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Hot Off the Press: B-lines and Focused Lung Ultrasound to Diagnose Acute Heart Failure in Dyspneic Patients

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BACKGROUND

Emergency department (ED) patients with shortness of breath often present a diagnostic challenge. Common diagnostic modalities used in the work-up of acute dyspnea, including physical examination, chest x-ray (CXR), and B-type natriuretic peptide (BNP), delay treatment decisions and lack acceptable diagnostic accuracy.^{1,2} Focused lung ultrasound (U/S) is noninvasive, can be done quickly at the patient's bedside, and may be more accurate than CXR and BNP for diagnosing acute heart failure (AHF).³

ARTICLE SUMMARY

Chiem et al. present a prospective, cross-sectional study of emergency medicine (EM) residents' performance of thoracic U/S on adult patients presenting to a single-center inner-city ED with undifferentiated acute dyspnea. Exclusion criteria included patients with dyspnea clearly caused by another diagnosis; patients whose CXR findings were available and known to the sonographer prior to U/S; and patients who were on positive pressure ventilation, were receiving nebulizer treatment, or were too ill for study consent. The primary outcome was to assess the diagnostic accuracy of novice EM residents to detect sonographic B-lines on bedside U/S compared to a blinded expert sonographer. The secondary outcome was the accuracy of novice and expert sonographer interpretation of B-lines to diagnose pulmonary edema due to AHF, as determined by two blinded expert reviewers. The study also analyzed the role of increasing lung zone positivity to diagnose AHF.

All 66 participating EM residents received a 30-minute thoracic U/S training session to identify B-lines using the eight-zone Volpicelli method⁴ on 380 patients. Although resident

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sonographers were not blinded to patient clinical status, the U/S were typically performed prior to chart review and patient examination. Research assistants recorded EM residents' bedside interpretations. In addition, an abbreviated two-zone examination was assessed. The expert sonographer, blinded to the resident interpretation and clinical information, provided independent interpretation of the saved video images, which served as the criterion standard for the primary outcome. Two expert reviewers independently assessed abstracted chart data to define the presence or absence of heart failure.

QUALITY ASSESSMENT

This is a high-quality study with a well-defined clinical issue and a study population representative of the target population. The Standards for Reporting of Diagnostic Accuracy (STARD)⁵ guidelines were largely adhered to with a few exceptions.

One potential study limitation is that 92% of patients were African American, which is not representative of all EDs and may limit generalizability of study findings. Also, convenience sampling creates the potential for selection bias, particularly spectrum bias.⁶ While expert sonographers and outcome assessors were blinded to patients' clinical statuses on presentation, novice sonographers were not. Although the sonographers "typically" performed the U/S prior to chart review or patient examination, it seems this was not always the case since some elements of physical examination are difficult to mask at the bedside. In these situations, the U/S interpretation might have been influenced by other clinical information, which is a form of incorporation bias and skews estimates of both sensitivity and specificity upward.⁶ Finally, in 36% of cases, nitroglycerin or furosemide treatment was initiated prior to the U/S examination, which may have influenced the novice sonographers' clinical interpretations toward the diagnosis of AHF.

KEY RESULTS

Acute heart failure was the cause of dyspnea in 35% of patients. In detecting B-lines, novice sonographers demonstrated 85% sensitivity, 84% specificity, positive likelihood ratio (LR) 5.2, and negative LR 0.2. Novice sonographers demonstrated 87% sensitivity and 49% specificity for using B-lines to diagnose AHF, compared to 85% sensitivity and 58% specificity in expert sonographers. As the number of positive lung zones increased, sensitivity decreased while specificity increased for both novice and expert sonographers. The areas under the receiver operator curves for novice and expert sonographers were almost identical: 0.77 and 0.76, respectively. The two-lung-zone approach was specific but insensitive compared to the eight-lung-zone approach, making it a reasonable starting point that necessitates conversion to the full eight-zone approach if negative.

AUTHOR COMMENTS

Failure to diagnose AHF in a timely fashion delays treatment and may adversely affect patient outcomes. No laboratory or radiology examination accurately distinguishes AHF from other causes of dyspnea; instead, quickly and accurately diagnosing AHF requires the combination of tests with history and physical examination. Bedside U/S is available

immediately and can be repeated throughout the patient's ED course to monitor treatment response. Most clinical U/S studies use a small group of expert sonographers to perform the scans. In contrast, this study used a large group of novice sonographers with minimal lung U/S training, yielding more broadly applicable results to residents in academic teaching hospitals and ED physicians with less advanced bedside U/S skills. Furthermore, novice and expert sonographers had similar B-line detection accuracy with sensitivities and specificities greater than 80%. Most novice sonographers' images were deemed adequate, making lung U/S an easily learned and feasible tool. Future studies should assess the clinical impact of bedside lung U/S and establish whether the results are applicable to clinical settings lacking an U/S fellowship and expert faculty.

TOP 5 SOCIAL MEDIA COMMENTS

Andrew Healey, MD, and Mark Mensour, MD (comment on The Skeptics Guide to Emergency Medicine [SGEM] blog): "It is tremendously challenging to determine what the 'truth' about lung ultrasound is in heart failure until we have consistency in practice. The International guidelines on lung ultrasound will go a long way at establishing some consistency but the user-dependency of ultrasound will always be a 'problem'."

Jacob Avila (comment on the SGEM blog): "The international lung ultrasound consensus statements defines pulmonary edema as >3 b-lines in 2 or more zones in each side (using 4 zones on each hemothorax), and when just that criteria is looked at, novice sonographers had a sns of 57% and a spc of 84%, +LR of 3.5 and a -LR of 0.5, while expert sonographers had a sns 38% and a spc 89%, +LR of 3.4 and -LR 0.7. To me, this is odd. Most of the studies I've read report a much higher accuracy for b-lines in the undifferentiated SOB patient. For instance, study that came out in chest this year (PMID: 25654562) included 1005 dyspneic patients and reported U/S to be 90.5% sensitive and 93.5% specific with +LR 14 and -LR 0.1 for acute decompensated heart failure (ADHF). Any thoughts as to why the discrepancy?"

Daniel Theodoro, MD (comment on the SGEM blog): "I still feel there's a grey data zone (no pun intended) where I see a B line, then it goes away, then I see 3, then they go away and I'm still flummoxed. But every now and then I get 3 comet tails lighting up the dark universe of diagnostic uncertainty and at least I feel better about my thinking! Oh and I think novices are about as good as experts in this because it's just not that hard."

Greg Hall (comment on the SGEM blog): "Bedside ultrasound has three distinct skill requirements: image acquisition, image interpretation, and image integration into care paths. I am able to generate an image of B-lines, I can recognize the B-lines, but can I put this finding into proper clinical context? ... Ultrasound research is trapped between assessing the untrained/minimally trained and the single highly experienced power user. As we develop a greater number of physicians well trained in ultrasound image generation, interpretation, and

integration into patient care, I think we will have more success in determining patient-oriented outcome effect.”

TAKE-TO-WORK POINTS

Acute heart failure accounts for approximately 3 million hospital admissions annually and 80% are initially evaluated in the ED.⁷ AHF represents a heterogeneous clinical entity, and patients may present at different points on the hemodynamic spectrum. Following a 30-minute training session, novice EM resident sonographers used bedside U/S to detect B-lines in ED dyspneic patients with similar accuracy compared with expert sonographers. Clinicians may consider incorporating bedside U/S for the acute evaluation of undifferentiated dyspnea, although essential outcomes-based research is needed.⁸

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