bruce@scrippshealth.org. Manuscript received March 19, 2002; revised manuscript received and accepted June 25, 2002.

  The American Journal of Cardiology Vol. 90 November 1, 2002

- •2 sessions echo training: Low EF
- •10/13 residents improved diagnosis in 12 patients (5 low EF; 7 nls)
- •>80% exams of fair or good quality.

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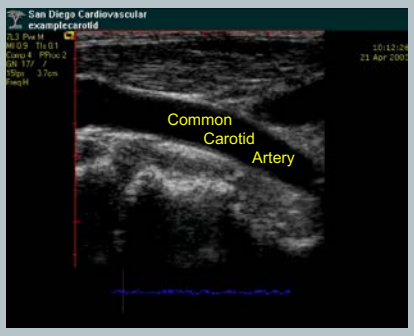
Specific Examinations: *Carotid artery*

Paradigm for ultrasound-assisted physical examination



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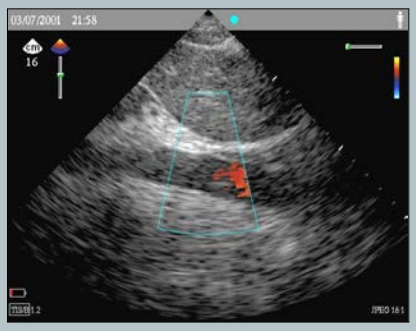
Detection of Abdominal Aortic Aneurysm



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CARDIOVASCULAR LIMITED ULTRASOUND EXAMINATION (CLUE)

Value of a Cardiovascular Limited Ultrasound Examination Using a Hand-Carried Ultrasound Device on Clinical Management in an Outpatient Medical Clinic

Bruce J. Kimura, MD[a,*], David J. Shaw, MD[a], Donna L. Agan, EdD[a], Stan A. Amundson, MD[a], Andrew C. Ping, MD[a], and Anthony N. DeMaria, MD[b]

Limited ultrasound imaging studies using hand-carried ultrasound devices at the point of care have individually shown feasibility in the detection of carotid atheroma, left ventricular systolic dysfunction, left atrial enlargement, and abdominal aortic aneurysm. To evaluate the utility of a specific cardiovascular limited ultrasound examination (CLUE) designed to detect all 4 entities in patients seen in an outpatient medical clinic. One hundred ninety-six patients underwent coronary heart disease risk stratification by National Cholesterol Education Program guidelines and CLUE with a hand-carried ultrasound device with cardiac and vascular transducers. CLUE included brief imaging of the carotid arteries, the heart, and the intra-abdominal aorta. The prevalence of abnormal CLUE results and their effect on clinical management were tabulated and stratified by coronary heart disease risk class. Patient age (mean ± SD) was 56 ± 14 years (range 22 to 95), and 32.1% were at low risk, 30.6% at intermediate risk, and 37.2% at high risk. Of the 196 CLUEs, abnormalities were present in 37.2% (32.7% had carotid atheroma, 3.1% had systolic dysfunction, 6.1% had left atrial enlargement, and 1.0% had abdominal aortic aneurysm) and were related to age, increasing coronary heart disease risk, and male gender. Overall, CLUE resulted in new management recommendations in 20% of patients, primarily in coronary heart disease risk prevention. In patients at intermediate risk or aged 60 to 69 years, CLUE resulted in new recommendations in 39% and 37%, respectively. In conclusion, when applied to a clinic population, brief cardiovascular ultrasound exams frequently demonstrate unsuspected findings that can change management. (Am J Cardiol 2007;100:321–325)

- 196 pts in Medicine Clinic (40% new)
- Risk stratified by NCEP guidelines
- HCU of carotid, heart, abd aorta
- ***36% had undetected abnormality***
- ***20% had change in management***

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So why isn't everyone using bedside ultrasound examination?

1. Reimbursement issues (there is none)
   a. Perceived threat to standard ultrasound studies
   "low quality," "cursory exam," "nonstandard documentation"
   b. Potential for abuse of current CPT billing codes
   i. LMRP in some states applies >6lb wt requirement
   ii. ASE Guidelines suggest this is not comprehensive data.
   iii. No ICD-9 code for "ultrasound-enhanced" physical.

2. ~~Devices still not ideal~~
   ~~a. still too expensive: >$10,000~~
   ~~b. too bulky to carry, unlike stethoscope~~

3. Physician training, unfamiliarity
   a. lack of formal ultrasound training at level of primary-care.
   b. medico-legal implications unknown.

4. Lack of published data on USE model
   a. evidence-basis for "screening" needed

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MAJOR ISSUES IN POCUS

- Incidental findings (Incidentalomas)
- Archiving
  - Hard copy?
  - Insertion in medical record/
- Liability

Contextual Imaging

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CONTEXTUAL IMAGING

POCUS as ultrasound-augment physical exam	POCUS at a formal limited study
1. Contextual imaging used for specific findings or signs sought 2. Data is formative, of a differential diagnosis 3. Not responsible for incidental findings 4. Archival optional; signs found recorded as a part of the physical exam 5. Less extensive training necessary 6. No separate billing	1. Complete definitive interpretation and delineation of all findings from a limited number of views 2. Detection of all findings (primary, incidental) regardless of context, held to the level of standard expert practice 3. Expert knowledge needed 4. Archival of images required 5. Billing possible

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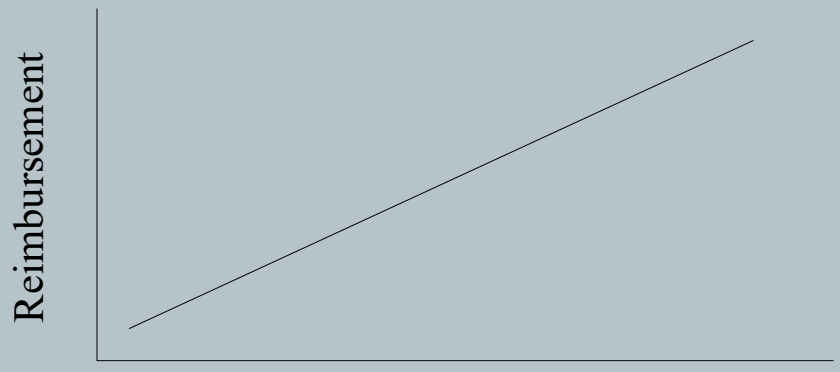
Variable Echo Reimbursement??



Exam	Limited	Focused	Complete
Operator	Novice	Experience	Expert
Instrument	Stripped	Basic	Full feature

45