# “You saw what?”

## Findings on Bedside Ultrasound That Change Patient Management

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# Disclosures: GE Consultant

# Objectives:

- To discuss the literature that supports bedside imaging
- To discuss common bedside ultrasound exams
- To discuss pathology easily identified on those exams
- To spark an interest in bedside imaging

# Bedside Ultrasound

**Advantages**

- Safer procedures
- Rapid
- Bedside
- Repeatable
- No radiation or contrast
- More accurate, timely diagnoses

**Disadvantages**

- User dependent
- Image acquisition may be limited

# Support for Bedside Ultrasound: The Evidence

# American Medical Association

- AMA HR. 802 Passed in 1999

(1) AMA affirms that ultrasound imaging is within the scope of practice of appropriately trained physicians;

(2) AMA policy on ultrasound acknowledges that broad and diverse use and application of ultrasound imaging technologies exist in medical practice;

(3) AMA policy on ultrasound imaging affirms that privileging of the physician to perform ultrasound imaging procedures in a hospital setting should be a function of hospital medical staffs and should be specifically delineated on the Department's Delineation of Privileges form; and

(4) AMA policy on ultrasound imaging states that each hospital medical staff should review and approve criteria for granting ultrasound privileges based upon background and training for the use of ultrasound technology and strongly recommends that these criteria are in accordance with recommended training and education standards developed by each physician's respective specialty.

# American College of Radiology

- Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations. 2017.
- "…physicians should be able to provide evidence of the training and competence needed to perform diagnostic ultrasound examinations successfully."

The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the publishedpractice parameter and technical standard by those entities not providing these services is not authorized.

Revised 2017 (Resolution 32)*

**ACR – SPR –SRU PRACTICE PARAMETER FOR THE PERFORMING AND INTERPRETING DIAGNOSTIC ULTRASOUND EXAMINATIONS**

**PREAMBLE**

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the practice parameters, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the practice parameters when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the practice parameters. However, a practitioner who employs an approach substantially different from these practice parameters is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these practice parameters will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these practice parameters is to assist practitioners in achieving this objective.

[1] Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing N.W.2d (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

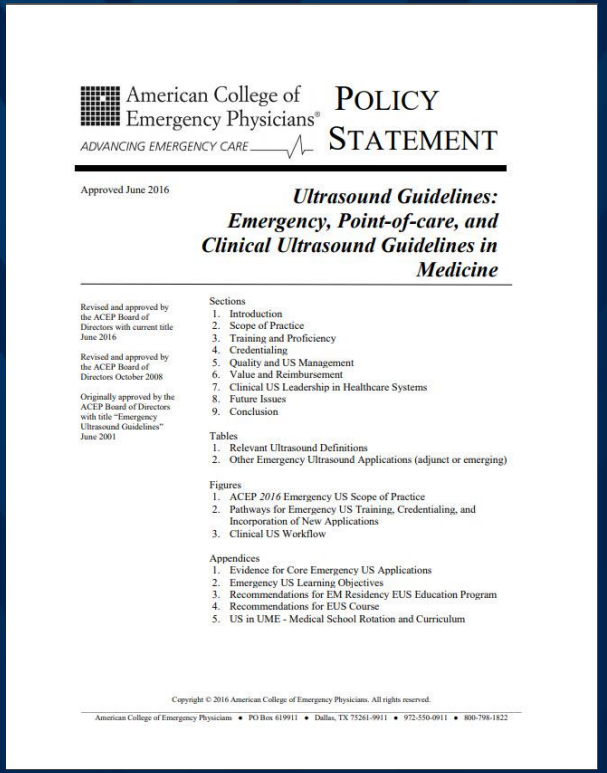
Performing and Interpreting Ultrasound 1 PRACTICE PARAMETER



ACR-SPR-SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations. 2017. https://www.acr.org/-/media/ACR/Files/PracticeParameters/us-perf-interpret.pdf

# American College of Emergency Physicians

- ACEP Policy Statement Ultrasound Guidelines: Emergency, Point-of-care, and Clinical Ultrasound Guidelines in Medicine Ann Emerg Med. 2017
- “It (EUS,POCUS) is utilized for diagnosis of any emergency condition, resuscitation of the acutely ill, critically ill or injured, guidance of procedures, monitoring of certain pathologic states and as an adjunct to therapy.”



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

POLICY STATEMENT

Approved June 2016

***Ultrasound Guidelines: Emergency, Point-of-care, and Clinical Ultrasound Guidelines in Medicine***

Revised and approved by the ACEP Board of Directors with current title June 2016

Revised and approved by the ACEP Board of Directors October 2008

Originally approved by the ACEP Board of Directors with title “Emergency Ultrasound Guidelines” June 2001

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ACEP Policy Statement Ultrasound Guidelines: Emergency, Point-of-care, and Clinical Ultrasound Guidelines in Medicine Ann Emerg Med. 2017 May;69(5):e27-e54. doi: 10.1016/j.annemergmed.2016.08.457

# POCUS for Hospitalists

REVIEWS

**Diagnostic Point-of-Care Ultrasound for Hospitalists**

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We review the literature on diagnostic point-of-care ultrasound applications most relevant to hospital medicine and highlight gaps in the evidence base. Diagnostic point-of-care applications most relevant to hospitalists include cardiac ultrasound for left ventricular systolic function, pericardial effusion, and severe mitral regurgitation; lung ultrasound for pneumonia, pleural effusion, pneumothorax, and pulmonary edema; abdominal ultrasound for ascites, aortic aneurysm, and hydronephrosis; and venous ultrasound for central venous volume assessment and lower extremity deep venous thrombosis. Hospitalists and other frontline providers, as well as physician trainees at various levels of training, have moderate to excellent diagnostic accuracy after brief training programs for most of these applications. Despite the evidence supporting the diagnostic accuracy of point-of-care ultrasound, experimental evidence supporting its clinical use by hospitalists is limited to cardiac ultrasound. *Journal of Hospital Medicine* 2014;9:000–000.


Similar to the physical exam, diagnostic point-of-care ultrasound exams are performed at the bedside in real time by hospitalists who are seeking a diagnosis. In contrast, referral ultrasound exams involve multiple providers and several steps. Typically, an ultrasound technologist acquires images, a radiologist or cardiologist interprets the images, a report is prepared, and results are sent to the referring hospitalist (Figure 1). Another important difference is that although referral ultrasound exams are usually comprehensive evaluations of entire organs or anatomic spaces, often without specific diagnoses in mind, point-of-care ultrasound exams are aimed at making specific diagnoses for well-defined clinical scenarios.[1]

The American Medical Association has reassured providers that "ultrasound imaging is within the scope of practice of appropriately trained physicians."[2] A growing body of literature demonstrates that point-of-care ultrasound is increasingly used by hospitalists for more than just bedside procedures. Incited by ongoing miniaturization of ultrasound devices, hospitalists are beginning to use point-of-care ultrasound for diagnosis, treatment, monitoring, and screening of patients (Figure 2). Our aim was to review the current literature for point-of-care ultrasound applications most relevant to hospitalists and highlight gaps in the current literature.

**ABDOMEN**

**Ascites**

Ultrasound is the gold standard for diagnosing ascites and can detect as little as 100 mL of ascitic fluid.[3] When ascites is not immediately evident, hospitalists can apply the principles of the FAST (Focused Assessment with Sonography in Trauma) examination to detect small amounts of ascites by evaluating the most dependent areas of the abdominopelvic cavity, the hepatorenal, left subdiaphragmatic, and rectovesicular or rectouterine spaces.[1] When ascites is identified and paracentesis is indicated, ultrasound guidance for site selection reduces bleeding complications.[4]

**Aortic Aneurysm**

Novice providers with limited ultrasound training can accurately screen patients for abdominal aortic aneurysm (AAA). Multiple studies from emergency departments have shown that point-of-care ultrasound can be used to accurately detect AAA, and a recent meta-analysis of 7 high-quality studies demonstrated a sensitivity of 99% (95% confidence interval [CI]: 96%-100%) and a specificity of 98% (95% CI: 97%-99%).[5] Hospitalists could use ultrasound to rapidly detect AAA in patients with acute abdominal pain, monitor the size in patients with known AAA, and possibly screen high-risk patients.[6]

**Hydronephrosis**

Once detected, relief of post–renal obstruction usually results in rapid reversal of acute kidney injury. Although diagnostic accuracy studies of detection of hydronephrosis have yet to be conducted with hospitalists, studies of other frontline providers with limited training in renal ultrasonography have revealed sensitivities of 72% to 87% and specificities of 73% to 82% in patients with renal colic.[7,8]

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- Diagnostic PoCUS for Hospitalists. Sonji et al.J. Hosp. Med 2014
- Applications: Ascites, AAA, Hydronephrosis, Heart, Lungs (PTX, PNA, effusion, edema), Venous (volume, thromboembolism)
- "Hospitalists and other frontline providers, as well as physician trainees at various levels of training, have moderate to excellent diagnostic accuracy after brief training programs for most of these applications."
- "…point-of-care ultrasound exams are aimed at making specific diagnoses for well-defined clinical scenarios."

Soni NJ, Lucas BP, PoCUS for Hospitalists. J. Hosp. Med 2015;2;120-124. doi:10.1002/jhm.2285

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# A Step Further…

# The Society of Hospital Medicine

- Point-of-Care Ultrasound for Hospitalists: A Position Statement of the Society of Hospital Medicine. 2019. Soni NJ et al
- “The purpose of this position statement is to inform a broad audience about how hospitalists are using diagnostic and procedural applications of POCUS.”
- “…is intended to provide guidance on the safe and effective use of POCUS by the hospitalists who use it and the administrators who oversee its use.”

ONLINE ONLY JANUARY 2, 2019—POSITION STATEMENT

Point-of-Care Ultrasound for Hospitalists:
A Position Statement of the Society of Hospital Medicine

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Many hospitalists incorporate point-of-care ultrasound (POCUS) into their daily practice to answer specific diagnostic questions or to guide performance of invasive bedside procedures. However, standards for hospitalists in POCUS training and assessment are not yet established. Most internal medicine residency training programs, the major pipeline for incoming hospitalists, have only recently begun to incorporate POCUS in their curricula. The purpose of this document is to inform a broad audience on what POCUS is and how hospitalists are using it. This document is intended to provide guidance for the hospitalists who use POCUS and administrators who oversee its use. We discuss POCUS 1) applications, 2) training, 3) assessments, and 4) program management. Practicing hospitalists must continue to collaborate with their local credentialing bodies to outline requirements for POCUS use. Hospitalists should be integrally involved in decision-making processes surrounding POCUS program management. *Journal of Hospital Medicine* 2019;14:E1-E6. © 2019 Society of Hospital Medicine

Many hospitalists incorporate point-of-care ultrasound (POCUS) into their daily practice because it adds value to their bedside evaluation of patients. However, standards for training and assessing hospitalists in POCUS have not yet been established. Other acute care specialties, including emergency medicine and critical care medicine, have already incorporated POCUS into their graduate medical education training programs, but most internal medicine residency programs are only beginning to provide POCUS training.[1]

Several features distinguish POCUS from comprehensive ultrasound examinations. First, POCUS is designed to answer focused questions, whereas comprehensive ultrasound examinations evaluate all organs in an anatomical region; for example, an abdominal POCUS exam may evaluate only for presence or absence of intraperitoneal free fluid, whereas a comprehensive examination of the right upper quadrant will evaluate the liver, gallbladder, and biliary ducts. Second, POCUS examinations are generally performed by the same clinician who generates the relevant clinical question to answer with POCUS and ultimately integrates the findings into the patient's care.[2] By contrast, comprehensive ultrasound examinations involve multiple providers and steps: a clinician generates a relevant clinical question and requests an ultrasound examination that is acquired by a sonographer, interpreted by

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Soni NJ, Schnobrich D, Benji K. Mathews, MD, Tierney DM, Trevor P. Jensen, MD, MS, Dancel R, Joel Cho, MD, RDMS, RDC, Renee K. Dversdal, MD, Gregory Mints, MD, Anjali Bhagra, MD, Kreegan Reierson, MD, Linda M. Kurian, MD, Gigi Y. Liu, MD, MSc, Candotti C, Brandon Boesch, DO, LoPresti CM, Joshua Lenchus, DO, Tanping Wong, MD, Gordon Johnson, MD, Anna M. Maw, MD, MS, Ricardo Franco-Sadud, MD, Lucas BP, Point-of-Care Ultrasound for Hospitalists: A Position Statement of the Society of Hospital Medicine. Published Online Only January 2, 2019. doi: 10.12788/jhm.3079

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# Applications in Position Statement

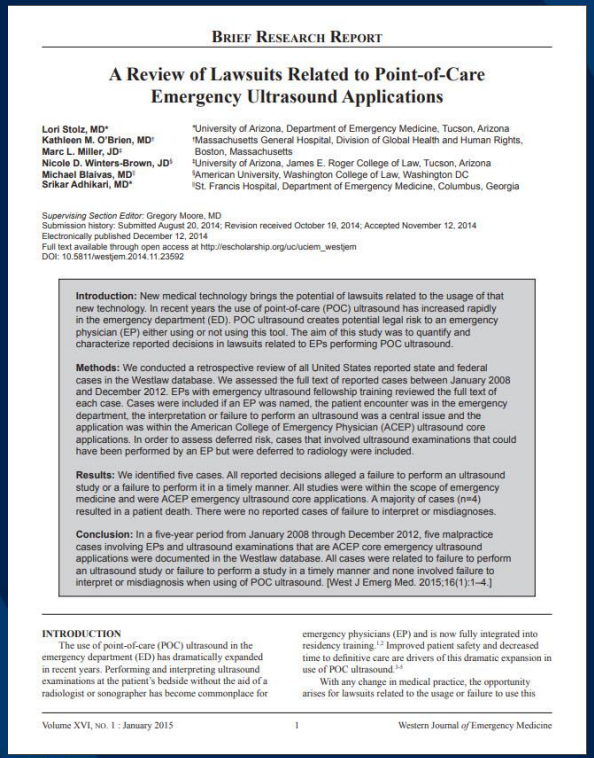
- Cardiac
  - LV and RV assessment, Atrial size, CVP (IJ/IVC), Pericardial Effusion, Hypertrophy, Gross Valvular Abnormalities
- Pulmonary
  - Effusions, Alveolar and Interstitial Syndromes, PTX
- Abdominal
  - FF, Kidney Size, Hydronephrosis, Bladder Volume, Gallbladder, Spleen and Liver Size
- Vascular
  - DVT, AAA
- MSK
  - Cellulitis, Abscess, Joint Effusions, Fractures
- Procedural
  - Paracentesis, Thoracentisis, Central Lines, Peripheral Lines, Arterial Lines, Arthrocentesis, Abscess Drainage, LP



Soni NJ et.al. Point-of-Care Ultrasound for Hospitalists: A Position Statement of the Society of Hospital Medicine. Published Online Only January 2, 2019. doi: 10.12788/jhm.3079

# Even Further…

# The Evidence for POCUS



BRIEF RESEARCH REPORT

**A Review of Lawsuits Related to Point-of-Care Emergency Ultrasound Applications**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**Introduction:** New medical technology brings the potential of lawsuits related to the usage of that new technology. In recent years the use of point-of-care (POC) ultrasound has increased rapidly in the emergency department (ED). POC ultrasound creates potential legal risk to an emergency physician (EP) either using or not using this tool. The aim of this study was to quantify and characterize reported decisions in lawsuits related to EPs performing POC ultrasound.

**Methods:** We conducted a retrospective review of all United States reported state and federal cases in the Westlaw database. We assessed the full text of reported cases between January 2008 and December 2012. EPs with emergency ultrasound fellowship training reviewed the full text of each case. Cases were included if an EP was named, the patient encounter was in the emergency department, the interpretation or failure to perform an ultrasound was a central issue and the application was within the American College of Emergency Physician (ACEP) ultrasound core applications. In order to assess deferred risk, cases that involved ultrasound examinations that could have been performed by an EP but were deferred to radiology were included.

**Results:** We identified five cases. All reported decisions alleged a failure to perform an ultrasound study or a failure to perform it in a timely manner. All studies were within the scope of emergency medicine and were ACEP emergency ultrasound core applications. A majority of cases (n=4) resulted in a patient death. There were no reported cases of failure to interpret or misdiagnoses.

**Conclusion:** In a five-year period from January 2008 through December 2012, five malpractice cases involving EPs and ultrasound examinations that are ACEP core emergency ultrasound applications were documented in the Westlaw database. All cases were related to failure to perform an ultrasound study or failure to perform a study in a timely manner and none involved failure to interpret or misdiagnosis when using of POC ultrasound. [West J Emerg Med. 2015;16(1):1–4.]


**INTRODUCTION**

The use of point-of-care (POC) ultrasound in the emergency department (ED) has dramatically expanded in recent years. Performing and interpreting ultrasound examinations at the patient's bedside without the aid of a radiologist or sonographer has become commonplace for emergency physicians (EP) and is now fully integrated into residency training.[1,2] Improved patient safety and decreased time to definitive care are drivers of this dramatic expansion in use of POC ultrasound.[3,4]

With any change in medical practice, the opportunity arises for lawsuits related to the usage or failure to use this



- A review of lawsuits related to point-of-care emergency ultrasound applications. Stolz L et al. West J Emerg Med. 2014
- Total of 5 cases related to POCUS
- "There were no reported cases of failure to interpret or misdiagnoses."
- "All reported decisions alleged a failure to perform an ultrasound study or a failure to perform it in a timely manner."

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Stolz L, O'Brien KM, Miller ML, Winters-Brown ND, Blaivas M, Adhikari S. A review of lawsuits related to point-of-care emergency ultrasound applications. West J Emerg Med. 2014;16(1):1–4. doi:10.5811/westjem.2014.11.23592

# How Can POCUS Help?

# Case #1

- 74 yo male with shortness of breath
- PMHx of CAD, CHF, COPD, HTN, DM
- Vitals:
  - HR 118
  - BP 140/85
  - RR 32
  - Sat 86% on 15L via Non rebreather Mask

# POCUS Echo Questions

- Is there squeeze or not?
- How is the global function?
- Is there right heart strain?
- Is there a pericardial effusion?
- Are there obvious structural abnormalities?

# Differential Diagnosis in Dyspnea

- ACS
- Asthma/COPD exacerbation
- CHF exacerbation
- PE
- Pleural effusions
- Pericardial effusion
- Pneumonia
- Cardiomyopathy
- Pneumothorax
- Allergic response
- Anemia
- Anxiety

# Pocus Affected Differential Diagnosis in Dyspnea

- ACS
- Asthma/COPD exacerbation
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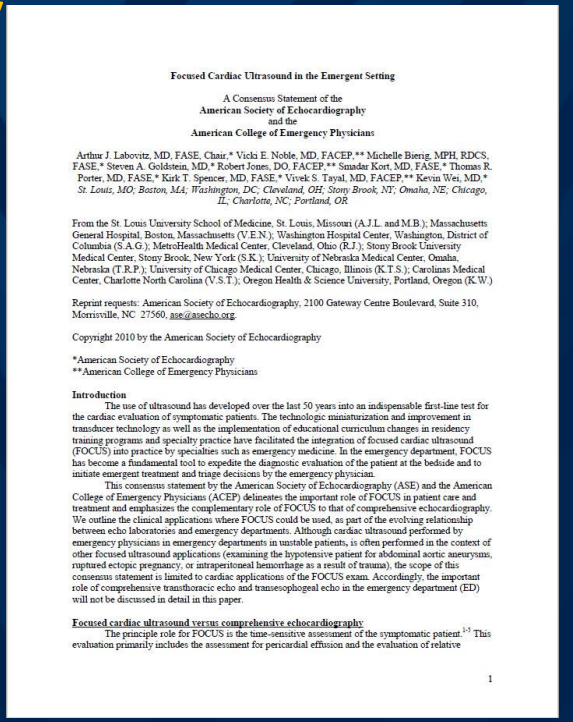
- Pleural effusions
- Pericardial effusion
- Pneumonia
- Cardiomyopathy
- Pneumothorax
- Allergic response
- Anemia
- Anxiety

# Bedside Echo

# American College of Echocardiography

- Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. Labovitz AJ et al J Am Soc Echocardiogr 2010
- "…focused cardiac ultrasound has become a fundamental tool to expedite the diagnostic evaluation of the patient at the bedside and to initiate emergent treatment…"



**Focused Cardiac Ultrasound in the Emergent Setting**

A Consensus Statement of the
**American Society of Echocardiography**
and the
**American College of Emergency Physicians**

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**American College of Emergency Physicians

**Introduction**

The use of ultrasound has developed over the last 50 years into an indispensable first-line test for the cardiac evaluation of symptomatic patients. The technologic miniaturization and improvement in transducer technology as well as the implementation of educational curriculum changes in residency training programs and specialty practice have facilitated the integration of focused cardiac ultrasound (FOCUS) into practice by specialties such as emergency medicine. In the emergency department, FOCUS has become a fundamental tool to expedite the diagnostic evaluation of the patient at the bedside and to initiate emergent treatment and triage decisions by the emergency physician.

This consensus statement by the American Society of Echocardiography (ASE) and the American College of Emergency Physicians (ACEP) delineates the important role of FOCUS in patient care and treatment and emphasizes the complementary role of FOCUS to that of comprehensive echocardiography. We outline the clinical applications where FOCUS could be used, as part of the evolving relationship between echo laboratories and emergency departments. Although cardiac ultrasound performed by emergency physicians in emergency departments in unstable patients, is often performed in the context of other focused ultrasound applications (examining the hypotensive patient for abdominal aortic aneurysms, ruptured ectopic pregnancy, or intraperitoneal hemorrhage as a result of trauma), the scope of this consensus statement is limited to cardiac applications of the FOCUS exam. Accordingly, the important role of comprehensive transthoracic echo and transesophogeal echo in the emergency department (ED) will not be discussed in detail in this paper.

**Focused cardiac ultrasound versus comprehensive echocardiography**

The principle role for FOCUS is the time-sensitive assessment of the symptomatic patient.[1-5] This evaluation primarily includes the assessment for pericardial effusion and the evaluation of relative

1

Labovitz AJ, Noble VE, Bierig M, et al. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. J Am Soc Echocardiogr. 2010;23:1225-30.

# Evidence

- Diagnostic performance of cardiopulmonary ultrasound performed by the emergency physician in the management of acute dyspnea. Gallard et al. Am J Emerg Med 2014
- 130 patients analyzed with dyspnea
- Standard of Care performed (EKG, XR, Labs). Diagnosis based on 2 separate independent physicians
- Based on initial US, physician was asked diagnosis.
  - CHF accuracy of 90%
  - PNA or Pleural effusion accuracy of 86%
  - COPD/Asthma exacerbation accuracy of 96%

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Original Contribution

## Diagnostic performance of cardiopulmonary ultrasound performed by the emergency physician in the management of acute dyspnea ☆

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ABSTRACT

*Objective:* The etiologic diagnosis of acute dyspnea in the emergency department (ED) remains difficult, especially for elderly patients or those with previous cardiorespiratory medical history. This may lead to inappropriate treatment and potentially a higher mortality rate. Our objective was to evaluate the performance of cardiopulmonary ultrasound compared with usual care for the etiologic diagnosis of acute dyspnea in the ED.

*Methods:* Patients admitted to the ED for acute dyspnea underwent upon arrival a cardiopulmonary ultrasound performed by an emergency physician, in addition to standard care. The performances of the clinical examination, chest x-ray, N-terminal brain natriuretic peptide (NT-proBNP), and cardiopulmonary ultrasound were compared with the final diagnosis made by 2 independent physicians.

*Results:* One hundred thirty patients were analyzed. For the diagnosis of acute left-sided heart failure, cardiopulmonary ultrasound had an accuracy of 90% (95% confidence interval [CI], 84-95) vs 67% (95% CI, 57-75), $P = .0001$ for clinical examination, and 81% (95% CI, 72-88), $P = .04$ for the combination "clinical examination–NT-proBNP–x-ray". Cardiopulmonary ultrasound led to the diagnosis of pneumonia or pleural effusion with an accuracy of 86% (95% CI, 80-92) and decompensated chronic obstructive pulmonary disease or asthma with an accuracy of 95% (95% CI, 92-99). Cardiopulmonary ultrasound lasted an average of 12 ± 3 minutes.

*Conclusions:* Cardiopulmonary ultrasounds performed in the ED setting allow one to rapidly establish the etiology of acute dyspnea with an accuracy of 90%.



### 1. Introduction

The etiologic diagnosis of acute dyspnea in the ED remains difficult, especially in elderly patients or those with previous medical history of cardiorespiratory disease [1-6]. If the diagnostic hypothesis and the resulting treatment are wrong, mortality increases significantly among elderly subjects with acute heart failure [7], stressing the importance of finding reliable diagnostic tools. The European Society of Cardiology has recently reviewed the limitations of commonly used methods: electrocardiogram, chest x-ray, N-terminal brain natriuretic peptide (NT-proBNP) testing, or blood samples [8]. Performance of an echocardiogram is recommended, but in practice, this is rarely possible because of lack of an available cardiologist in the ED. The significant value of lung ultrasound for the diagnosis of acute respiratory failure has also been suggested [9,10]. Recently, the interest of early chest ultrasonography for the diagnosis of severe dyspnea cases admitted into intensive care units has been shown [11], but there is little data concerning acute dyspnea in the ED [12-15].

The aim of our study was to evaluate the performance of cardiopulmonary ultrasound performed by an emergency physician in the ED setting for the etiologic diagnosis of acute dyspnea, considering routine examinations as the standard of care.

### 2. Methods

This prospective cohort study was conducted between January 2012 and December 2012 in the ED of a general hospital with approximately 19 000 ED visits per year. The study protocol was approved by the local ethics committee (ref. 130627), which did not require the signing of a written consent form.

2.1. Patients

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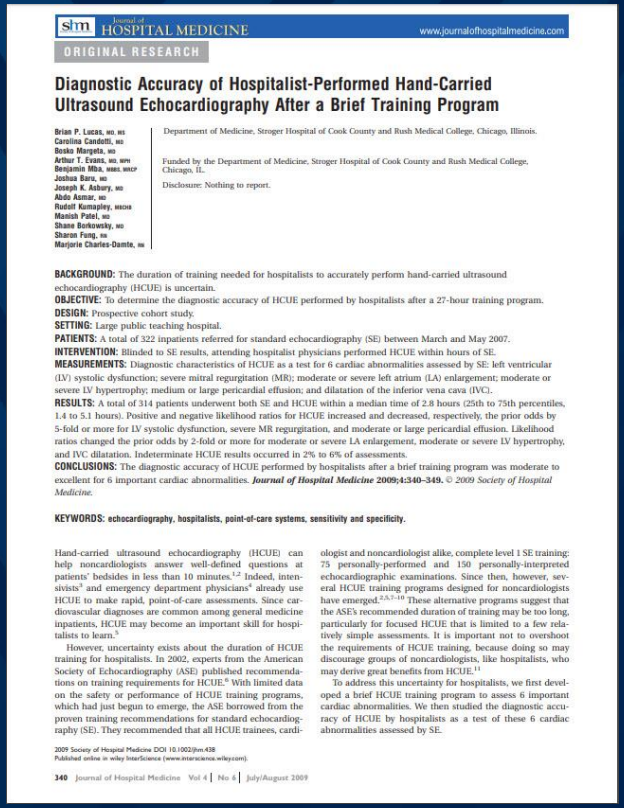
Gallard et al. Diagnostic performance of cardiopulmonary ultrasound performed by the emergency physician in the management of acute dyspnea. Am J Emerg Med.

# Evidence

- Accuracy of Hospitalist-Performed HCUE. Lucas et al. J. Hosp. Med 2009
- 314 patients compared standard echo to POC echo
- 27 hour course for hospitalist for LV systolic function, Severe MV regurg, LA enlargement, LV hypertrophy, Pericardial effusion, IVC dilatation
- “Accuracy of POC was moderate to excellent in all areas evaluated”



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ORIGINAL RESEARCH

## Diagnostic Accuracy of Hospitalist-Performed Hand-Carried Ultrasound Echocardiography After a Brief Training Program

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Funded by the Department of Medicine, Stroger Hospital of Cook County and Rush Medical College, Chicago, IL.

Disclosure: Nothing to report.

**BACKGROUND:** The duration of training needed for hospitalists to accurately perform hand-carried ultrasound echocardiography (HCUE) is uncertain.
**OBJECTIVE:** To determine the diagnostic accuracy of HCUE performed by hospitalists after a 27-hour training program.
**DESIGN:** Prospective cohort study.
**SETTING:** Large public teaching hospital.
**PATIENTS:** A total of 322 inpatients referred for standard echocardiography (SE) between March and May 2007.
**INTERVENTION:** Blinded to SE results, attending hospitalist physicians performed HCUE within hours of SE.
**MEASUREMENTS:** Diagnostic characteristics of HCUE as a test for 6 cardiac abnormalities assessed by SE: left ventricular (LV) systolic dysfunction; severe mitral regurgitation (MR); moderate or severe left atrium (LA) enlargement; moderate or severe LV hypertrophy; medium or large pericardial effusion; and dilatation of the inferior vena cava (IVC).
**RESULTS:** A total of 314 patients underwent both SE and HCUE within a median time of 2.8 hours (25th to 75th percentiles, 1.4 to 5.1 hours). Positive and negative likelihood ratios for HCUE increased and decreased, respectively, the prior odds by 5-fold or more for LV systolic dysfunction, severe MR regurgitation, and moderate or large pericardial effusion. Likelihood ratios changed the prior odds by 2-fold or more for moderate or severe LA enlargement, moderate or severe LV hypertrophy, and IVC dilatation. Indeterminate HCUE results occurred in 2% to 6% of assessments.
**CONCLUSIONS:** The diagnostic accuracy of HCUE performed by hospitalists after a brief training program was moderate to excellent for 6 important cardiac abnormalities. ***Journal of Hospital Medicine* 2009;4:340–349.** © *2009 Society of Hospital Medicine.*

**KEYWORDS:** echocardiography, hospitalists, point-of-care systems, sensitivity and specificity.

Hand-carried ultrasound echocardiography (HCUE) can help noncardiologists answer well-defined questions at patients' bedsides in less than 10 minutes.[1,2] Indeed, intensivists[3] and emergency department physicians[4] already use HCUE to make rapid, point-of-care assessments. Since cardiovascular diagnoses are common among general medicine inpatients, HCUE may become an important skill for hospitalists to learn.[5]

However, uncertainty exists about the duration of HCUE training for hospitalists. In 2002, experts from the American Society of Echocardiography (ASE) published recommendations on training requirements for HCUE.[6] With limited data on the safety or performance of HCUE training programs, which had just begun to emerge, the ASE borrowed from the proven training recommendations for standard echocardiography (SE). They recommended that all HCUE trainees, cardiologist and noncardiologist alike, complete level 1 SE training: 75 personally-performed and 150 personally-interpreted echocardiographic examinations. Since then, however, several HCUE training programs designed for noncardiologists have emerged.[2,3,7–10] These alternative programs suggest that the ASE's recommended duration of training may be too long, particularly for focused HCUE that is limited to a few relatively simple assessments. It is important not to overshoot the requirements of HCUE training, because doing so may discourage groups of noncardiologists, like hospitalists, who may derive great benefits from HCUE.[11]

To address this uncertainty for hospitalists, we first developed a brief HCUE training program to assess 6 important cardiac abnormalities. We then studied the diagnostic accuracy of HCUE by hospitalists as a test of these 6 cardiac abnormalities assessed by SE.

2009 Society of Hospital Medicine DOI 10.1002/jhm.438
Published online in wiley InterScience (www.interscience.wiley.com).

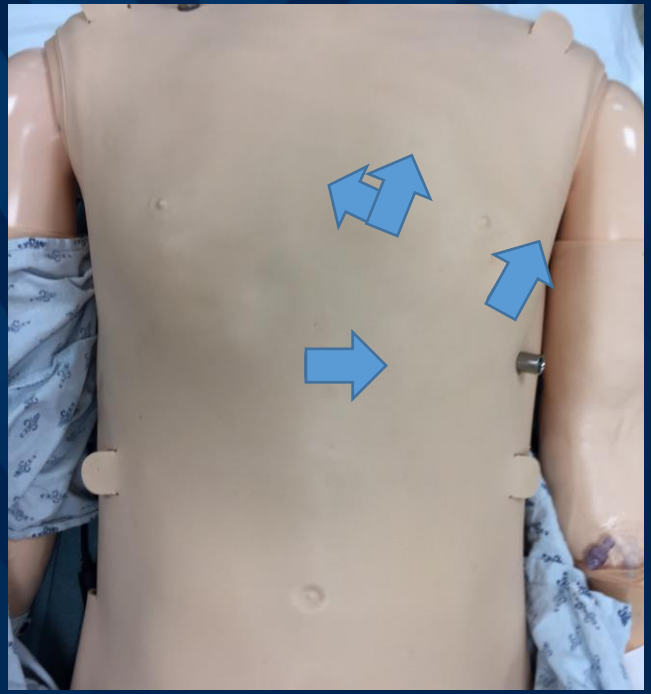


WestVirginiaUniversity.

Lucas et al. Accuracy of Hospitalist-Performed HCUE. J. Hosp. Med 2009

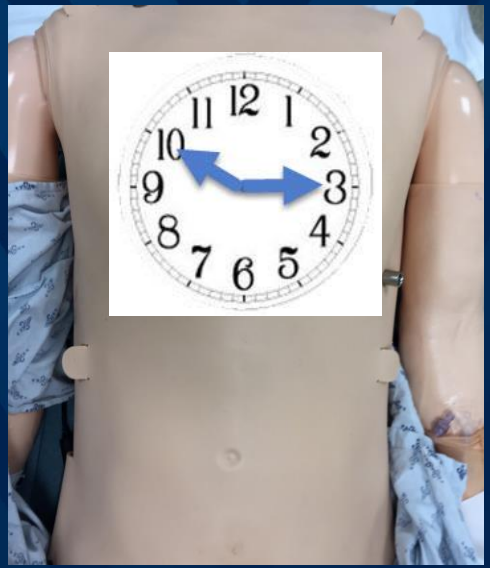
# The Exam

- 4 views using phased array or low frequency transducer
- Work in a clockwise fashion
- Left lateral decubitus may aid in views

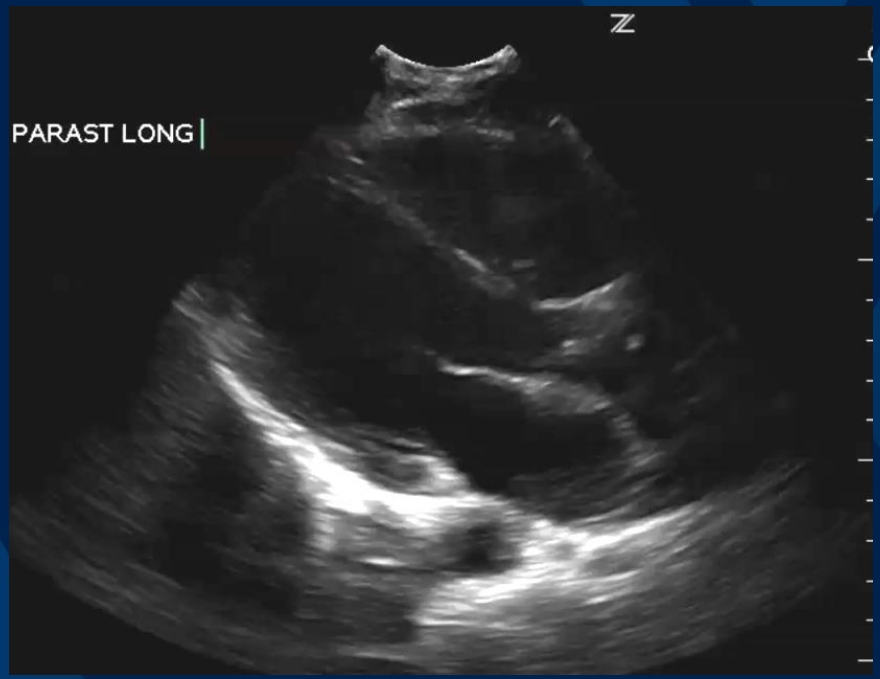


# The Exam

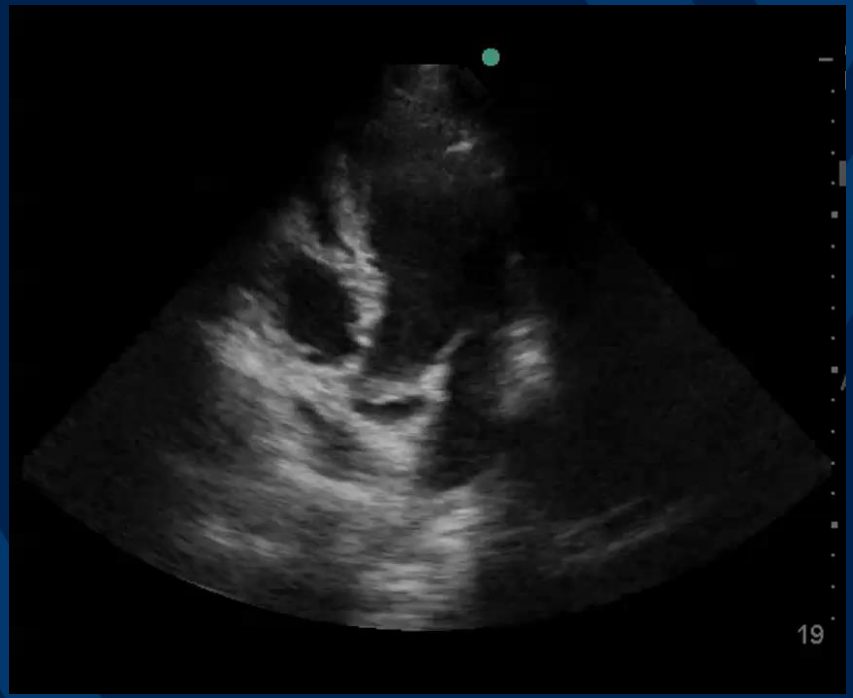
- 4 views using phased array or low frequency transducer
- Work in a clockwise fashion
- Left lateral decubitus may aid in views



# To Know Abnormal…

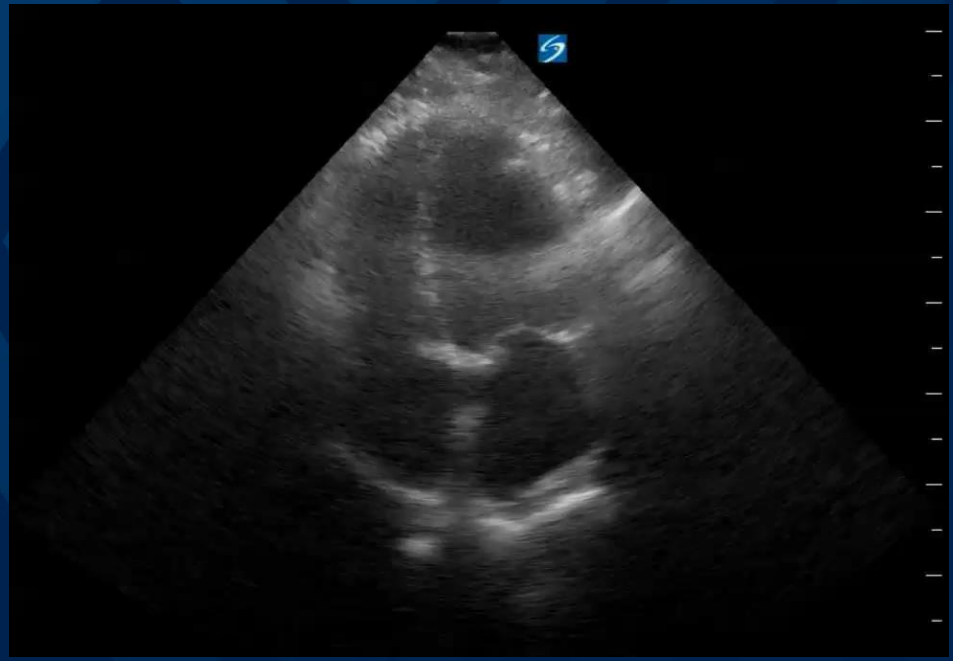



# To Know Abnormal…



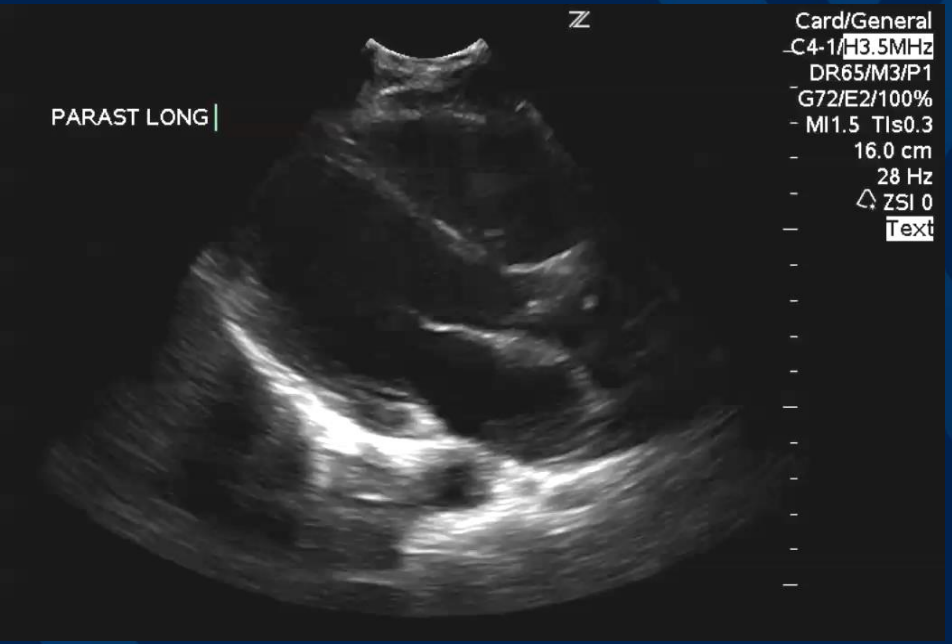

# Our Patient

- 74 yo male with shortness of breath
- PMHx of CAD, CHF, COPD, HTN, DM
- Vitals:
  - HR 118
  - BP 140/85
  - RR 32
  - Sat 86% on 15L via Non rebreather Mask

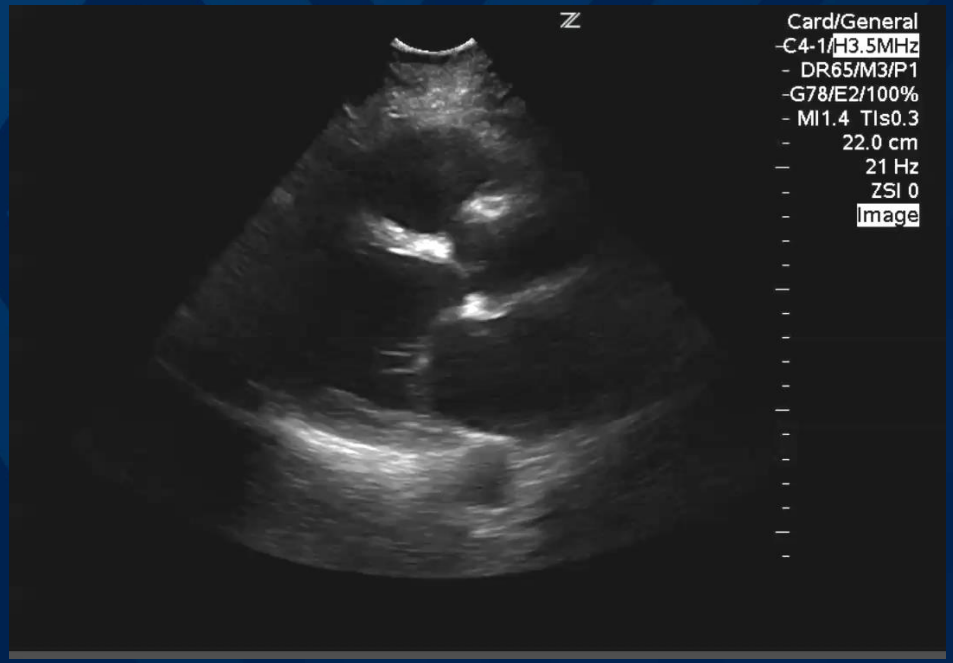


# Low EF

## Normal

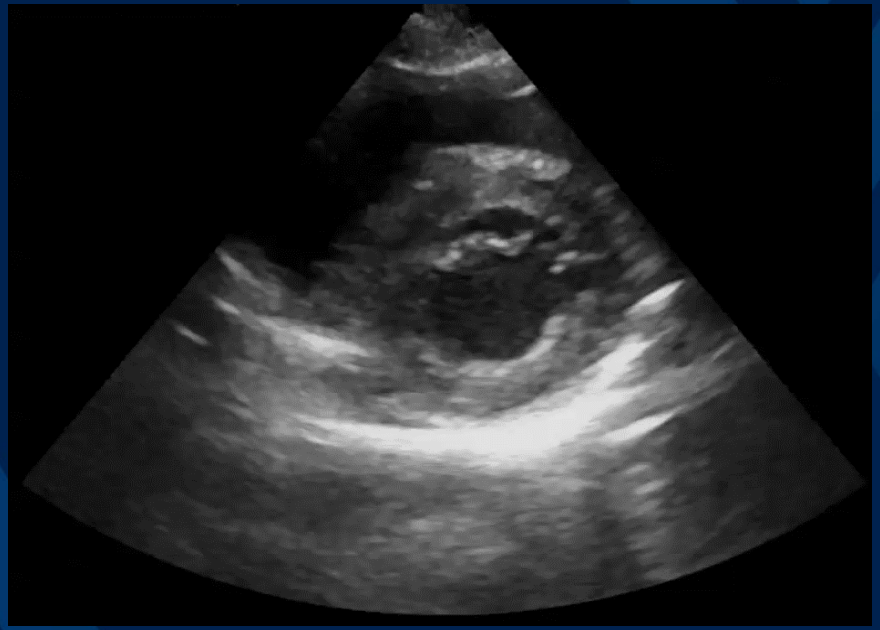



## Reduced EF



# Low EF

**Normal**



**Reduced EF**

# Low EF

- Pearls and Pitfalls
  - Body habitus, patient positioning may limit views
  - Tachycardia, dysrhythmia and bradycardia can cause over/under-estimation of EF

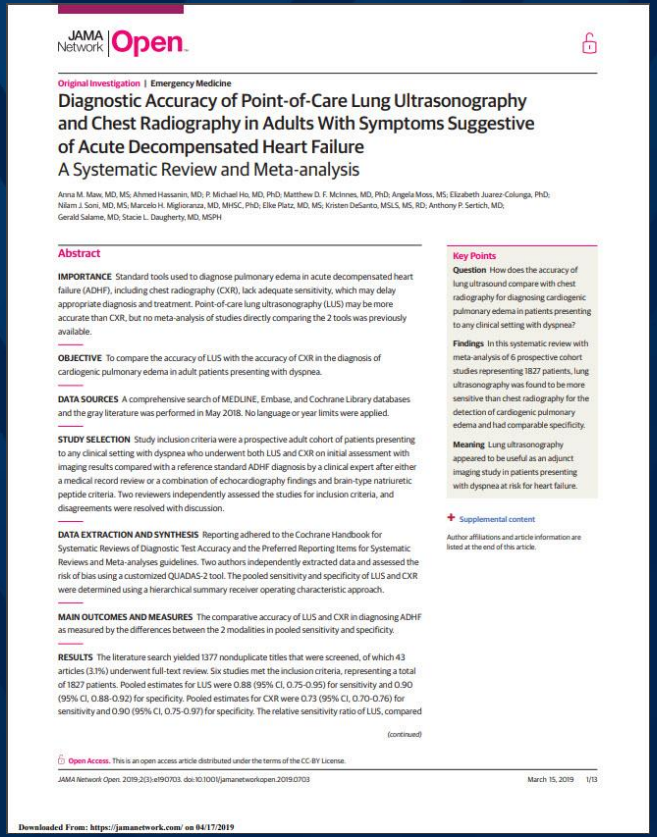
# Lung Ultrasound

# POCUS Lung Questions?

- Is there sliding?
- Are there B-Lines?
- Is there an effusion?
- Are there consolidations?

# Evidence

- Diagnostic Accuracy of Point-of-Care Lung Ultrasonography and Chest Radiography in Adults With Symptoms Suggestive of Acute Decompensated Heart Failure: A Systematic Review and Meta-analysis. Maw AM et al.  JAMA Six studies with total of 1827 patients
- LUS 88% sensitive and 90% specific
- CXR 73% sensitive and 90% specific
- “The findings suggest that LUS is more sensitive than CXR in detecting pulmonary edema in ADHF”



JAMA Network Open

Original Investigation | Emergency Medicine

**Diagnostic Accuracy of Point-of-Care Lung Ultrasonography and Chest Radiography in Adults With Symptoms Suggestive of Acute Decompensated Heart Failure**
A Systematic Review and Meta-analysis

Anna M. Maw, MD, MS; Ahmed Hassanin, MD; P. Michael Ho, MD, PhD; Matthew D. F. McInnes, MD, PhD; Angela Moss, MS; Elizabeth Juarez-Colunga, PhD; Nilam J. Soni, MD, MS; Marcelo H. Miglioranza, MD, MHSC, PhD; Elke Platz, MD, MS; Kristen DeSanto, MSLS, MS, RD; Anthony P. Sertich, MD; Gerald Salame, MD; Stacie L. Daugherty, MD, MSPH

**Abstract**

**IMPORTANCE** Standard tools used to diagnose pulmonary edema in acute decompensated heart failure (ADHF), including chest radiography (CXR), lack adequate sensitivity, which may delay appropriate diagnosis and treatment. Point-of-care lung ultrasonography (LUS) may be more accurate than CXR, but no meta-analysis of studies directly comparing the 2 tools was previously available.

**OBJECTIVE** To compare the accuracy of LUS with the accuracy of CXR in the diagnosis of cardiogenic pulmonary edema in adult patients presenting with dyspnea.

**DATA SOURCES** A comprehensive search of MEDLINE, Embase, and Cochrane Library databases and the gray literature was performed in May 2018. No language or year limits were applied.

**STUDY SELECTION** Study inclusion criteria were a prospective adult cohort of patients presenting to any clinical setting with dyspnea who underwent both LUS and CXR on initial assessment with imaging results compared with a reference standard ADHF diagnosis by a clinical expert after either a medical record review or a combination of echocardiography findings and brain-type natriuretic peptide criteria. Two reviewers independently assessed the studies for inclusion criteria, and disagreements were resolved with discussion.

**DATA EXTRACTION AND SYNTHESIS** Reporting adhered to the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy and the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. Two authors independently extracted data and assessed the risk of bias using a customized QUADAS-2 tool. The pooled sensitivity and specificity of LUS and CXR were determined using a hierarchical summary receiver operating characteristic approach.

**MAIN OUTCOMES AND MEASURES** The comparative accuracy of LUS and CXR in diagnosing ADHF as measured by the differences between the 2 modalities in pooled sensitivity and specificity.

**RESULTS** The literature search yielded 1377 nonduplicate titles that were screened, of which 43 articles (3.1%) underwent full-text review. Six studies met the inclusion criteria, representing a total of 1827 patients. Pooled estimates for LUS were 0.88 (95% CI, 0.75-0.95) for sensitivity and 0.90 (95% CI, 0.88-0.92) for specificity. Pooled estimates for CXR were 0.73 (95% CI, 0.70-0.76) for sensitivity and 0.90 (95% CI, 0.75-0.97) for specificity. The relative sensitivity ratio of LUS, compared

(continued)

**Key Points**

**Question** How does the accuracy of lung ultrasound compare with chest radiography for diagnosing cardiogenic pulmonary edema in patients presenting to any clinical setting with dyspnea?

**Findings** In this systematic review with meta-analysis of 6 prospective cohort studies representing 1827 patients, lung ultrasonography was found to be more sensitive than chest radiography for the detection of cardiogenic pulmonary edema and had comparable specificity.

**Meaning** Lung ultrasonography appeared to be useful as an adjunct imaging study in patients presenting with dyspnea at risk for heart failure.

Supplemental content

Author affiliations and article information are listed at the end of this article.



JAMA Network Open. 2019;2(3):e190703. doi:10.1001/jamanetworkopen.2019.0703 March 15, 2019 1/13



WestVirginiaUniversity.

Maw AM et al. Diagnostic Accuracy of Point-of-Care Lung Ultrasonography and Chest Radiography in Adults With Symptoms Suggestive of Acute Decompensated Heart Failure: A Systematic Review and Meta-analysis. JAMA Netw Open. 2019

# Lung Ultrasound

- Low frequency transducer
- Depth dependent on what you are looking to find
- Divide the anterior and posterior thorax into 4 quadrants each

Gargani and Volpicelli *Cardiovascular Ultrasound* 2014, **12**:25
http://www.cardiovascularultrasound.com/content/12/1/25

CARDIOVASCULAR ULTRASOUND

**HOW I DO IT ARTICLE** **Open Access**

## How I do it: Lung ultrasound

Luna Gargani[1*] and Giovanni Volpicelli[2]

**Abstract**

In the last 15 years, a new imaging application of sonography has emerged in the clinical arena: lung ultrasound (LUS). From its traditional assessment of pleural effusions and masses, LUS has moved towards the revolutionary approach of imaging the pulmonary parenchyma, mainly as a point-of-care technique. Although limited by the presence of air, LUS has proved to be useful in the evaluation of many different acute and chronic conditions, from cardiogenic pulmonary edema to acute lung injury, from pneumothorax to pneumonia, from interstitial lung disease to pulmonary infarctions and contusions. It is especially valuable since it is a relatively easy-to-learn application of ultrasound, less technically demanding than other sonographic examinations. It is quick to perform, portable, repeatable, non-ionizing, independent from specific acoustic windows, and therefore suitable for a meaningful evaluation in many different settings, both inpatient and outpatient, in both acute and chronic conditions.
In the next few years, point-of-care LUS is likely to become increasingly important in many different clinical settings, from the emergency department to the intensive care unit, from cardiology to pulmonology and nephrology wards.

**Keywords:** Lung ultrasound, B-lines, Point-of-care ultrasound, Chest sonography

**What is lung ultrasound?**

Assessment of the lung has always been considered off-limits for ultrasound, since it is standard textbook knowledge that «because ultrasound energy is rapidly dissipated by air, ultrasound imaging is not useful for the evaluation of the pulmonary parenchyma» [1]. The concept that ultrasound cannot be employed for evaluating the lung is linked to the presence of air, which determines a high acoustic mismatch with the surrounding tissues, causing a complete reflection of the ultrasound beam, preventing the creation of direct imaging of the pulmonary parenchyma [2]. In a normally aerated lung, the only detectable structure is the pleura, visualized as a hyperechoic horizontal line. It is debated whether this line represents an artefact due to a reflection phenomenon at the interface between alveolar air and the soft tissues of the thoracic wall, or it images the real pleura. The pleural line moves synchronously with respiration [3]: this dynamic horizontal movement is called *lung sliding*. In addition, there are some hyperechoic, horizontal lines arising at regular intervals from the pleural line: the A-lines. When combined with lung sliding, these reverberation artefacts represent a sign of normal or excessive content of air in the alveolar spaces (Figure 1, Additional file 1). When the air content decreases and lung density increases due to the presence in the lung of exudate, transudate, collagen, blood, etc. the acoustic mismatch between the lung and the surrounding tissues is lowered, and the ultrasound beam can be partly reflected at deeper zones and repeatedly. This phenomenon creates some vertical reverberation artefacts known as B-lines (Figure 2, Additional file 2). B-lines belong to the family of the comet-tail artifacts, well known in the setting of abdominal ultrasound [4]. B-lines have also been addressed as comet-tail artifacts or ultrasound lung comets before an expert agreement on nomenclature was obtained [3]. B-lines are defined as discrete laser-like vertical hyperechoic reverberation artifacts that arise from the pleural line, extend to the bottom of the screen without fading, and move synchronously with lung sliding [3]. Multiple B-lines are considered the sonographic sign of lung interstitial syndrome, and their number increases along with decreasing air content and increase in lung density [5,6]. When the air content further decreases, such as in lung consolidations, the acoustic window on the lung becomes completely open, and the lung may be directly visualized as a solid parenchyma, like the liver or the spleen (Figure 3). Consolidation of the lung may be the result of an infectious process, an infarction due to

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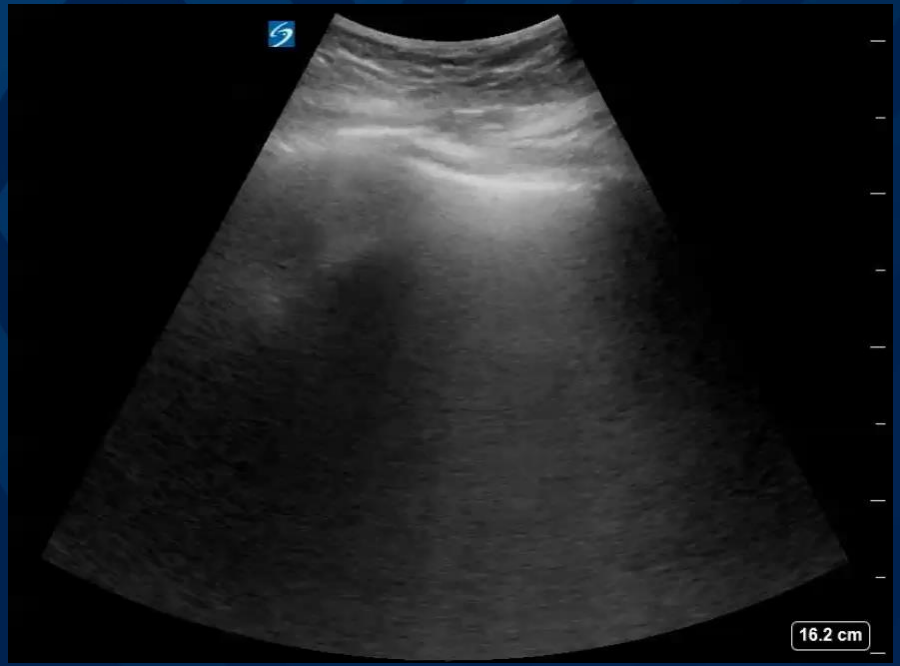
Gargani L, Volpicelli G. How I do it: lung ultrasound. Cardiovasc Ultrasound. 2014;12:25. Published 2014 Jul 4. doi:10.1186/1476-7120-12-25

# Pulmonary Edema

**Normal**

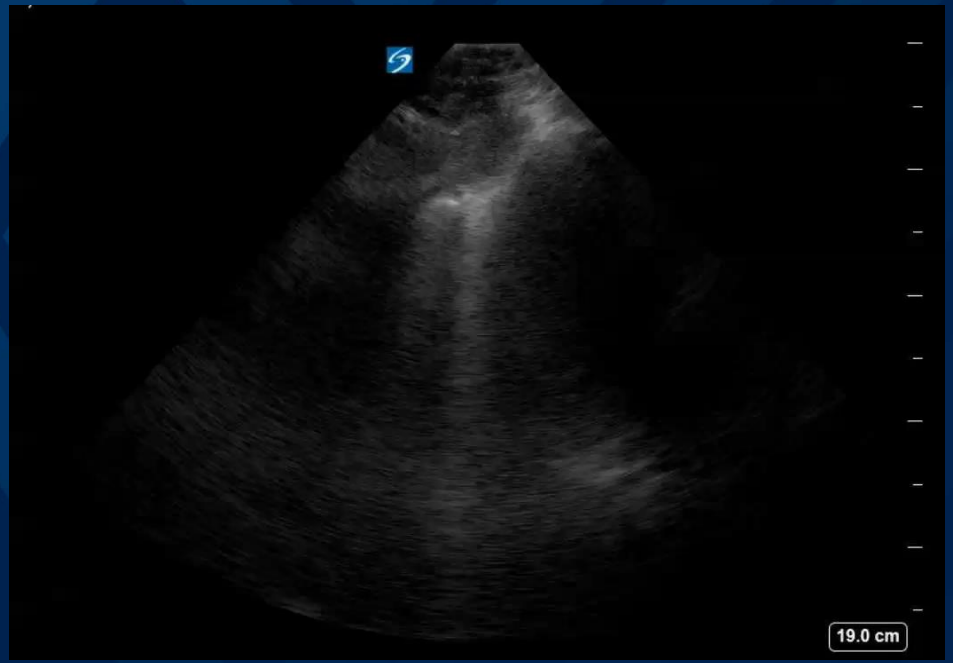

**Edema**



# Pulmonary Edema

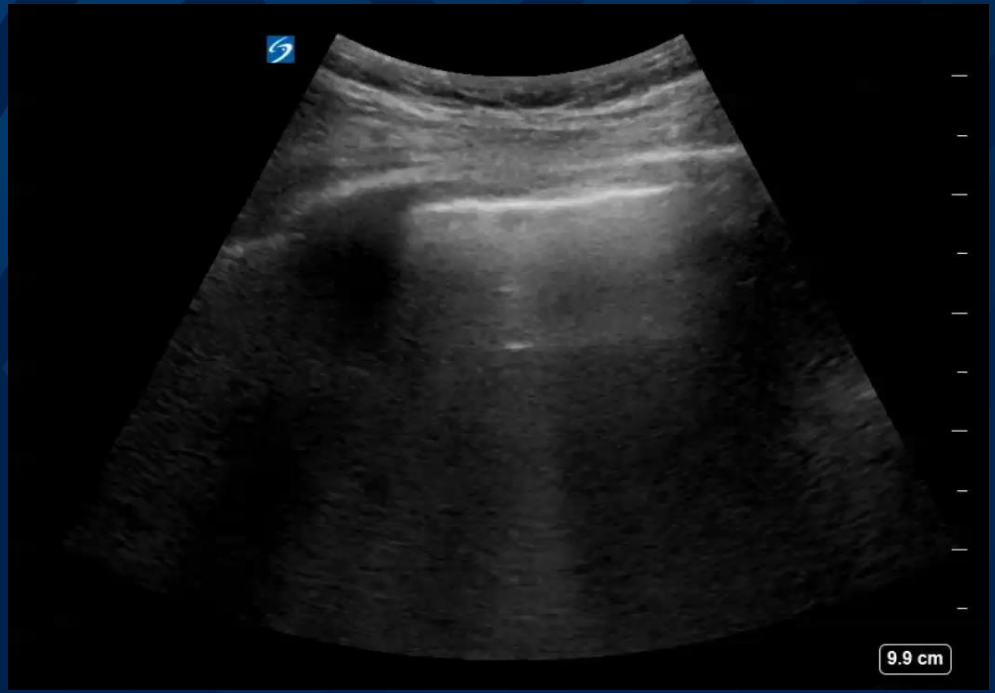
**Normal**


**Edema**



# Pulmonary Edema

- Pearls and Pitfalls
  - Look in several lung fields
  - Look for pleural effusions
  - Must use in context with patient presentation



# Take Home Points Case 1

- POCUS of heart and lungs can provide critical information in the evaluation of the dyspneic patient
- Focused echo evaluating global function is within the scope of practice for Hospitalists
- Lung ultrasound can be quickly and accurately be used to evaluate for alveolar fluid
- Symmetric B lines = Edema
- Patchy or Focal B Lines = Infectious/Inflammatory

# Case #2

- 54 yo male with dyspnea on exertion and right leg pain with ambulation
- PMHx of HTN, Asthma, DVT/PE, GI bleed
- Vitals:
  - HR 104
  - BP 108/68
  - RR 21
  - Sat 90% on RA

# POCUS Echo Questions

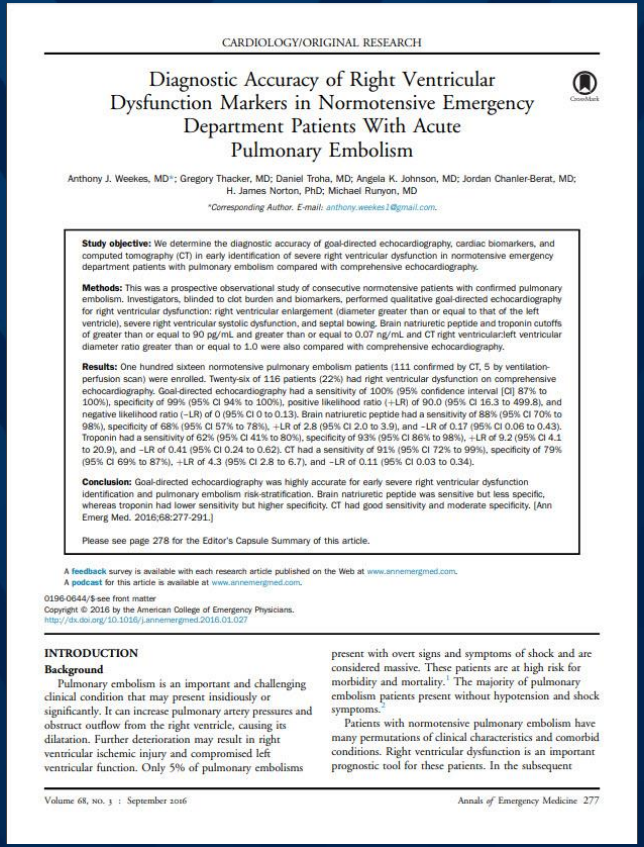
- Is there squeeze or not?
- How is the global function?
- Is there right heart strain?
- Is there a pericardial effusion?
- Are there obvious structural abnormalities?

# POCUS Echo Questions

- Is there squeeze or not?
- How is the global function?
- Is there right heart strain?
- Is there a pericardial effusion?
- Are there obvious structural abnormalities?

# Evidence

- Diagnostic Accuracy of Right Ventricular Dysfunction Markers in Normotensive Emergency Department Patients With Acute Pulmonary Embolism. Weekes, Anthony J. et al. Annals of Emergency Medicine
- Prospective observational study Investigators were blinded
  - 116 patient's with confirmed PE had focused US looking for RV strain
  - 5 investigators (1 Staff US director, 1 US Fellow, 3 EM Residents)
  - 100% Sensitivity and 99% Specificity for RV strain compared to comprehensive echo
- "Goal-directed echocardiography was highly accurate for early severe right ventricular dysfunction identification and pulmonary embolism risk-stratification."



CARDIOLOGY/ORIGINAL RESEARCH

Diagnostic Accuracy of Right Ventricular Dysfunction Markers in Normotensive Emergency Department Patients With Acute Pulmonary Embolism

Anthony J. Weekes, MD*; Gregory Thacker, MD; Daniel Troha, MD; Angela K. Johnson, MD; Jordan Chanler-Berat, MD; H. James Norton, PhD; Michael Runyon, MD

*Corresponding Author. E-mail: anthony.weekes1@gmail.com.

**Study objective:** We determine the diagnostic accuracy of goal-directed echocardiography, cardiac biomarkers, and computed tomography (CT) in early identification of severe right ventricular dysfunction in normotensive emergency department patients with pulmonary embolism compared with comprehensive echocardiography.

**Methods:** This was a prospective observational study of consecutive normotensive patients with confirmed pulmonary embolism. Investigators, blinded to clot burden and biomarkers, performed qualitative goal-directed echocardiography for right ventricular dysfunction: right ventricular enlargement (diameter greater than or equal to that of the left ventricle), severe right ventricular systolic dysfunction, and septal bowing. Brain natriuretic peptide and troponin cutoffs of greater than or equal to 90 pg/mL and greater than or equal to 0.07 ng/mL and CT right ventricular:left ventricular diameter ratio greater than or equal to 1.0 were also compared with comprehensive echocardiography.

**Results:** One hundred sixteen normotensive pulmonary embolism patients (111 confirmed by CT, 5 by ventilation-perfusion scan) were enrolled. Twenty-six of 116 patients (22%) had right ventricular dysfunction on comprehensive echocardiography. Goal-directed echocardiography had a sensitivity of 100% (95% confidence interval [CI] 87% to 100%), specificity of 99% (95% CI 94% to 100%), positive likelihood ratio (+LR) of 90.0 (95% CI 16.3 to 499.8), and negative likelihood ratio (–LR) of 0 (95% CI 0 to 0.13). Brain natriuretic peptide had a sensitivity of 88% (95% CI 70% to 98%), specificity of 68% (95% CI 57% to 78%), +LR of 2.8 (95% CI 2.0 to 3.9), and –LR of 0.17 (95% CI 0.06 to 0.43). Troponin had a sensitivity of 62% (95% CI 41% to 80%), specificity of 93% (95% CI 86% to 98%), +LR of 9.2 (95% CI 4.1 to 20.9), and –LR of 0.41 (95% CI 0.24 to 0.62). CT had a sensitivity of 91% (95% CI 72% to 99%), specificity of 79% (95% CI 69% to 87%), +LR of 4.3 (95% CI 2.8 to 6.7), and –LR of 0.11 (95% CI 0.03 to 0.34).

**Conclusion:** Goal-directed echocardiography was highly accurate for early severe right ventricular dysfunction identification and pulmonary embolism risk-stratification. Brain natriuretic peptide was sensitive but less specific, whereas troponin had lower sensitivity but higher specificity. CT had good sensitivity and moderate specificity. [Ann Emerg Med. 2016;68:277-291.]

Please see page 278 for the Editor's Capsule Summary of this article.

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0196-0644/$-see front matter

http://dx.doi.org/10.1016/j.annemergmed.2016.01.027

**INTRODUCTION**

**Background**

Pulmonary embolism is an important and challenging clinical condition that may present insidiously or significantly. It can increase pulmonary artery pressures and obstruct outflow from the right ventricle, causing its dilatation. Further deterioration may result in right ventricular ischemic injury and compromised left ventricular function. Only 5% of pulmonary embolisms present with overt signs and symptoms of shock and are considered massive. These patients are at high risk for morbidity and mortality.[1] The majority of pulmonary embolism patients present without hypotension and shock symptoms.[2]

Patients with normotensive pulmonary embolism have many permutations of clinical characteristics and comorbid conditions. Right ventricular dysfunction is an important prognostic tool for these patients. In the subsequent

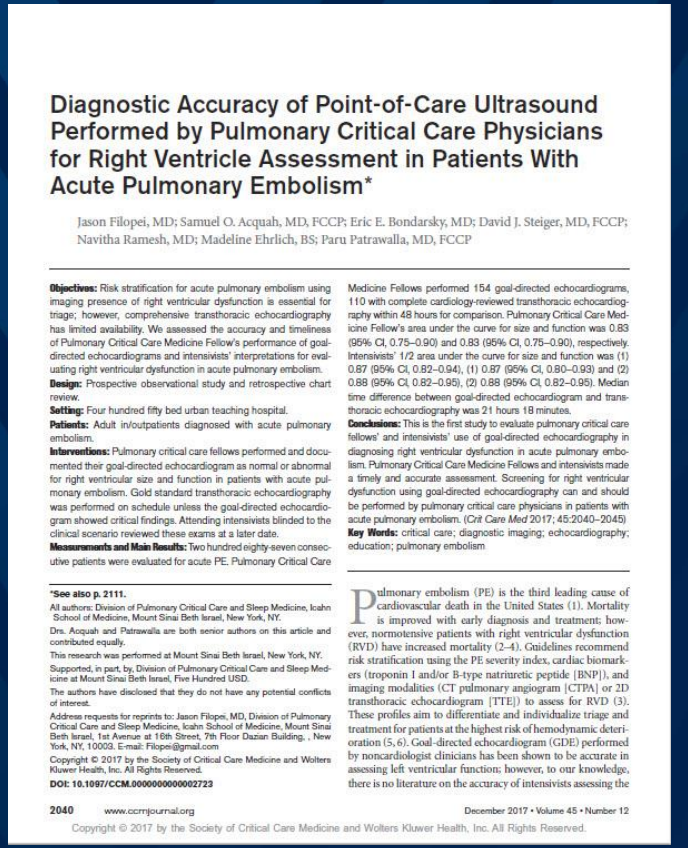


Weekes, Anthony J. et al. Diagnostic Accuracy of Right Ventricular Dysfunction Markers in Normotensive Emergency Department Patients With Acute Pulmonary Embolism. Annals of Emergency Medicine , Volume 68 , Issue 3 , 277 – 291

WestVirginiaUniversity.

# Evidence

- Diagnostic Accuracy of Point-of-Care Ultrasound Performed by Pulmonary Critical Care Physicians for Right Ventricle Assessment in Patients With Acute Pulmonary Embolism. Filopei J. et al. Crit Care Med. 2017
  - Prospective observational study
  - 154 focused echo's
  - CC Fellows were 83% sensitive and specific, Staff was 87% sensitive and specific at diagnosing RV enlargement compared to comprehensive echo
  - Median time to get comprehensive echo was 21 hours 18 minutes
  - "Screening for right ventricular dysfunction using goal-directed echocardiography can and should be performed by pulmonary critical care physicians in patients with acute pulmonary embolism".



## Diagnostic Accuracy of Point-of-Care Ultrasound Performed by Pulmonary Critical Care Physicians for Right Ventricle Assessment in Patients With Acute Pulmonary Embolism*

Jason Filopei, MD; Samuel O. Acquah, MD, FCCP; Eric E. Bondarsky, MD; David J. Steiger, MD, FCCP; Navitha Ramesh, MD; Madeline Ehrlich, BS; Paru Patrawalla, MD, FCCP

**Objectives:** Risk stratification for acute pulmonary embolism using imaging presence of right ventricular dysfunction is essential for triage; however, comprehensive transthoracic echocardiography has limited availability. We assessed the accuracy and timeliness of Pulmonary Critical Care Medicine Fellow's performance of goal-directed echocardiograms and intensivists' interpretations for evaluating right ventricular dysfunction in acute pulmonary embolism.

**Design:** Prospective observational study and retrospective chart review.

**Setting:** Four hundred fifty bed urban teaching hospital.

**Patients:** Adult in/outpatients diagnosed with acute pulmonary embolism.

**Interventions:** Pulmonary critical care fellows performed and documented their goal-directed echocardiogram as normal or abnormal for right ventricular size and function in patients with acute pulmonary embolism. Gold standard transthoracic echocardiography was performed on schedule unless the goal-directed echocardiogram showed critical findings. Attending intensivists blinded to the clinical scenario reviewed these exams at a later date.

**Measurements and Main Results:** Two hundred eighty-seven consecutive patients were evaluated for acute PE. Pulmonary Critical Care Medicine Fellows performed 154 goal-directed echocardiograms, 110 with complete cardiology-reviewed transthoracic echocardiography within 48 hours for comparison. Pulmonary Critical Care Medicine Fellow's area under the curve for size and function was 0.83 (95% CI, 0.75–0.90) and 0.83 (95% CI, 0.75–0.90), respectively. Intensivists' 1/2 area under the curve for size and function was (1) 0.87 (95% CI, 0.82–0.94), (1) 0.87 (95% CI, 0.80–0.93) and (2) 0.88 (95% CI, 0.82–0.95), (2) 0.88 (95% CI, 0.82–0.95). Median time difference between goal-directed echocardiogram and transthoracic echocardiography was 21 hours 18 minutes.

**Conclusions:** This is the first study to evaluate pulmonary critical care fellows' and intensivists' use of goal-directed echocardiography in diagnosing right ventricular dysfunction in acute pulmonary embolism. Pulmonary Critical Care Medicine Fellows and intensivists made a timely and accurate assessment. Screening for right ventricular dysfunction using goal-directed echocardiography can and should be performed by pulmonary critical care physicians in patients with acute pulmonary embolism. (*Crit Care Med* 2017; 45:2040–2045)

**Key Words:** critical care; diagnostic imaging; echocardiography; education; pulmonary embolism

*See also p. 2111.

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Drs. Acquah and Patrawalla are both senior authors on this article and contributed equally.

This research was performed at Mount Sinai Beth Israel, New York, NY.

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Pulmonary embolism (PE) is the third leading cause of cardiovascular death in the United States (1). Mortality is improved with early diagnosis and treatment; however, normotensive patients with right ventricular dysfunction (RVD) have increased mortality (2–4). Guidelines recommend risk stratification using the PE severity index, cardiac biomarkers (troponin I and/or B-type natriuretic peptide [BNP]), and imaging modalities (CT pulmonary angiogram [CTPA] or 2D transthoracic echocardiogram [TTE]) to assess for RVD (3). These profiles aim to differentiate and individualize triage and treatment for patients at the highest risk of hemodynamic deterioration (5, 6). Goal-directed echocardiogram (GDE) performed by noncardiologist clinicians has been shown to be accurate in assessing left ventricular function; however, to our knowledge, there is no literature on the accuracy of intensivists assessing the





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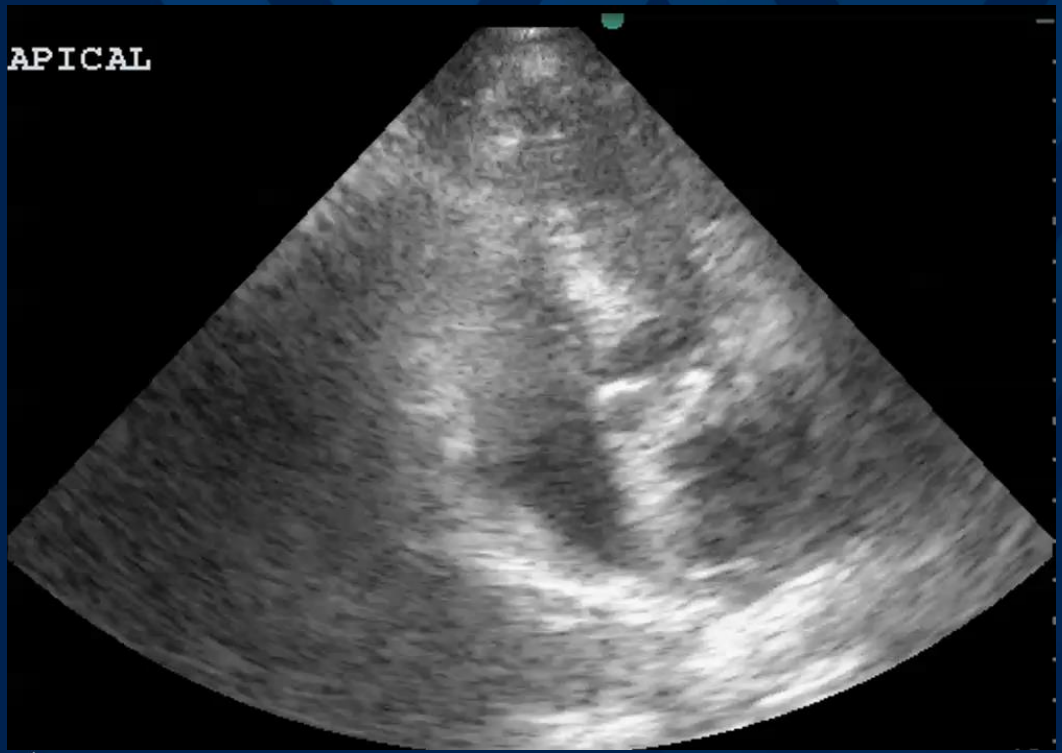
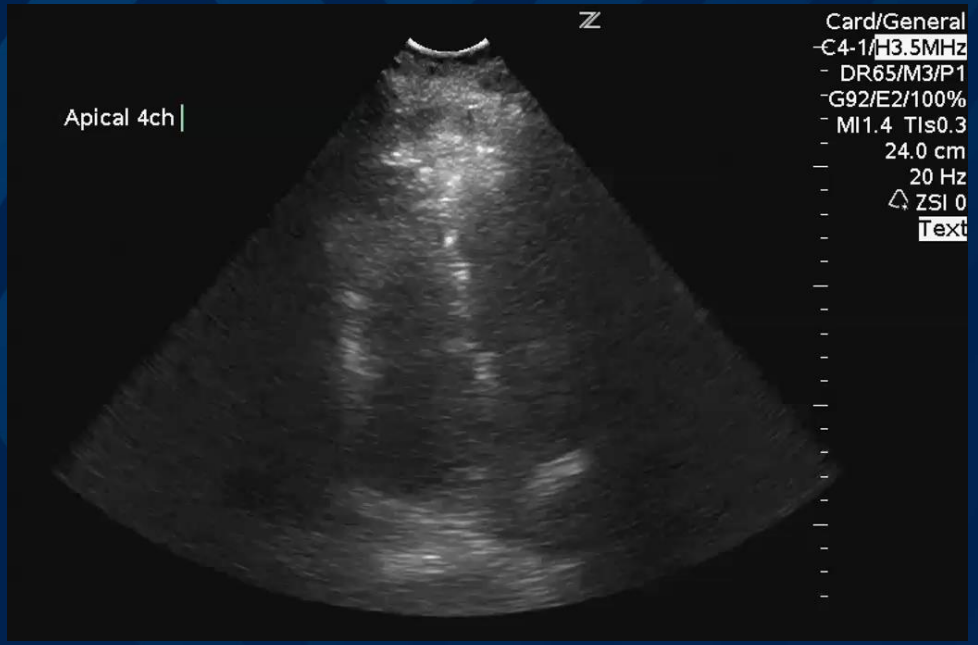
Filopei J. et al. Diagnostic Accuracy of Point-of-Care Ultrasound Performed by Pulmonary Critical Care Physicians for Right Ventricle Assessment in Patients With Acute Pulmonary Embolism. Crit Care Med. 2017 Dec;45(12):2040-2045. doi: 10.1097/CCM.0000000000002723.

# Sometimes We Get Lucky



# RV Strain

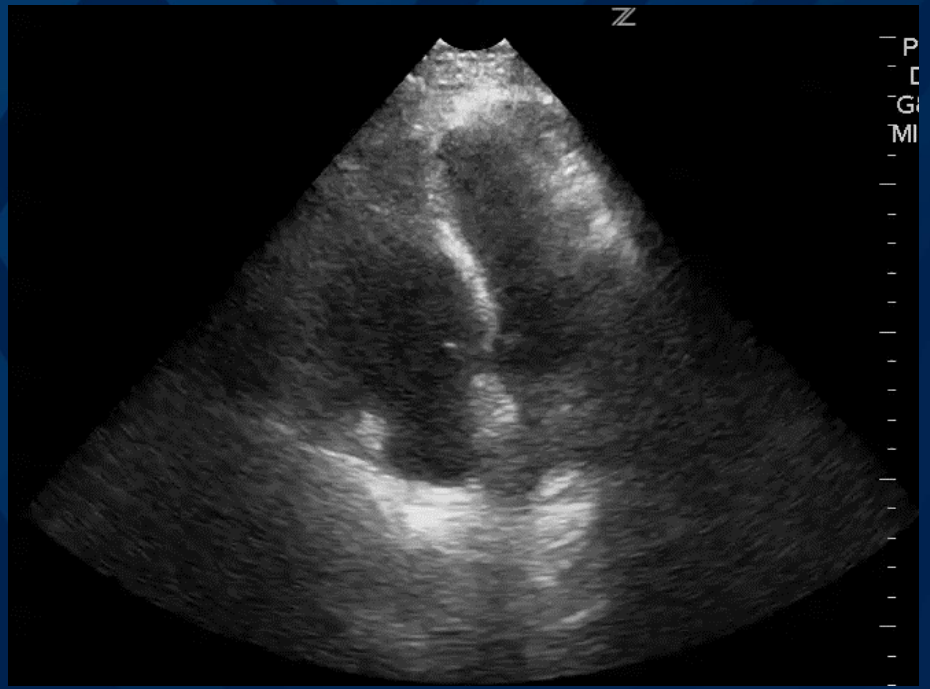
- RV enlargement to >2/3 size of the LV
- Compression of the septal wall (D Sign)
- Septal dyssynchrony
- Akinesis of the RV with hyper-dynamic apex (McConnell's Sign)



# RV Strain

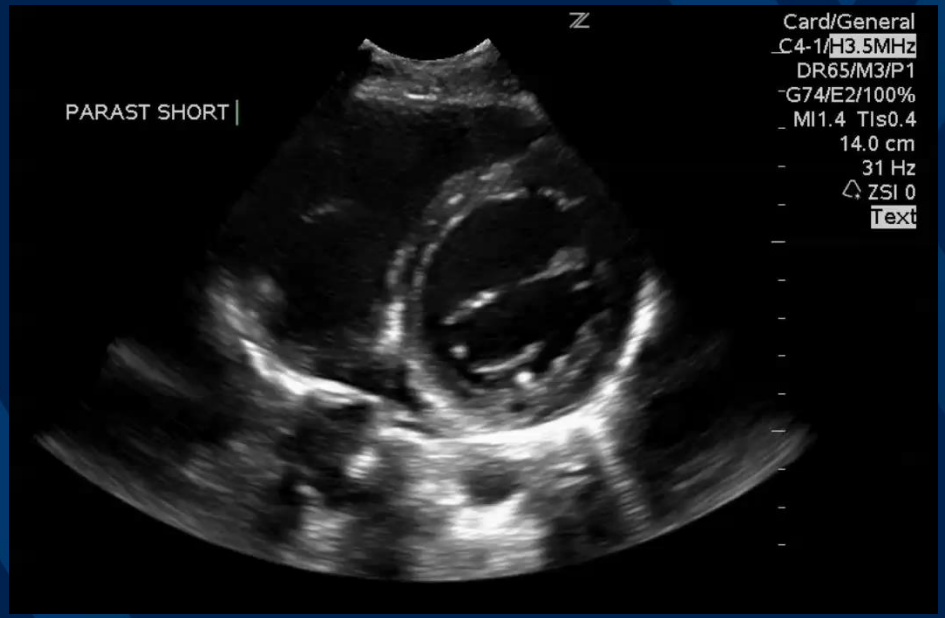
**Normal**


**RV Strain**

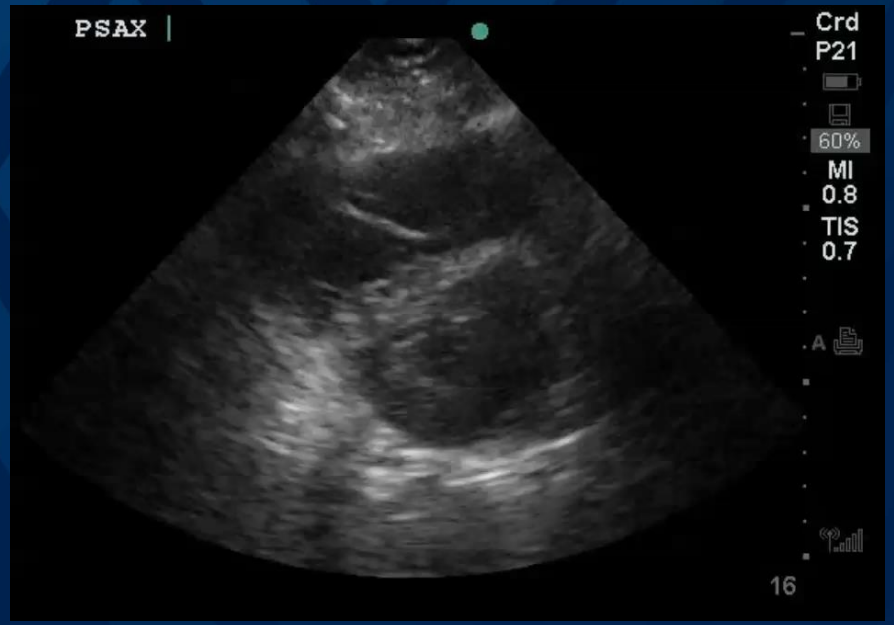


# RV Strain

**Normal**




**RV Strain**

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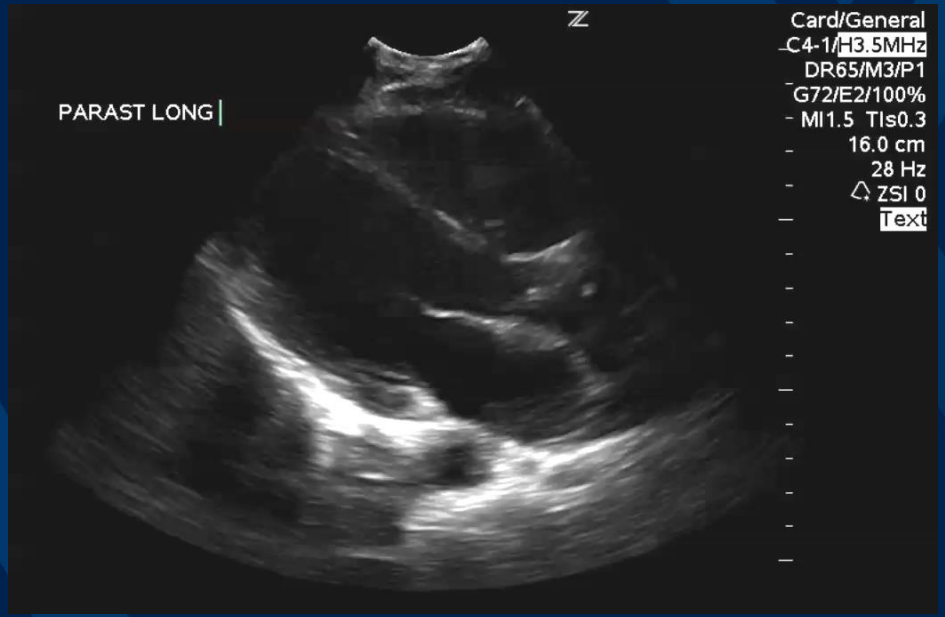
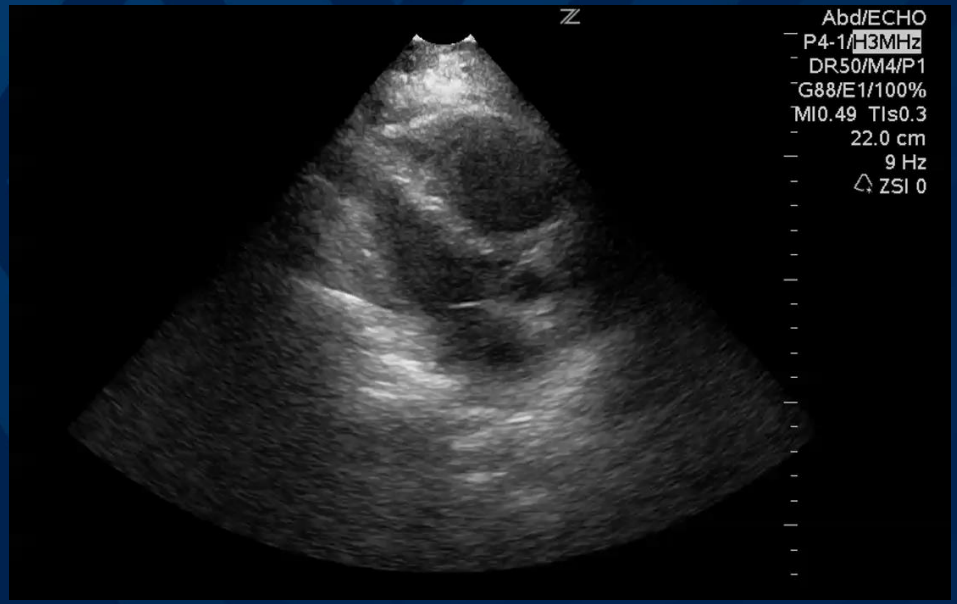
# RV Strain

## Normal




## RV Strain



# RV Strain

- Pearls and Pitfalls:
- Absence of RV dilation does not exclude PE
- Mimicks:
  - Pulmonary HTN
    - RV hypertrophy
    - RA dilation
  - LBBB

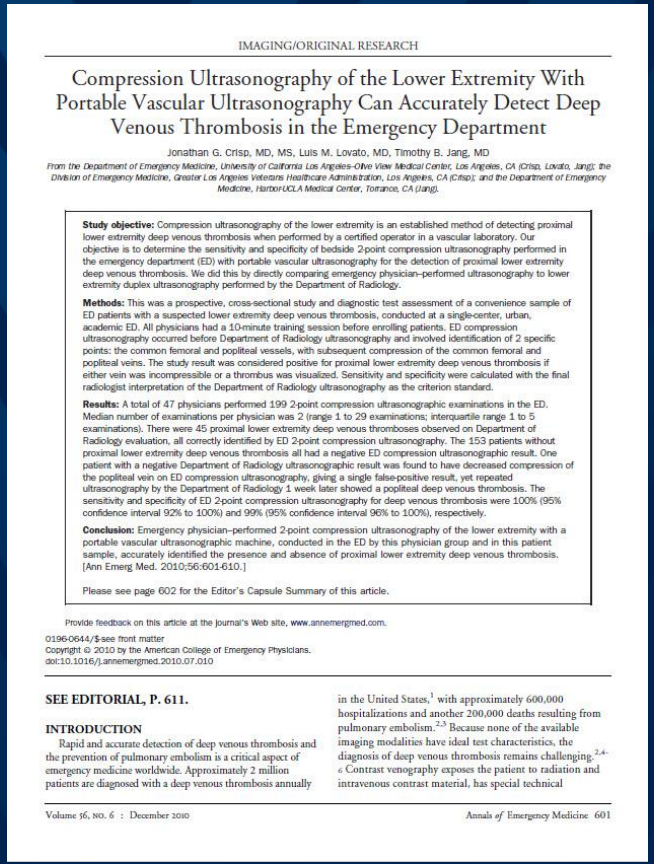
# Extremity Ultrasound for DVT

# Questions for LE DVT Ultrasound

- Does the vein compress?
- Is there visible thrombosis?

# Evidence

- Compression ultrasonography of the lower extremity with portable vascular ultrasonography can accurately detect deep venous thrombosis in the emergency department. Crisp JG et al. Ann Emerg Med 2010
  - Prospective, cross-sectional study for proximal DVT
  - 47 physicians underwent a 10 minute training session
  - 199 Bedside 2 point compression studies performed compared to Radiology performed DVT study
  - 45 true positives, 1 false positive (had a DVT 1 wk later), 153 true negatives
  - 100% sensitivity and 99% specificity



IMAGING/ORIGINAL RESEARCH

## Compression Ultrasonography of the Lower Extremity With Portable Vascular Ultrasonography Can Accurately Detect Deep Venous Thrombosis in the Emergency Department

Jonathan G. Crisp, MD, MS, Luis M. Lovato, MD, Timothy B. Jang, MD

*From the Department of Emergency Medicine, University of California Los Angeles–Olive View Medical Center, Los Angeles, CA (Crisp, Lovato, Jang); the Division of Emergency Medicine, Greater Los Angeles Veterans Healthcare Administration, Los Angeles, CA (Crisp); and the Department of Emergency Medicine, Harbor-UCLA Medical Center, Torrance, CA (Jang).*

**Study objective:** Compression ultrasonography of the lower extremity is an established method of detecting proximal lower extremity deep venous thrombosis when performed by a certified operator in a vascular laboratory. Our objective is to determine the sensitivity and specificity of bedside 2-point compression ultrasonography performed in the emergency department (ED) with portable vascular ultrasonography for the detection of proximal lower extremity deep venous thrombosis. We did this by directly comparing emergency physician–performed ultrasonography to lower extremity duplex ultrasonography performed by the Department of Radiology.

**Methods:** This was a prospective, cross-sectional study and diagnostic test assessment of a convenience sample of ED patients with a suspected lower extremity deep venous thrombosis, conducted at a single-center, urban, academic ED. All physicians had a 10-minute training session before enrolling patients. ED compression ultrasonography occurred before Department of Radiology ultrasonography and involved identification of 2 specific points: the common femoral and popliteal vessels, with subsequent compression of the common femoral and popliteal veins. The study result was considered positive for proximal lower extremity deep venous thrombosis if either vein was incompressible or a thrombus was visualized. Sensitivity and specificity were calculated with the final radiologist interpretation of the Department of Radiology ultrasonography as the criterion standard.

**Results:** A total of 47 physicians performed 199 2-point compression ultrasonographic examinations in the ED. Median number of examinations per physician was 2 (range 1 to 29 examinations; interquartile range 1 to 5 examinations). There were 45 proximal lower extremity deep venous thromboses observed on Department of Radiology evaluation, all correctly identified by ED 2-point compression ultrasonography. The 153 patients without proximal lower extremity deep venous thrombosis all had a negative ED compression ultrasonographic result. One patient with a negative Department of Radiology ultrasonographic result was found to have decreased compression of the popliteal vein on ED compression ultrasonography, giving a single false-positive result, yet repeated ultrasonography by the Department of Radiology 1 week later showed a popliteal deep venous thrombosis. The sensitivity and specificity of ED 2-point compression ultrasonography for deep venous thrombosis were 100% (95% confidence interval 92% to 100%) and 99% (95% confidence interval 96% to 100%), respectively.

**Conclusion:** Emergency physician–performed 2-point compression ultrasonography of the lower extremity with a portable vascular ultrasonographic machine, conducted in the ED by this physician group and in this patient sample, accurately identified the presence and absence of proximal lower extremity deep venous thrombosis. [Ann Emerg Med. 2010;56:601-610.]

Please see page 602 for the Editor's Capsule Summary of this article.

Provide feedback on this article at the journal's Web site, www.annemergmed.com.

0196-0644/$-see front matter

doi:10.1016/j.annemergmed.2010.07.010

SEE EDITORIAL, P. 611.

### INTRODUCTION

Rapid and accurate detection of deep venous thrombosis and the prevention of pulmonary embolism is a critical aspect of emergency medicine worldwide. Approximately 2 million patients are diagnosed with a deep venous thrombosis annually in the United States,[1] with approximately 600,000 hospitalizations and another 200,000 deaths resulting from pulmonary embolism.[2,3] Because none of the available imaging modalities have ideal test characteristics, the diagnosis of deep venous thrombosis remains challenging.[2,4-6] Contrast venography exposes the patient to radiation and intravenous contrast material, has special technical

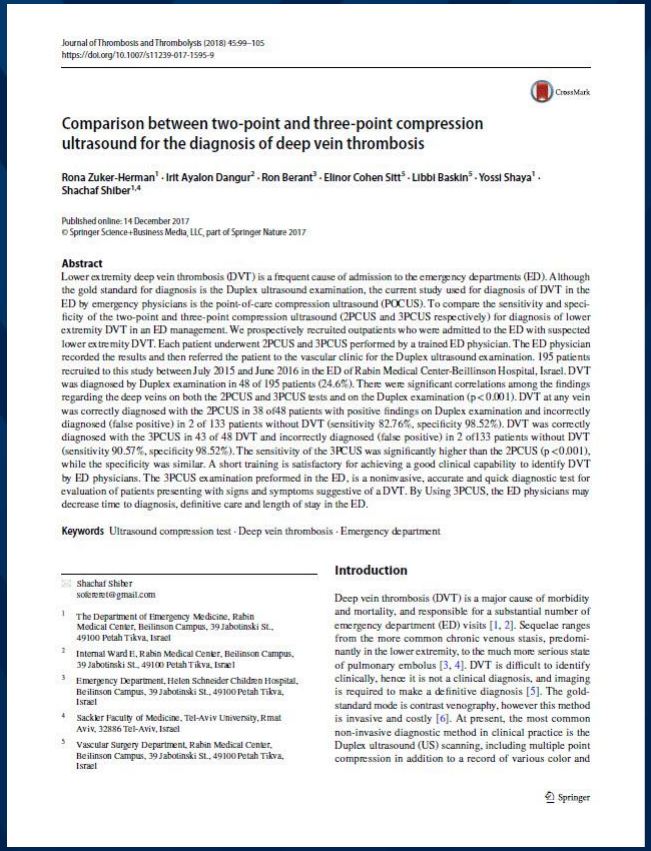




Crisp JG, Lovato LM, Jang TB (2010) Compression ultrasonography of the lower extremity with portable vascular ultrasonography can accurately detect deep venous thrombosis in the emergency department. Ann Emerg Med 56:601–610

# Evidence

- Comparison between two-point and three-point compression ultrasound for the diagnosis of deep vein thrombosis. Zuker-Herman R. et al. J Thromb Thrombolysis 2018
- 195 patients enrolled and 48 were found to have DVT by complete duplex
  - 2 point
    - sensitivity 82.76%, specificity 98.52%
  - 3 point
    - sensitivity 90.57%, specificity 98.52%
- “The 3PCUS examination preformed in the ED, is a noninvasive, accurate and quick diagnostic test for evaluation of patients presenting with signs and symptoms suggestive of a DVT.”



Journal of Thrombosis and Thrombolysis (2018) 45:99–105
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## Comparison between two-point and three-point compression ultrasound for the diagnosis of deep vein thrombosis

Rona Zuker-Herman[1] · Irit Ayalon Dangur[2] · Ron Berant[3] · Elinor Cohen Sitt[5] · Libbi Baskin[5] · Yossi Shaya[1] · Shachaf Shiber[1,4]

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**Abstract**
Lower extremity deep vein thrombosis (DVT) is a frequent cause of admission to the emergency departments (ED). Although the gold standard for diagnosis is the Duplex ultrasound examination, the current study used for diagnosis of DVT in the ED by emergency physicians is the point-of-care compression ultrasound (POCUS). To compare the sensitivity and specificity of the two-point and three-point compression ultrasound (2PCUS and 3PCUS respectively) for diagnosis of lower extremity DVT in an ED management. We prospectively recruited outpatients who were admitted to the ED with suspected lower extremity DVT. Each patient underwent 2PCUS and 3PCUS performed by a trained ED physician. The ED physician recorded the results and then referred the patient to the vascular clinic for the Duplex ultrasound examination. 195 patients recruited to this study between July 2015 and June 2016 in the ED of Rabin Medical Center-Beilinson Hospital, Israel. DVT was diagnosed by Duplex examination in 48 of 195 patients (24.6%). There were significant correlations among the findings regarding the deep veins on both the 2PCUS and 3PCUS tests and on the Duplex examination ($p < 0.001$). DVT at any vein was correctly diagnosed with the 2PCUS in 38 of48 patients with positive findings on Duplex examination and incorrectly diagnosed (false positive) in 2 of 133 patients without DVT (sensitivity 82.76%, specificity 98.52%). DVT was correctly diagnosed with the 3PCUS in 43 of 48 DVT and incorrectly diagnosed (false positive) in 2 of133 patients without DVT (sensitivity 90.57%, specificity 98.52%). The sensitivity of the 3PCUS was significantly higher than the 2PCUS ($p < 0.001$), while the specificity was similar. A short training is satisfactory for achieving a good clinical capability to identify DVT by ED physicians. The 3PCUS examination preformed in the ED, is a noninvasive, accurate and quick diagnostic test for evaluation of patients presenting with signs and symptoms suggestive of a DVT. By Using 3PCUS, the ED physicians may decrease time to diagnosis, definitive care and length of stay in the ED.

**Keywords** Ultrasound compression test · Deep vein thrombosis · Emergency department

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### Introduction

Deep vein thrombosis (DVT) is a major cause of morbidity and mortality, and responsible for a substantial number of emergency department (ED) visits [1, 2]. Sequelae ranges from the more common chronic venous stasis, predominantly in the lower extremity, to the much more serious state of pulmonary embolus [3, 4]. DVT is difficult to identify clinically, hence it is not a clinical diagnosis, and imaging is required to make a definitive diagnosis [5]. The gold-standard mode is contrast venography, however this method is invasive and costly [6]. At present, the most common non-invasive diagnostic method in clinical practice is the Duplex ultrasound (US) scanning, including multiple point compression in addition to a record of various color and

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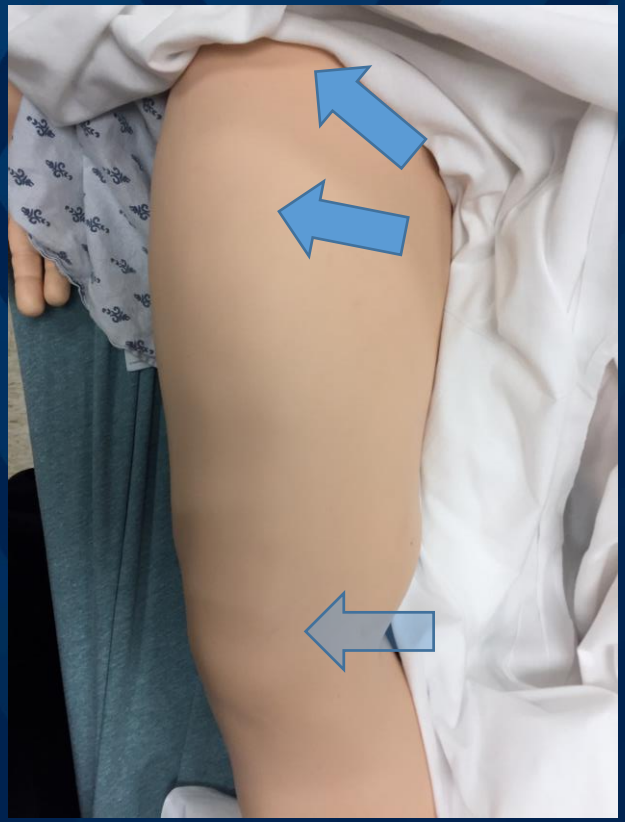
Zuker-Herman R. et al. Comparison between two-point and three-point compression ultrasound for the diagnosis of deep vein thrombosis. J Thromb Thrombolysis. 2018 Jan;45(1):99-105. doi: 10.1007/s11239-017-1595-9.

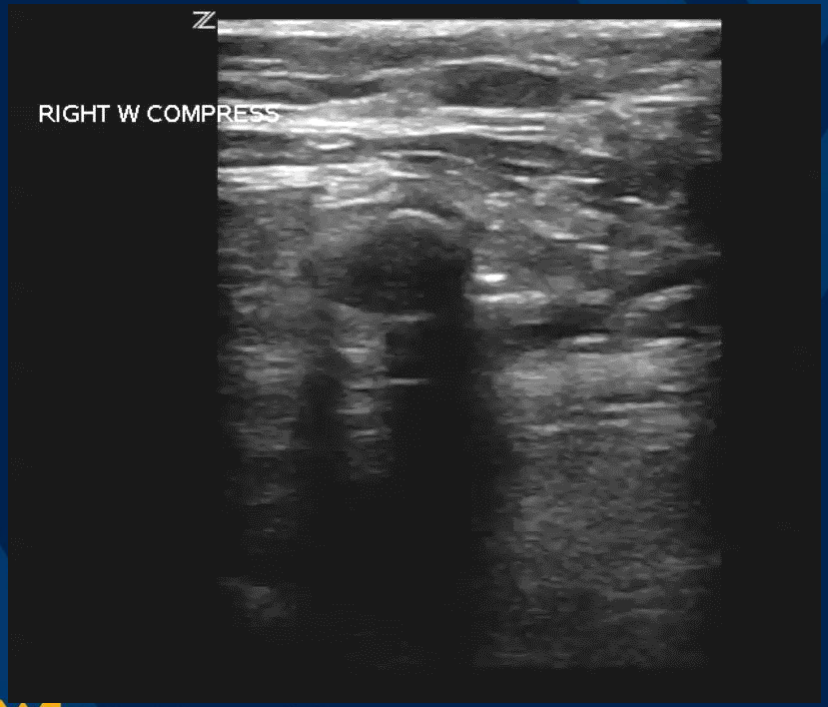
# Exam for LE DVT

- Linear or Low Frequency Transducer
- 3-point compression study
  - Great Saphenous and Common Femoral Junction
  - Deep Femoral and (Superficial) Femoral Junction
  - Popliteal Vein

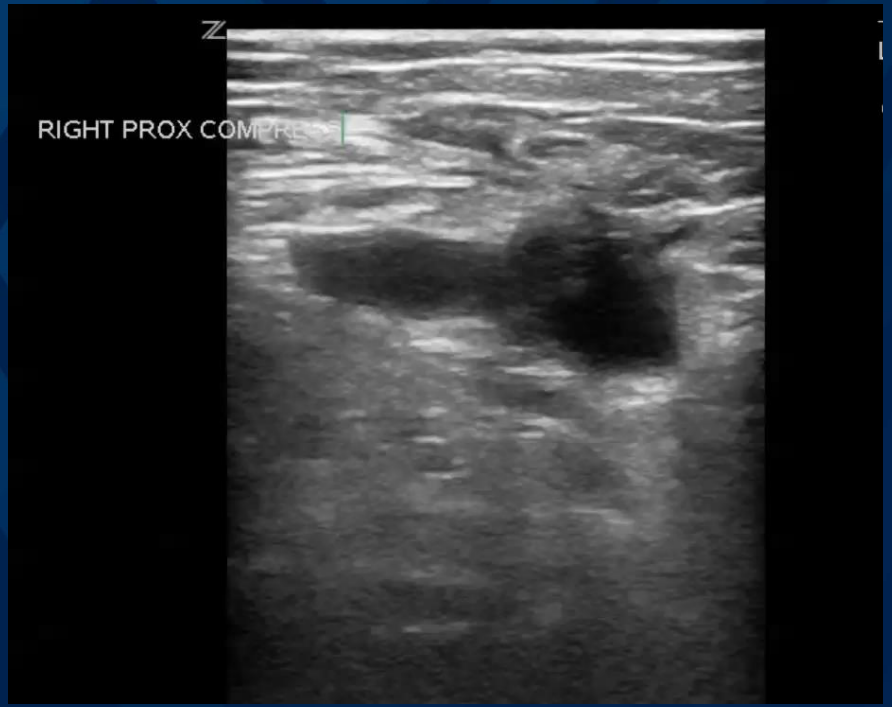


# Thromboembolism

**Normal**



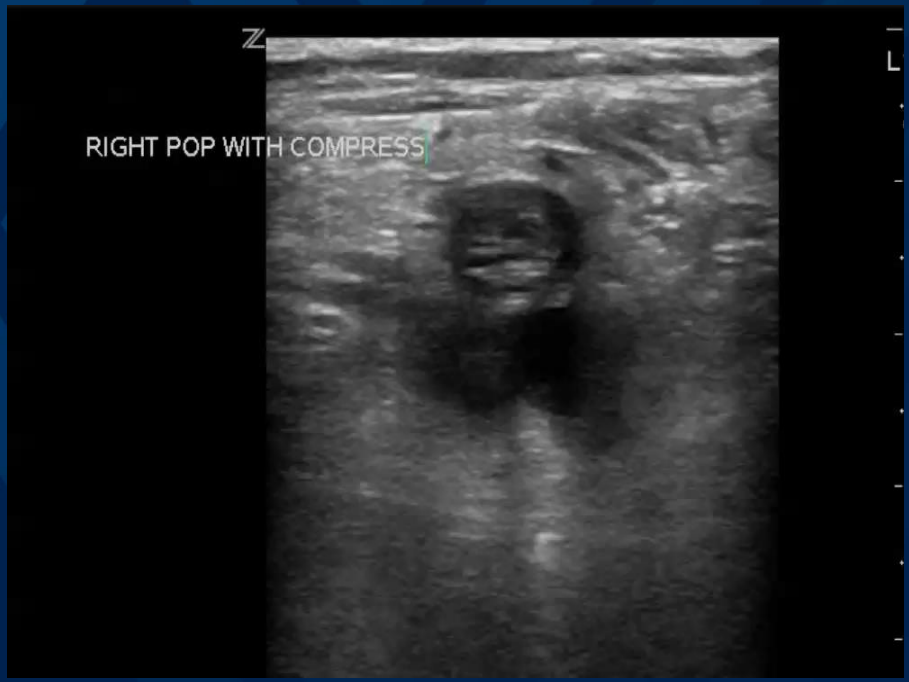

**DVT**



# Thromboembolism

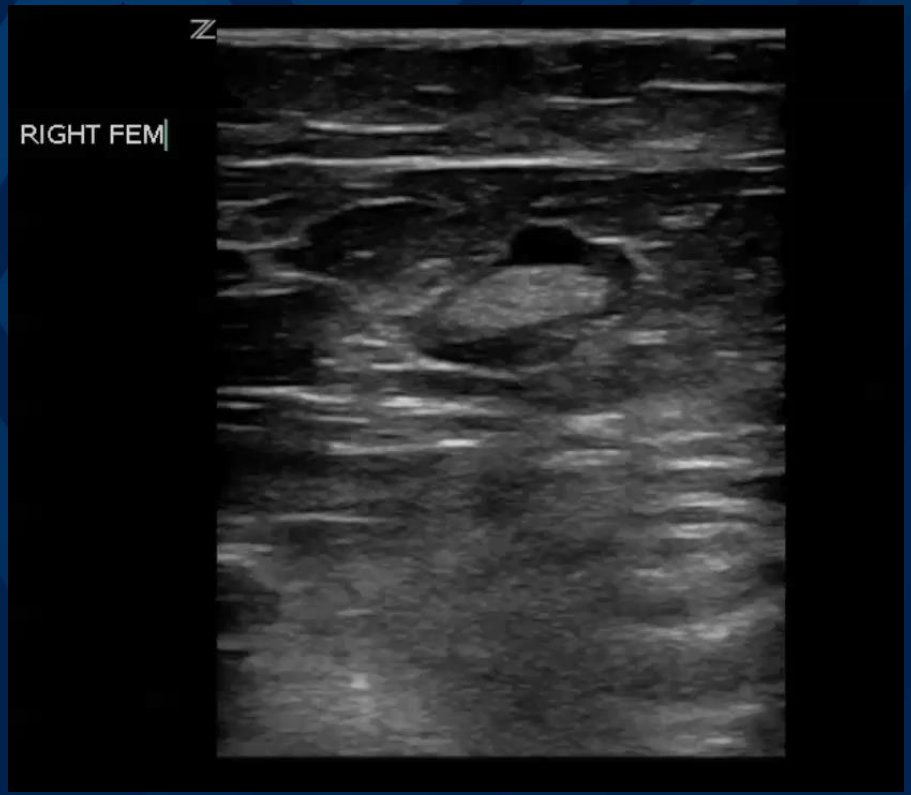
**Normal**


**DVT**



# Thromboembolism

- Pearls and Pitfalls:
  - Find the artery!
  - Mimicks
    - Lymph Nodes
    - Superficial Thrombophlebitis
  - Always get enough depth



# Take Home Points Case 2

- RV strain can be accurately and rapidly diagnosed at the bedside to guide treatment
- Use POCUS for DVT within the context of patient presentation
  - 2-point and 3-point compression studies miss calf DVT
  - In high risk, high suspicion patient, DVT can be ruled in but not out with 3-point study

# Case #3

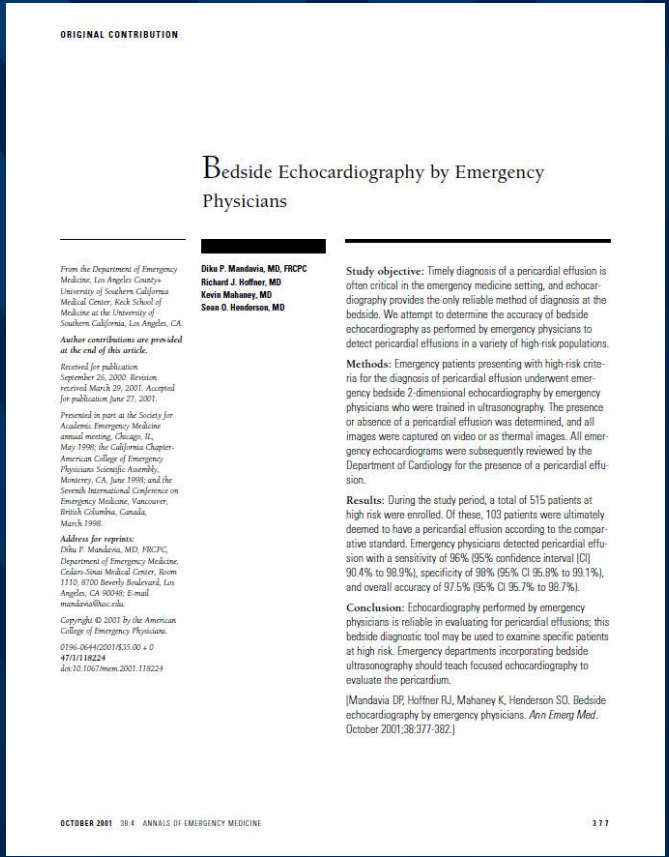
- 84 yo female with dyspnea and syncope
- PMHx of HTN, Hypothyroidism, hyperlipidemia
- Vitals:
  - HR 98
  - BP 118/88
  - RR 22
  - Sat 93% on RA

# POCUS Echo Questions

- Is there squeeze or not?
- How is the global function?
- Is there right heart strain?
- Is there a pericardial effusion?
- Are there obvious structural abnormalities?

# Evidence

- Bedside echocardiography by emergency physicians. Mandavia DP et al. Ann Emerg Med.
  - Physicians had a 16 hour course with 1 hour lecture and 4 hour lab on echo
  - 515 “high risk” patients, 478 studies were considered adequate
  - 103 effusions identified
  - Sensitivity was 96% and Specificity was 98% for diagnosis of effusion



ORIGINAL CONTRIBUTION

Bedside Echocardiography by Emergency Physicians

From the Department of Emergency Medicine, Los Angeles County+University of Southern California Medical Center, Keck School of Medicine at the University of Southern California, Los Angeles, CA.

Author contributions are provided at the end of this article.

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47/1/118224
doi:10.1067/mem.2001.118224

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Richard J. Hoffner, MD
Kevin Mahaney, MD
Sean O. Henderson, MD

**Study objective:** Timely diagnosis of a pericardial effusion is often critical in the emergency medicine setting, and echocardiography provides the only reliable method of diagnosis at the bedside. We attempt to determine the accuracy of bedside echocardiography as performed by emergency physicians to detect pericardial effusions in a variety of high-risk populations.

**Methods:** Emergency patients presenting with high-risk criteria for the diagnosis of pericardial effusion underwent emergency bedside 2-dimensional echocardiography by emergency physicians who were trained in ultrasonography. The presence or absence of a pericardial effusion was determined, and all images were captured on video or as thermal images. All emergency echocardiograms were subsequently reviewed by the Department of Cardiology for the presence of a pericardial effusion.

**Results:** During the study period, a total of 515 patients at high risk were enrolled. Of these, 103 patients were ultimately deemed to have a pericardial effusion according to the comparative standard. Emergency physicians detected pericardial effusion with a sensitivity of 96% (95% confidence interval [CI] 90.4% to 98.9%), specificity of 98% (95% CI 95.8% to 99.1%), and overall accuracy of 97.5% (95% CI 95.7% to 98.7%).

**Conclusion:** Echocardiography performed by emergency physicians is reliable in evaluating for pericardial effusions; this bedside diagnostic tool may be used to examine specific patients at high risk. Emergency departments incorporating bedside ultrasonography should teach focused echocardiography to evaluate the pericardium.

[Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. *Ann Emerg Med.* October 2001;38:377-382.]



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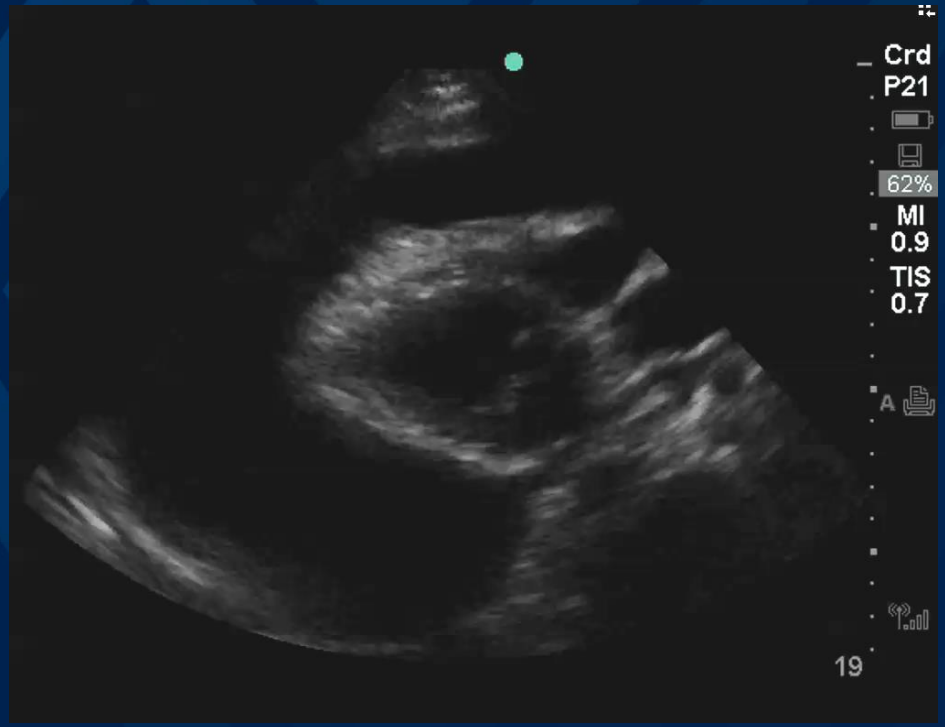
Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. Ann Emerg Med. 2001;38:377–82.

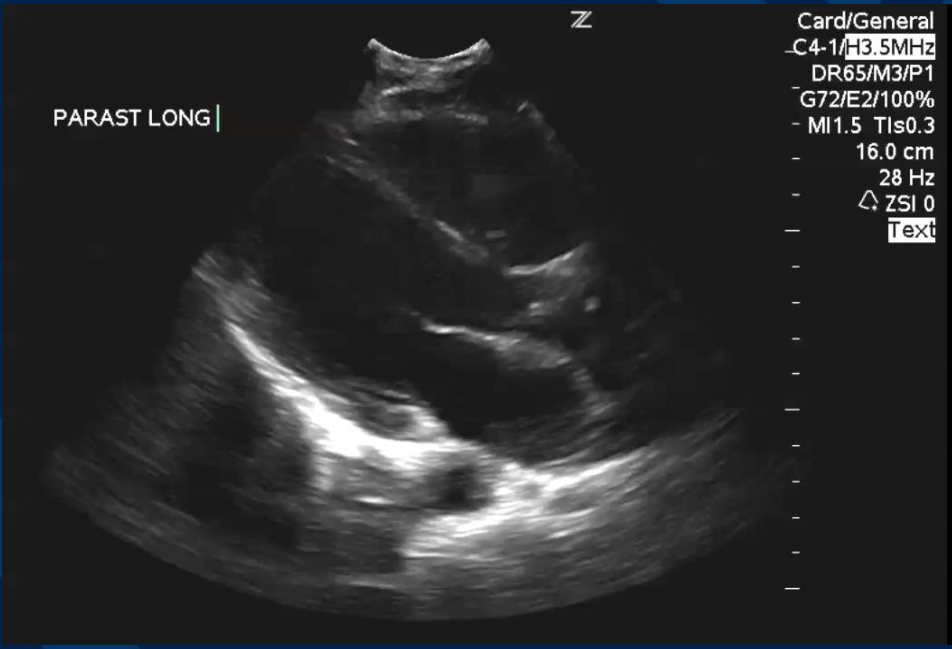
# Pericardial Effusion

- Use all 4 views to evaluate
- Simple fluid is hypoechoic
  - Uremic effusion
  - Malignant effusion
  - Pericarditis
  - Early blood
- Complex fluid will have hypoechoic areas with hyperechoic inclusions
  - Clotted blood
  - Purulent effusions

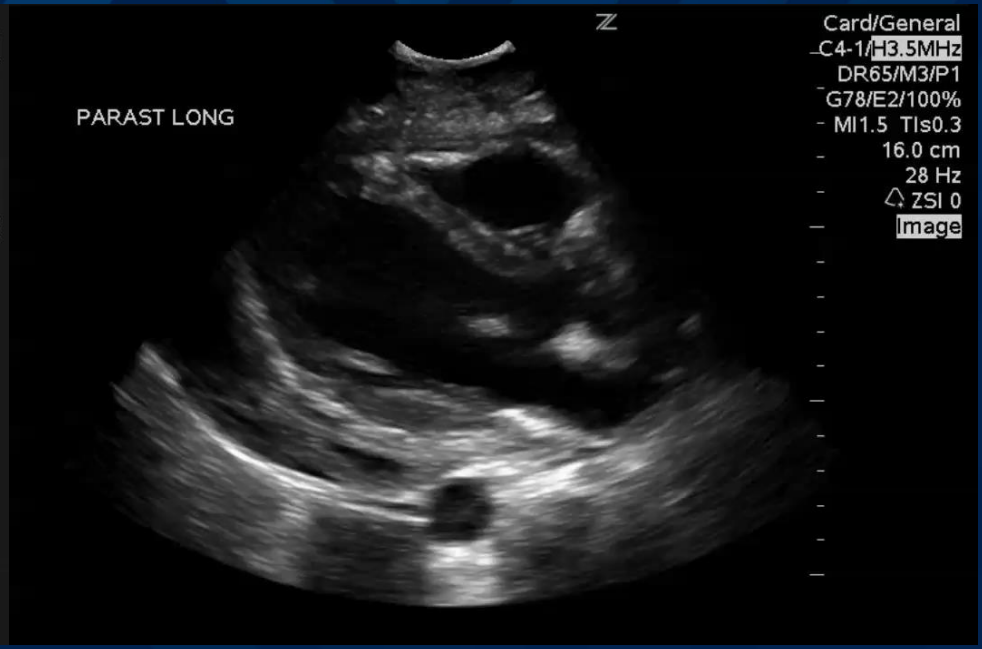


# Pericardial Effusion

**Normal**




**Effusion**

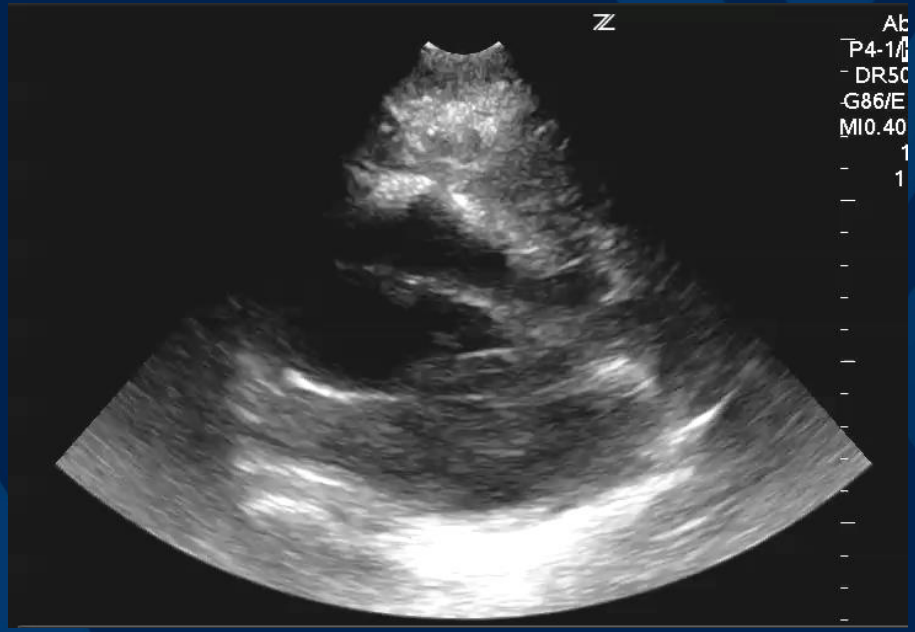


# Pericardial Effusion

**Normal**


**Effusion**

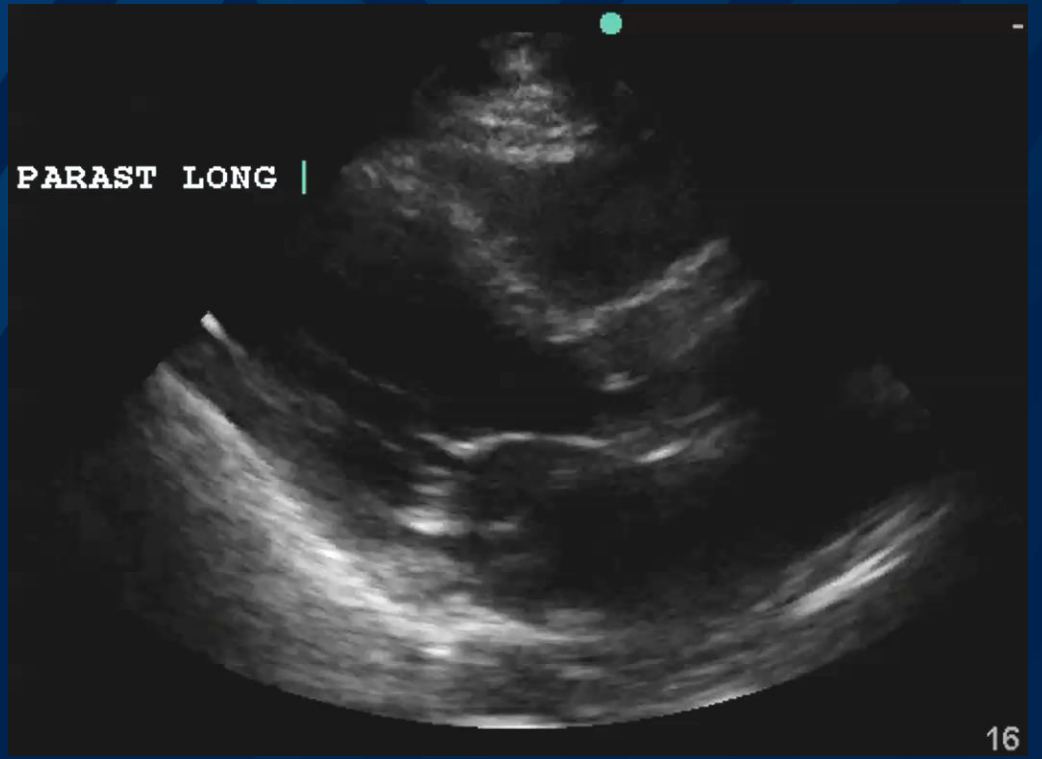
# Tamponade


Ab
P4-1/
DR50
G86/E
MI0.40


Ab/ECHO
P4-1/H3MHz
DR50/M4/P1
G82/E1/100%
MI0.44 TIs0.3
20.0 cm
10 Hz
ZSI 0

# Pericardial Effusion

- Pearls and Pitfalls:
- Tamponade is a clinical diagnosis!
- Mimics:
  - Prominent epicardial fat
  - Pleural Effusion



# Take Home Points Case 3

- Pericardial effusion can be accurately and rapidly identified on bedside ultrasound
- Tamponade is a clinical diagnosis, but ultrasound can indicate impending cardiovascular collapse

# Case #4

- 58 yo female with fatigue, dizziness, confusion
- PMHx of HTN, DM, CAD, Hyperlipidemia, COPD
- Vitals:
  - HR 122
  - BP 80/42
  - RR 26
  - Sat 91% on 2L NC

# Undifferentiated Shock Ultrasound

# Etiologies of Shock

- Cardiogenic
  - Pump failure
- Hypovolemic/hemorrhagic
  - Blood loss (thoracoabd, GI, AAA), fluid loss
- Distributive
  - Anaphylactic, neurogenic, sepsis*
- Obstructive
  - Cardiac tamponade, PE, tension ptx
- Endocrine

# Etiologies of Shock

- Cardiogenic
  - Pump failure
- Hypovolemic/hemorrhagic
  - Blood loss (thoracoabdominal, GI, AAA), fluid loss
- Distributive
  - Anaphylactic, neurogenic, sepsis
- Obstructive
  - Cardiac tamponade, PE, tension ptx
- Endocrine

# Undifferentiated Shock Questions?

- How is the global heart function?
- Is there right ventricular heart strain?
- Is there a pericardial effusion?
- Are there obvious cardiac structural abnormalities?
- Is the IVC collapsed?
- Is there an AAA?
- Is there FF in abdomen or thorax?
- Is there lung sliding?
- Do the proximal deep veins compress?
- Is there an obvious infectious source?

# RUSH Exam

- The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically lll. Perera P et al. Emerg Med Clin North Am. 2010
- In undifferentiated hypotension obtain the following: Heart, IVC, Aorta, RUQ, LUQ, Pelvis, Lungs, LE veins
- “The RUSH exam, presented in this article, represents a comprehensive algorithm for the integration of bedside ultrasound into the care of the patient in shock.”

**The RUSH Exam: Rapid Ultrasound in SHock in the Evaluation of the Critically lll**

Phillips Perera, MD, RDMS, FACEP[a,*], Thomas Mailhot, MD, RDMS[b], David Riley, MD, MS, RDMS[a], Diku Mandavia, MD, FACEP, FRCPC[b,c]

**KEYWORDS**
• Rapid ultrasound in shock examination • RUSH exam
• Shock • Ultrasound

Care of the patient with shock can be one of the most challenging issues in emergency medicine. Even the most seasoned clinician, standing at the bedside of the patient in extremis, can be unclear about the cause of shock and the optimal initial therapeutic approach. Traditional physical examination techniques can be misleading given the complex physiology of shock.[1] Patients in shock have high mortality rates, and these rates are correlated to the amount and duration of hypotension. Therefore, diagnosis and initial care must be accurate and prompt to optimize patient outcomes.[2] Failure to make the correct diagnosis and act appropriately can lead to potentially disastrous outcomes and high-risk situations.

Ultrasound technology has been rapidly integrated into Emergency Department care in the last decade. More practicing emergency physicians (EPs) are now trained in bedside point of care or goal-directed ultrasound, and this training is now included in all United States Accreditation Council for Graduate Medical Education Emergency Medicine residency programs.[3,4] Furthermore, the American College of Emergency Physicians (ACEP) has formally endorsed and embraced bedside ultrasound by the EP for multiple applications.[5] This technology is ideal in the care of the critical patient in shock, and the most recent ACEP guidelines further delineate a new category of

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Emerg Med Clin N Am 28 (2010) 29–56
doi:10.1016/j.emc.2009.09.010 emed.theclinics.com
0733-8627/09/$ – see front matter 

WestVirginiaUniversity.

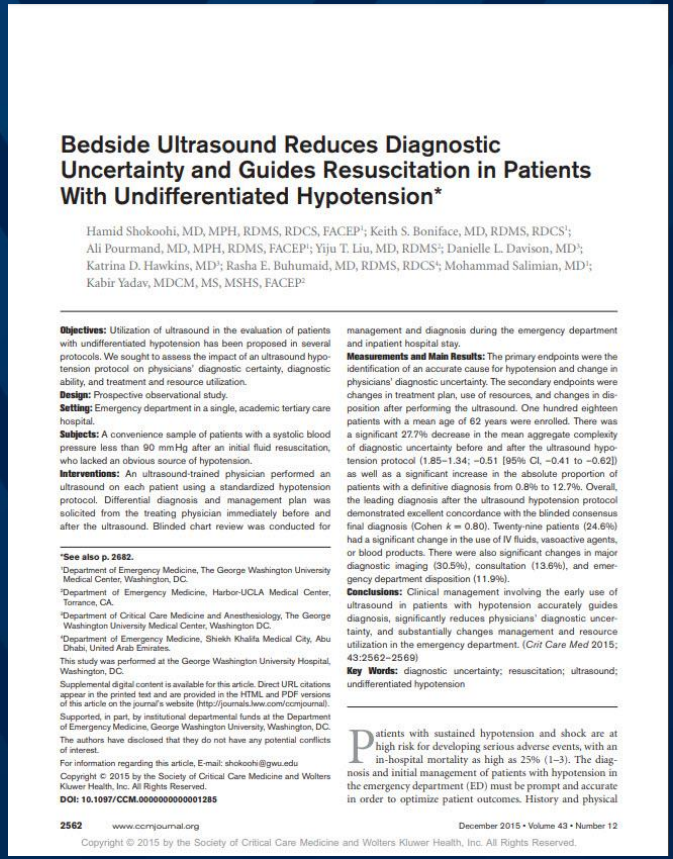
Perera P et.al. The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically lll. Emerg Med Clin North Am. 2010 Feb;28(1):29-56, vii. doi: 10.1016/j.emc.2009.09.010

# RUSH Exam

- Focuses on 3 main areas:
  - Pump
    - Contractility, Chamber Size, Effusion, RV Strain
  - Tank
    - IVC, Peritoneal Fluid, Thoracic Fluid/PTX/Pulmonary Edema
  - Pipes
    - Aorta and DVT

# Evidence

- Bedside Ultrasound Reduces Diagnostic Uncertainty and Guides Resuscitation in Patients With Undifferentiated Hypotension. Shokoohi H, et al. Crit Care Med. 2015
- Prospective observational study
  - 118 patients evaluated by ultrasound trained physicians
- “Clinical management involving the early use of ultrasound in patients with hypotension accurately guides diagnosis, significantly reduces physicians' diagnostic uncertainty, and substantially changes management and resource utilization…”



## Bedside Ultrasound Reduces Diagnostic Uncertainty and Guides Resuscitation in Patients With Undifferentiated Hypotension*

Hamid Shokoohi, MD, MPH, RDMS, RDCS, FACEP[1]; Keith S. Boniface, MD, RDMS, RDCS[1]; Ali Pourmand, MD, MPH, RDMS, FACEP[1]; Yiju T. Liu, MD, RDMS[2]; Danielle L. Davison, MD[3]; Katrina D. Hawkins, MD[3]; Rasha E. Buhumaid, MD, RDMS, RDCS[4]; Mohammad Salimian, MD[1]; Kabir Yadav, MDCM, MS, MSHS, FACEP[2]

**Objectives:** Utilization of ultrasound in the evaluation of patients with undifferentiated hypotension has been proposed in several protocols. We sought to assess the impact of an ultrasound hypotension protocol on physicians' diagnostic certainty, diagnostic ability, and treatment and resource utilization.
**Design:** Prospective observational study.
**Setting:** Emergency department in a single, academic tertiary care hospital.
**Subjects:** A convenience sample of patients with a systolic blood pressure less than 90 mmHg after an initial fluid resuscitation, who lacked an obvious source of hypotension.
**Interventions:** An ultrasound-trained physician performed an ultrasound on each patient using a standardized hypotension protocol. Differential diagnosis and management plan was solicited from the treating physician immediately before and after the ultrasound. Blinded chart review was conducted for management and diagnosis during the emergency department and inpatient hospital stay.
**Measurements and Main Results:** The primary endpoints were the identification of an accurate cause for hypotension and change in physicians' diagnostic uncertainty. The secondary endpoints were changes in treatment plan, use of resources, and changes in disposition after performing the ultrasound. One hundred eighteen patients with a mean age of 62 years were enrolled. There was a significant 27.7% decrease in the mean aggregate complexity of diagnostic uncertainty before and after the ultrasound hypotension protocol (1.85–1.34; −0.51 [95% CI, −0.41 to −0.62]) as well as a significant increase in the absolute proportion of patients with a definitive diagnosis from 0.8% to 12.7%. Overall, the leading diagnosis after the ultrasound hypotension protocol demonstrated excellent concordance with the blinded consensus final diagnosis (Cohen $k = 0.80$). Twenty-nine patients (24.6%) had a significant change in the use of IV fluids, vasoactive agents, or blood products. There were also significant changes in major diagnostic imaging (30.5%), consultation (13.6%), and emergency department disposition (11.9%).
**Conclusions:** Clinical management involving the early use of ultrasound in patients with hypotension accurately guides diagnosis, significantly reduces physicians' diagnostic uncertainty, and substantially changes management and resource utilization in the emergency department. (*Crit Care Med* 2015; 43:2562–2569)
**Key Words:** diagnostic uncertainty; resuscitation; ultrasound; undifferentiated hypotension

Patients with sustained hypotension and shock are at high risk for developing serious adverse events, with an in-hospital mortality as high as 25% (1–3). The diagnosis and initial management of patients with hypotension in the emergency department (ED) must be prompt and accurate in order to optimize patient outcomes. History and physical

*See also p. 2682.

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This study was performed at the George Washington University Hospital, Washington, DC.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccmjournal).
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The authors have disclosed that they do not have any potential conflicts of interest.

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West Virginia University

Shokoohi H, et al. Bedside Ultrasound Reduces Diagnostic Uncertainty and Guides Resuscitation in Patients With Undifferentiated Hypotension.Crit Care Med. 2015 Dec;43(12):2562-9. doi: 10.1097/CCM.0000000000001285.

# IVC Exam

- Low frequency transducer
- Mid epigastrium or right lateral view with indicator to the patient head
- Collapsing IVC can indicate hypovolemia
- Dilated IVC can indicate fluid overload
- Postulated that IVC diameter is indirect measurement of CVP which can be used to assess fluid responsiveness.

# Evidence for IVC Guided Management

Intensive Care Med (2004) 30:1740–1746
DOI 10.1007/s00134-004-2294-8

ORIGINAL

Christophe Barbier
Yann Loubières
Christophe Schmit
Jan Hayon
Jean-Louis Ricôme
François Jardin
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**Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients**

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**Abstract** *Objective:* To evaluate the extent to which respiratory changes in inferior vena cava (IVC) diameter can be used to predict fluid responsiveness. *Design:* Prospective clinical study. *Setting:* Hospital intensive care unit. *Patients:* Twenty-three patients with acute circulatory failure related to sepsis and mechanically ventilated because of an acute lung injury. *Measurements:* Inferior vena cava diameter (D) at end-expiration (Dmin) and at end-inspiration (Dmax) was measured by echocardiography using a subcostal approach. The distensibility index of the IVC (dIVC) was calculated as the ratio of Dmax – Dmin / Dmin, and expressed as a percentage. The Doppler technique was applied in the pulmonary artery trunk to determine cardiac index (CI). Measurements were performed at baseline and after a 7 ml/kg volume expansion using a plasma expander. Patients were separated into responders (increase in CI ≥15%) and non-responders (increase in CI <15%). *Results:* Using a threshold dIVC of 18%, responders and non-responders were discriminated with 90% sensitivity and 90% specificity. A strong relation ($r^2$=0.9) was observed between dIVC at baseline and the CI increase following blood volume expansion. Baseline central venous pressure did not accurately predict fluid responsiveness. *Conclusion:* Our study suggests that respiratory change in IVC diameter is an accurate predictor of fluid responsiveness in septic patients.

**Keywords** Inferior vena cava · Central venous pressure · Echocardiography · Sepsis · Fluid responsiveness · Mechanical ventilation

**Introduction**

Circulatory failure in patients presenting septic shock is often the result of hypovolemia, which must be corrected. Volume expansion improves prognosis in this indication [1], whereas inappropriate use of vasoconstrictors leads to harmful tissue hypoperfusion [2]. However, volume expansion may prove ineffective or even deleterious through worsening of a pre-existing heart failure [3, 4] or by degrading gas exchanges in a patient ventilated for ARDS. It is therefore essential to have reliable tools to predict the efficacy of volume expansion.

Tools proposed hitherto have proven insufficiently reliable, whether invasive like the measurement of central venous pressure and pulmonary capillary wedge pressure, or non-invasive like the echocardiographic measurement of cavity size in diastole [5]. Only variation in pulse pressure currently seems to be a good predictor of the response to volume expansion [6].

Echocardiography is a non-invasive procedure which enables full assessment of cardiac function. The inferior vena cava (IVC) may be visualized by a subcostal approach. The IVC is a compliant blood vessel, easily distended, especially in cases of hypovolemia [7]. The aim of our study was to test the hypothesis that respiratory

Barbier C, Loubieres Y, Schmit C et al. Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients. Intensive Care Med 2004; 30:1740-1746.

- Prospective clinical study
- 23 patients in ICU on PP ventilation
- Dispensability of IVC and Cardiac index measured before and after volume expansion
- At 18% dIVC CI improved by 15%

Intensive Care Med (2004) 30:1834–1837
DOI 10.1007/s00134-004-2333-5

BRIEF REPORT

Marc Feissel
Frédéric Michard
Jean-Pierre Faller
Jean-Louis Teboul

**The respiratory variation in inferior vena cava diameter as a guide to fluid therapy**

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An editorial regarding this article can be found at http://dx.doi.org/10.1007/s00134-004-2562-x

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**Abstract** *Objective:* To investigate whether the respiratory variation in inferior vena cava diameter ($\Delta D_{IVC}$) could be related to fluid responsiveness in mechanically ventilated patients. *Design:* Prospective clinical study. *Setting:* Medical ICU of a non-university hospital. *Patients:* Mechanically ventilated patients with septic shock (n=39). *Intervention:* Volume loading with 8 ml/Kg of 6% hydroxyethylstarch over 20 min. *Measurements and results:* Cardiac output and $\Delta D_{IVC}$ were assessed by echography before and immediately after the standardized volume load. Volume loading induced an increase in cardiac output from 5.7±2.0 to 6.4±1.9 L/min ($P<0.001$) and a decrease in $\Delta D_{IVC}$ from 13.8±3.6 to 5.2±5.8% ($P<0.001$). Sixteen patients responded to volume loading by an increase in cardiac output ≥15% (responders). Before volume loading, the $\Delta D_{IVC}$ was greater in responders than in non-responders (25±5 vs 8±4%, $P<0.001$), closely correlated with the increase in cardiac output ($r=0.82$, $P<0.001$), and a 12% $\Delta D_{IVC}$ cut-off value allowed identification of responders with positive and negative predictive values of 93% and 92%, respectively. *Conclusion:* Analysis of $\Delta D_{IVC}$ is a simple and non invasive method to detect fluid responsiveness in mechanically ventilated patients with septic shock.

**Keywords** Fluid responsiveness · Echography · Inferior vena cava · Septic shock · Mechanical ventilation

**Introduction**

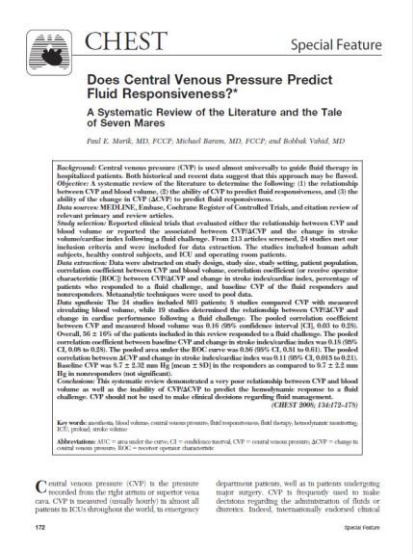
The detection of fluid responsiveness is of utmost importance in the management of patients with septic shock, answering the question "Can we improve cardiac output and hence hemodynamics by giving fluid ?" Although still widely used to determine fluid therapy, cardiac filling pressures do not reliably predict responsiveness of cardiovascular parameters to fluid challenge [1]. Mechanical ventilation induces cyclic variations in vena cava flow and diameter that are reflected in changes in aortic flow within the time frame of a few heart beats [2, 3]. The respiratory changes in aortic flow have previously been shown to be accurate predictors of fluid responsiveness [4, 5, 6, 7, 8, 9]. Assuming that mechanical insufflation-induced changes in systemic vesous return are more marked in hypovolemic than in normovolemic conditions, we postulated that the variation in vena cava diameter could also be useful in identifying patients who may benefit from a volume load.

Feissel M, Michard F, Faller JP et al. The respiratory variation in inferior vena cava diameter as a guide to fluid therapy. Intensive Care Med 2004; 30:1834-37.

- Prospective clinical study
- 16 patient's responded to bolus of hydroxyethylstarch by increasing cardiac index by 15%

West Virginia University.

# Problem with IVC Guided Management



CHEST Special Feature

**Does Central Venous Pressure Predict Fluid Responsiveness?***

**A Systematic Review of the Literature and the Tale of Seven Mares**

*Paul E. Marik, MD, FCCP; Michael Baram, MD, FCCP; and Bobbak Vahid, MD*

**Background:** Central venous pressure (CVP) is used almost universally to guide fluid therapy in hospitalized patients. Both historical and recent data suggest that this approach may be flawed.
**Objective:** A systematic review of the literature to determine the following: (1) the relationship between CVP and blood volume, (2) the ability of CVP to predict fluid responsiveness, and (3) the ability of the change in CVP (ΔCVP) to predict fluid responsiveness.
*Data sources:* MEDLINE, Embase, Cochrane Register of Controlled Trials, and citation review of relevant primary and review articles.
*Study selection:* Reported clinical trials that evaluated either the relationship between CVP and blood volume or reported the associated between CVP/ΔCVP and the change in stroke volume/cardiac index following a fluid challenge. From 213 articles screened, 24 studies met our inclusion criteria and were included for data extraction. The studies included human adult subjects, healthy control subjects, and ICU and operating room patients.
*Data extraction:* Data were abstracted on study design, study size, study setting, patient population, correlation coefficient between CVP and blood volume, correlation coefficient (or receive operator characteristic [ROC]) between CVP/ΔCVP and change in stroke index/cardiac index, percentage of patients who responded to a fluid challenge, and baseline CVP of the fluid responders and nonresponders. Metaanalytic techniques were used to pool data.
*Data synthesis:* The 24 studies included 803 patients; 5 studies compared CVP with measured circulating blood volume, while 19 studies determined the relationship between CVP/ΔCVP and change in cardiac performance following a fluid challenge. The pooled correlation coefficient between CVP and measured blood volume was 0.16 (95% confidence interval [CI], 0.03 to 0.28). Overall, 36 ± 16% of the patients included in this review responded to a fluid challenge. The pooled correlation coefficient between baseline CVP and change in stroke index/cardiac index was 0.15 (95% CI, 0.06 to 0.28). The pooled area under the ROC curve was 0.56 (95% CI, 0.51 to 0.61). The pooled correlation between ΔCVP and change in stroke index/cardiac index was 0.11 (95% CI, 0.015 to 0.21). Baseline CVP was 5.7 ± 2.32 mm Hg (mean ± SD) in the responders as compared to 5.7 ± 2.2 mm Hg in nonresponders (not significant).
**Conclusions:** This systematic review demonstrated a very poor relationship between CVP and blood volume as well as the inability of CVP/ΔCVP to predict the hemodynamic response to a fluid challenge. CVP should not be used to make clinical decisions regarding fluid management.
*(CHEST 2008; 134:172–178)*

**Key words:** anesthesia; blood volume; central venous pressure; fluid responsiveness; fluid therapy; hemodynamic monitoring; ICU; preload; stroke volume

**Abbreviations:** AUC = area under the curve; CI = confidence interval; CVP = central venous pressure; ΔCVP = change in central venous pressure; ROC = receiver operator characteristic

Central venous pressure (CVP) is the pressure recorded from the right atrium or superior vena cava. CVP is measured (usually hourly) in almost all patients in ICUs throughout the world, in emergency department patients, well as in patients undergoing major surgery. CVP is frequently used to make decisions regarding the administration of fluids or diuretics. Indeed, internationally endorsed clinical



Marik PE, Cavallazzi R. Does the Central Venous Pressure (CVP) predict fluid responsiveness: An update meta-analysis and a plea for some common sense. Crit Care Med 2013; 41:1774-81.

- 43 studies reviewed
- "There are no data to support the widespread practice of using central venous pressure to guide fluid therapy. This approach to fluid resuscitation should be abandoned."

Eskesen TG, Wetterslev M, Perner A. Systematic review including re-analyses of 1148 individual data sets of central venous pressure as a predictor of fluid responsiveness. Intensive Care Med 2015; 42:324-32.

- 51 studies reviewed
- 1148 data sets
- Zero predictive values were above 66% for any CVPs from 0 to 20 mmHg.

Intensive Care Med (2016) 42:324–332
DOI 10.1007/s00134-015-4168-4

SYSTEMATIC REVIEW

CrossMark

T. G. Eskesen
M. Wetterslev
A. Perner

**Systematic review including re-analyses of 1148 individual data sets of central venous pressure as a predictor of fluid responsiveness**

Received: 20 May 2015
Accepted: 23 November 2015
Published online: 9 December 2015
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**Take-home message:** In the re-analysis of 1148 individual data sets lower CVP values had low predictive power for fluid responsiveness.

**Electronic supplementary material** The online version of this article (doi:10.1007/s00134-015-4168-4) contains supplementary material, which is available to authorized users.

**Abstract** *Purpose:* Central venous pressure (CVP) has been shown to have poor predictive value for fluid responsiveness in critically ill patients. We aimed to re-evaluate this in a larger sample subgrouped by baseline CVP values. *Methods:* In April 2015, we systematically searched and included all clinical studies evaluating the value of CVP in predicting fluid responsiveness. We contacted investigators for patient data sets. We subgrouped data as lower (<8 mmHg), intermediate (8–12 mmHg) and higher (>12 mmHg) baseline CVP. *Results:* We included 51 studies; in the majority, mean/median CVP values were in the intermediate range (8–12 mmHg); in both fluid responders and non-responders. In an analysis of patient data sets (*n* = 1148) from 22 studies, the area under the receiver operating curve was above 0.50 in the <8 mmHg CVP group [0.57 (95 % CI 0.52–0.62)] in contrast to the 8–12 mmHg and >12 mmHg CVP groups in which the lower 95 % CI crossed 0.50. We identified some positive and negative predictive value for fluid responsiveness for specific low and high values of CVP, respectively, but none of the predictive values were above 66 % for any CVPs from 0 to 20 mmHg. There were less data on higher CVPs, in particular >15 mmHg, making the estimates on predictive values less precise for higher CVP. *Conclusions:* Most studies evaluating fluid responsiveness reported mean/median CVP values in the intermediate range of 8–12 mmHg both in responders and non-responders. In a re-analysis of 1148 patient data sets, specific lower and higher CVP values had some positive and negative predictive value for fluid responsiveness, respectively, but predictive values were low for all specific CVP values assessed.

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**Keywords** Central venous pressure · Critical illness · Fluid therapy · Haemodynamics · Intensive care

**Introduction**

Fluid therapy is a key intervention in optimizing the cardiovascular status in critically ill patients [1]. Previous studies have shown that only 50 % of patients respond to fluid administration with an increase in stroke volume (SV) or cardiac output (CO), so-called fluid responsiveness [2]. The ability to discriminate between fluid responders and non-responders is important, as fluid overload may be associated with increased mortality in critically ill patients [3].

Central venous pressure (CVP) continues to be widely used in guiding fluid therapy [4, 5] and is recommended to guide fluid therapy in patients with septic shock [6].

West Virginia University.

# IVC Debate

- Surviving Sepsis Campaign no longer includes recommendations on CVP (Prior was 8-12mmHg)
- Evidence based look at IVC/CVP: https://emcrit.org/isepsis/isepsis-vena-caval-ultrasonography-just-dont/

# Undifferentiated Shock Questions?

- How is the global heart function?
- Is there right ventricular heart strain?
- Is there a pericardial effusion?
- Are there obvious cardiac structural abnormalities?
- Is the IVC collapsed?
- Is there an AAA?
- Is there FF in abdomen or thorax?
- Is there lung sliding?
- Do the proximal deep veins compress?
- Is there an obvious infectious source?

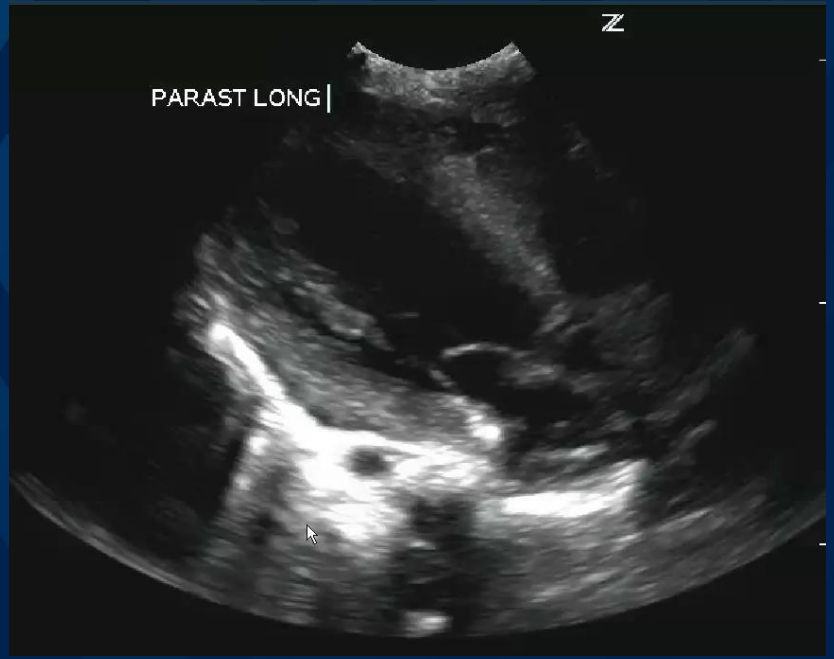
# US for Shock

- Heart
  - Global Function, Strain, Chamber Size, Effusion, Aortic Root, Obvious Valvular Pathology
- Abdomen
  - IVC, FF, AAA, Dissection
- Thorax
  - PTX, Effusions
- Infectious
  - PNA, Endocarditis, Cholecystitis, UTI/Hydronephrosis, Cellulitis

# Cardiomyopathy

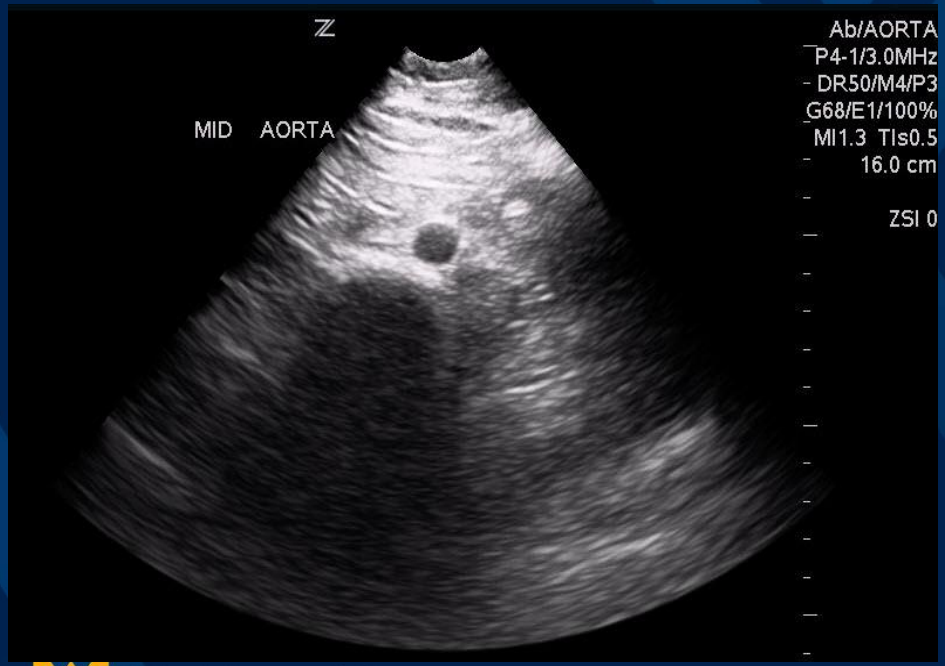
**Normal**


**Hypertrophic Cardiomyopathy**

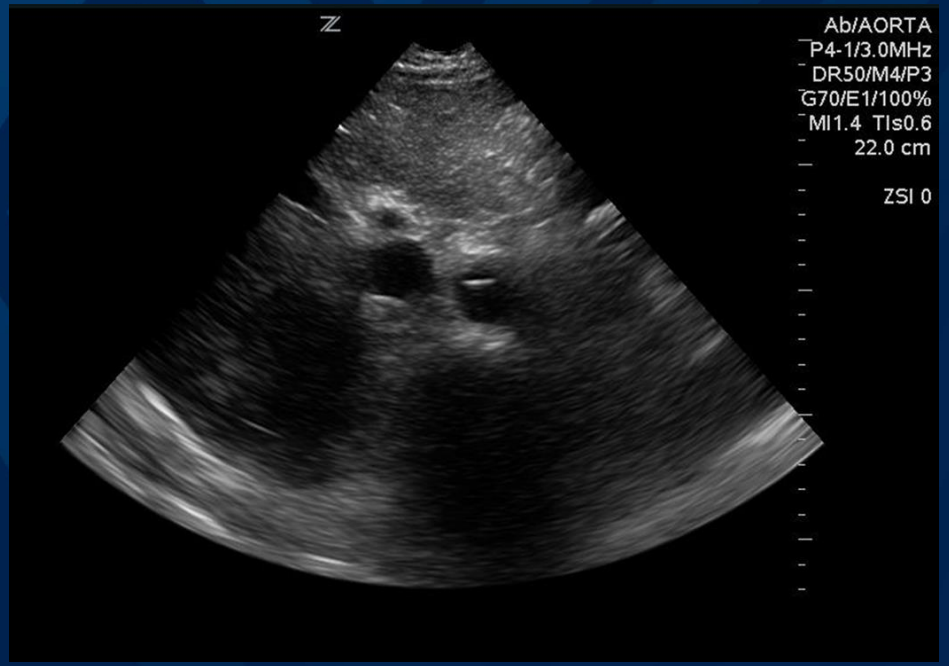


# Dissection

## Normal




## Dissection Flap



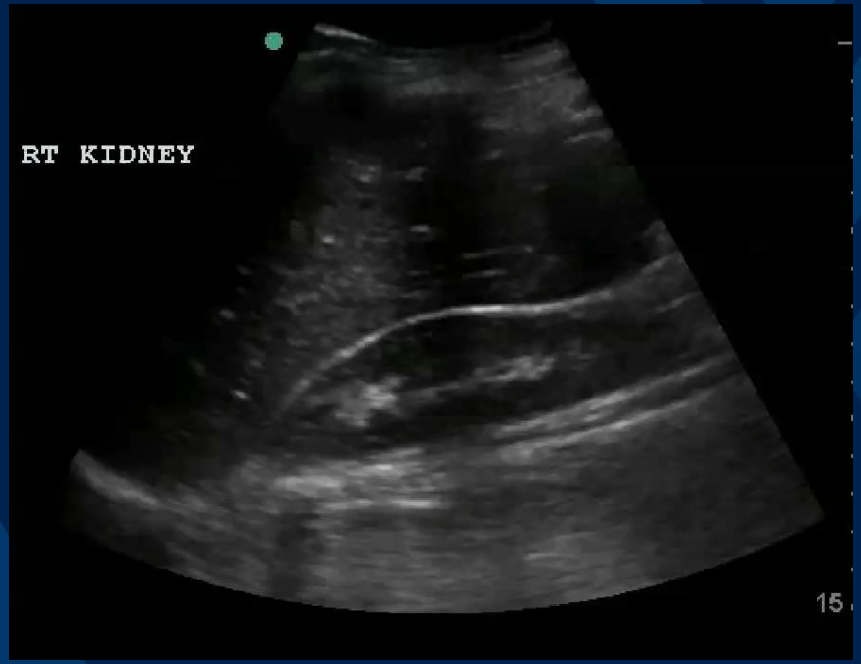
# AAA

## Normal


## AAA

# Hemoperitoneum

**Normal**




**Free Fluid**

# Hemoperitoneum

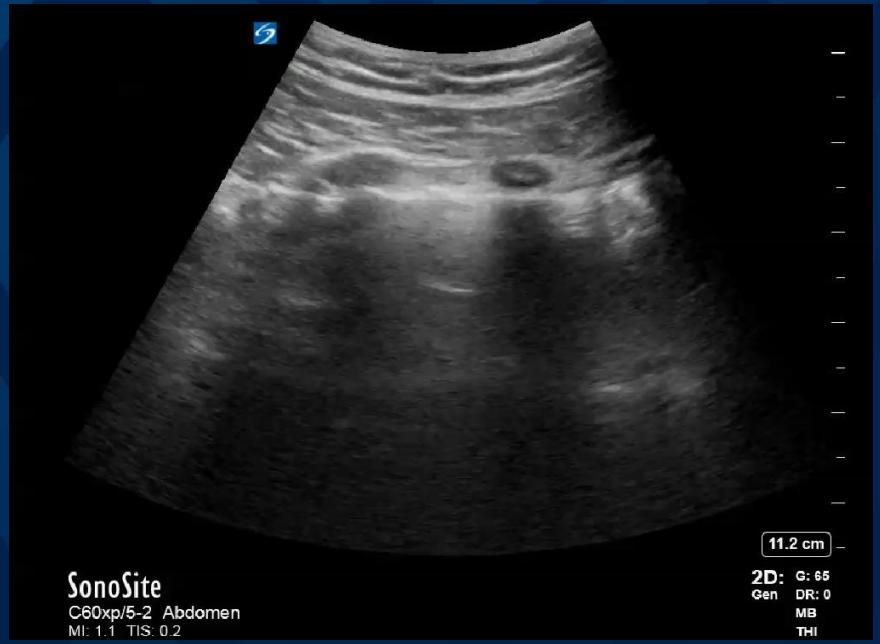
**Normal**


**Free Fluid**

# Pneumothorax

**Normal**


**PTX**



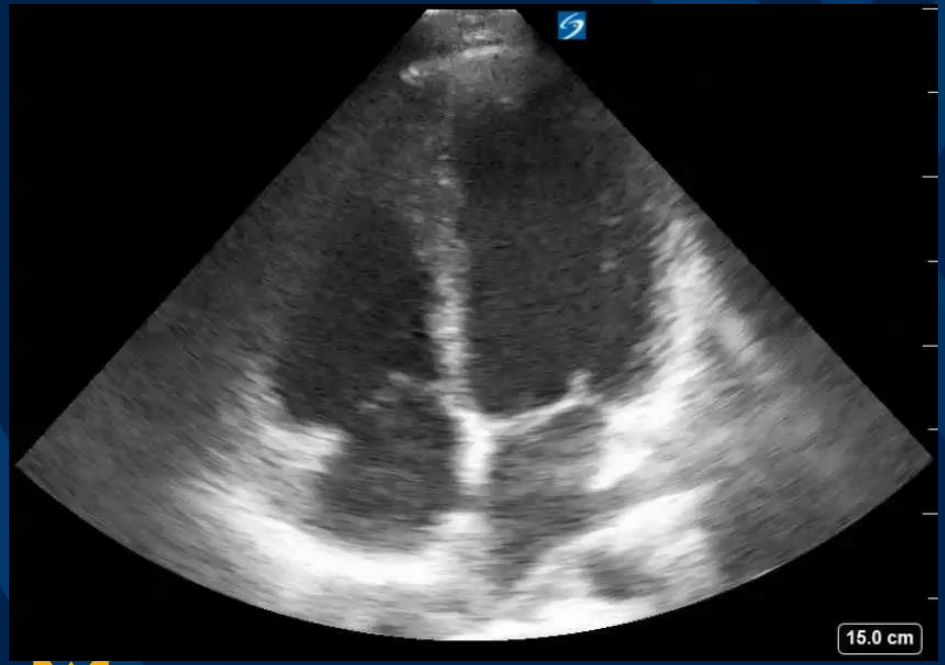
# Pneumonia

**Normal**


**Infiltrate**

# Endocarditis

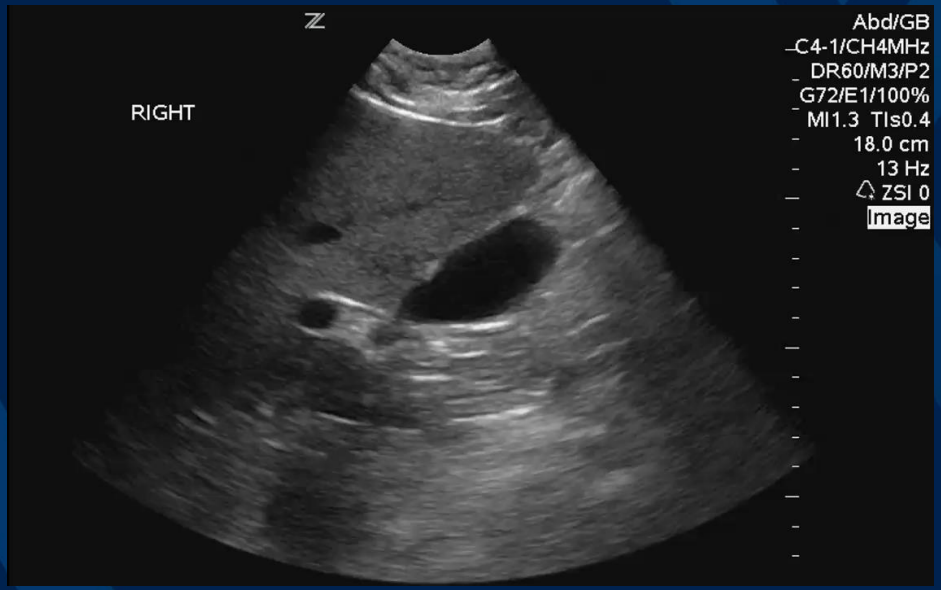
**Tricuspid Vegetation**



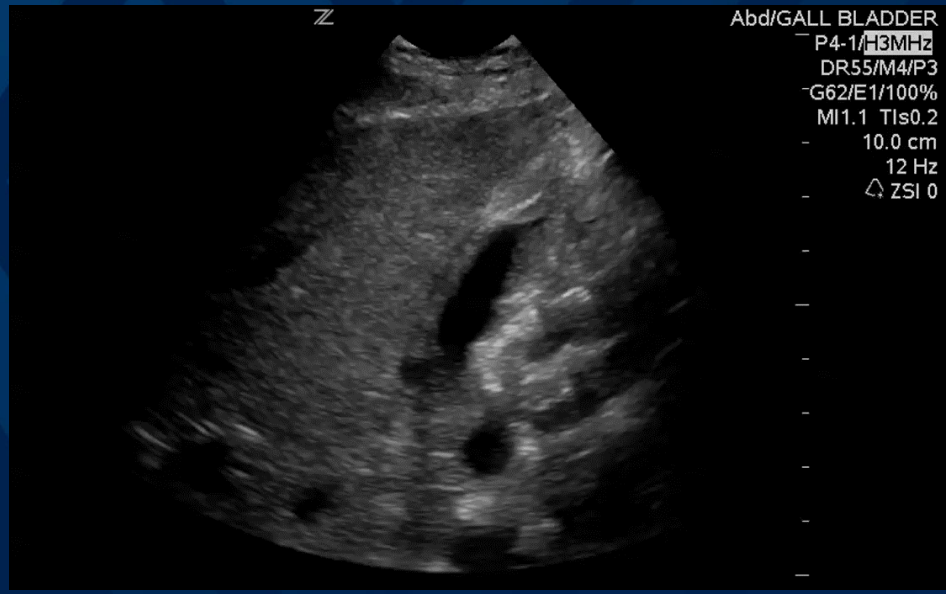

**Aortic Vegetation**

# RUQ

## Normal

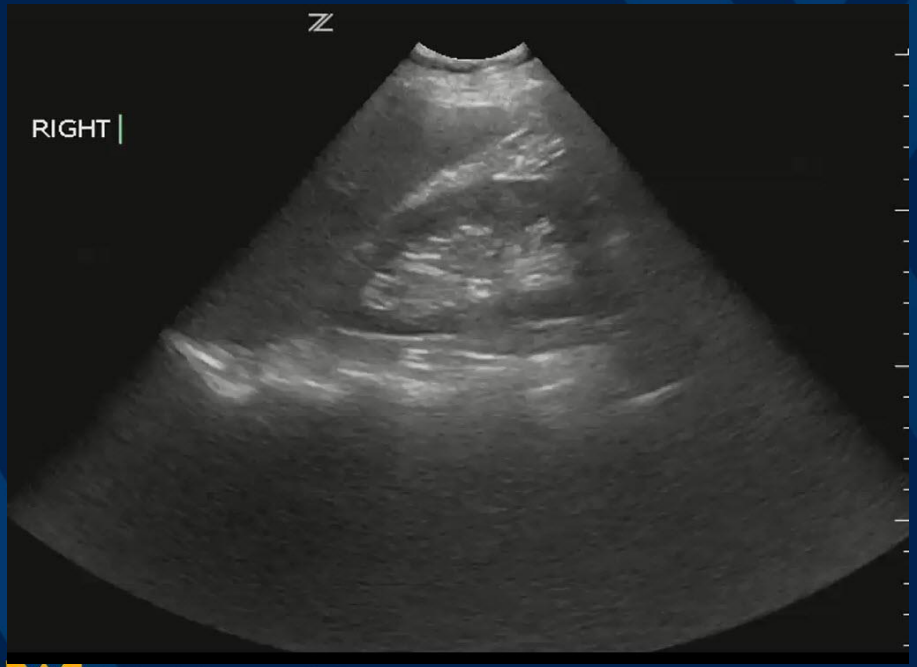



## Cholecystitis

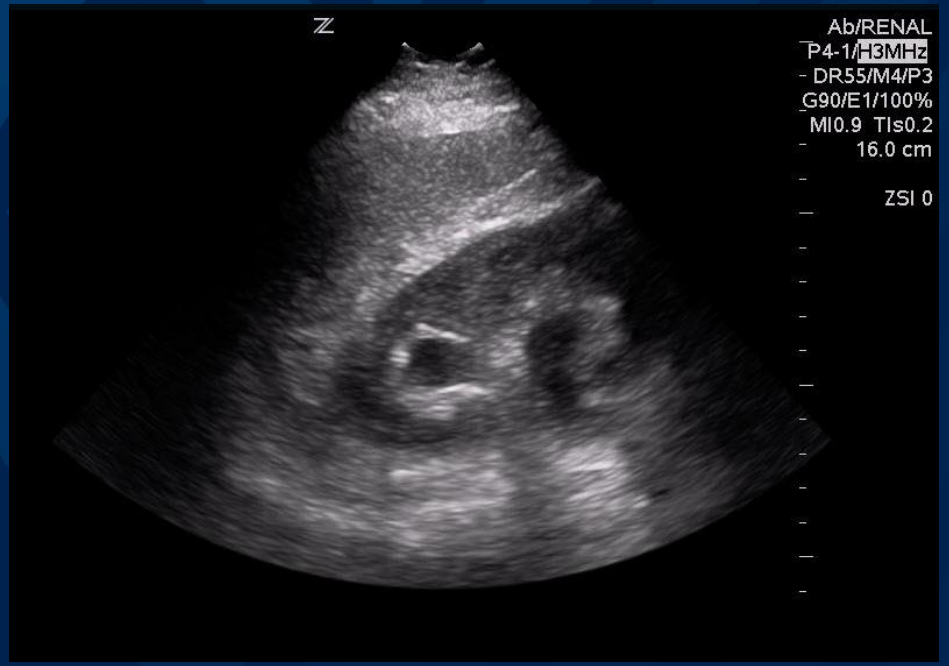


# Hydronephrosis

**Normal**




**Hydronephrosis**



# Skin and Soft Tissue

**Normal Skin**

**Necrotizing Fasciitis**

# Undifferentiated Shock

- Pearls and Pitfalls:
  - Let clinical context guide the exam
  - Not all FF is blood
  - Not all AAA's are ruptured

# Take Home Points Case 4

- POCUS can be used to guide evaluation and management of undifferentiated shock
- CVP to guide fluid management is not currently supported by the literature; therefore IVC measurement as a sole guide to fluid management cannot be recommended

# Conclusions

- The sicker the patient, the more useful POCUS can be at guiding evaluation and management
- Ultrasound is user dependent and skill is acquired through practice
- Practice often with normal exams or on individuals with known diagnoses to build skills for critical moments . . .

# Questions

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# References


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