Clinical Progress Note: Point-of-Care Ultrasound in the Evaluation of the Dyspneic Adult

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Point-of-care ultrasound (POCUS) continues to gain traction in contemporary clinical practice both as a diagnostic tool and as an extension of the physical examination. Hospital Medicine (HM) lags behind Emergency Medicine (EM) and Critical Care (CC) in our uptake of such technology, although momentum is gaining. Leaders in HM have published frameworks for competency and credentialing, and the Society of Hospital Medicine has created a pathway for certification.[1] POCUS use is the standard of care for several bedside procedures, but evidence for diagnostic applications is changing rapidly as the literature expands. However, the applicability of this evidence to HM patients can be challenging as most published studies are still from EM and CC settings. This *Progress Note* focuses on how a hospitalist might incorporate POCUS in the evaluation of adult patients with dyspnea. This topic was chosen after reviewing several relevant studies published in the past 5 years and recognizing the importance of dyspnea in HM. The *Progress Note* begins with a review of POCUS for undifferentiated dyspnea before exploring studies of common diagnoses that present with dyspnea, including pneumonia, pleural effusion, and acute decompensated heart failure (ADHF), with the aim of updating the knowledge of HM providers regarding this technology, as well as stimulating further study in this field.

SEARCH STRATEGY

In collaboration with an academic librarian in March 2019, the authors searched PubMed for studies published within the past 5 years using several MESH search terms for POCUS. The search originally focused on the field of HM using specific search terms, but this yielded a very limited number of studies. Therefore, the search strategy was expanded to include EM and CC studies. This final search generated 346 papers that were supplemented with additional literature searches using references from studies found in the initial search.

UNDIFFERENTIATED DYSPNEA

Dyspnea is common in HM, both as the reason for a patient's admission and as a symptom that develops during hospitalization such as after intravenous fluid resuscitation, a possible as-

piration event, or central line placement. The differential diagnosis is broad, and multiple studies suggest that POCUS can aid in the evaluation of undifferentiated dyspnea while also being cost effective and avoiding the potential radiation of other testing modalities. The pulmonary POCUS evaluation incorporates a combination of several findings, including "A-lines" or horizontal artifacts from normal aerated lung; "B-lines", vertical artifacts generated by extra-alveolar fluid, consolidation or "tissue-like pattern"; air bronchograms, consolidated lung surrounding airways; anechoic or hypoechoic areas in dependent zones of the lung; and the presence or absence of pleural sliding.[2]

In one prospective observational study of five internal medicine residents with no prior POCUS experience and 3 hours of training, the addition of handheld POCUS devices to usual clinical information improved the diagnostic accuracy for pneumonia, pulmonary edema, pleural effusion, and obstructive lung disease when evaluating patients with a primary complaint of dyspnea (area under the curve [AUC] 0.81 vs 0.87, $P < .01$).[2] However, the largest improvements in the operating characteristics were observed with the two residents who received an extended 2-week elective of training.

In another study of 383 consecutive patients presenting to the ED with dyspnea, physicians with basic and advanced POCUS training were blinded to all clinical information and recorded a diagnosis after performing a lung POCUS examination. The "ultrasound physician's" diagnosis was then compared to the treating emergency department (ED) physician's diagnosis using history, physical, and other diagnostic data. Lung POCUS had a sensitivity and a specificity of 87.6% and 96.2% for pulmonary edema, 85.7% and 99% for pneumonia, 98.2% and 67.3% for asthma/chronic obstructive pulmonary disease (COPD), 46.2% and 100% for pulmonary embolus (PE), and 71.4% and 100% for pneumothorax, respectively.[3] The scanning protocol used—the BLUE (Bedside Lung Ultrasound Examination) protocol—was focused on ruling out significant pulmonary etiologies of dyspnea. The protocol classified the finding of normal lung ultrasound (A-line profile) as COPD or asthma since these conditions will have a normal sonographic appearance. This approach could lead to incorrect labeling of other extrapulmonary causes of dyspnea as COPD or asthma. The findings of this study suggest that POCUS is most effective at ruling in pulmonary edema and pneumonia while being most effective at ruling out asthma or COPD as causes of dyspnea. It is both sensitive and specific for pneumothorax. However, as other studies have found, the sensitivity of PO-

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CUS for COPD, asthma, and PE was inferior to traditional clinical evaluation.[4] One of the few studies looking specifically at hospitalized ward patients compared a blinded lung POCUS diagnosis and a discharge clinical diagnosis classified as cardiac, pulmonary, or mixed dyspnea. The authors of that study found an "interstitial pattern" (two areas with more than two B-lines) in 94% of those classified as cardiac on discharge, but POCUS findings were less precise for those discharged with a pulmonary etiology of dyspnea.[5] Identifying B-lines on lung POCUS appears to be helpful in rapidly differentiating cardiac from pulmonary etiologies of dyspnea.

An additional advantage of POCUS is that multiple organ systems can be evaluated in rapid succession when the etiology of dyspnea is unknown. In a smaller ED study of patients presenting with undifferentiated dyspnea, a diagnosis was recorded after history taking and physical examination and then recorded again after lung, cardiac, and inferior vena cava POCUS. Clinician diagnostic accuracy improved from 53% to 77% with the use of POCUS (*P* = .003), compared with the final diagnosis.[6] The treating physician's primary impression changed in almost 50% of cases after using POCUS, most of which was driven by improved sensitivity and specificity of ADHF. In another study of 2,700 patients presenting to the ED with dyspnea, cardiopulmonary POCUS shortened the time to diagnosis (186 ± 72 minutes vs 24 ± 10 minutes, *P* = .025).[4] These studies suggest that the use of POCUS in the initial evaluation of patients with undifferentiated dyspnea is a valuable tool with respect to diagnostic accuracy and timeliness.

PNEUMONIA
There are several different sonographic findings that can indicate pneumonia, such as consolidation or "hepatization," the "shred" sign of an irregular border between consolidated lung and aerated lung, unilateral B-lines, and dynamic air bronchograms. Several recent systematic reviews and meta-analyses have investigated the operating characteristics of POCUS for the diagnosis of pneumonia. These reviews are limited by heterogeneity with respect to different patient populations, sonographers, and reference standards, but all three reviews found similar results, with the pooled AUC values ranging from 95% to 98%.[7-9] This recent evidence along with other reviews suggests that lung ultrasound can serve as a primary diagnostic tool in pneumonia and is probably superior to chest radiography.

PLEURAL EFFUSION
Pleural effusions are observed with POCUS as anechoic or hypoechoic areas, generally in dependent lung zones. POCUS may provide additional benefit by better characterizing the effusion as having septations or floating fibrin strands. One recent systematic review and meta-analysis including 1,554 patients found that POCUS had excellent sensitivity and specificity (94% and 98%, respectively) in detecting pleural effusion vs chest radiography (51% and 91%, respectively), both compared with reference standard imaging such as computed tomography. The subgroup analysis found that sensitivity was

higher for scanners who were intensivists or radiologists than for other physicians (97% vs 90%, *P* ≤ .001) and also found a nonstatistically significant trend toward reduced sensitivity when pocket-sized devices were used (90% vs 95%, *P* = .09).[10]

ACUTE DECOMPENSATED HEART FAILURE
It is extremely important to recognize that a POCUS finding of decreased left ventricular ejection fraction is not synonymous with a diagnosis of ADHF. Bedside providers can use POCUS to estimate cardiac function, but other clinical information is required to determine whether the syndrome of ADHF is present. In one study, examinations performed by 10 internists with approximately 18 hours of training in focused cardiac POCUS had a sensitivity and a specificity of 91% and 88%, respectively, for classifying left ventricular systolic function as normal or mildly, moderately, or severely depressed with "good/substantial" agreement (k = 0.77), compared with formal echocardiography.[11] The presence of bilateral B-lines as a sign of pulmonary edema suggests accompanying functional decompensation. A meta-analysis of seven articles including 1,075 patients in various clinical settings (ED, ICU, and inpatient wards) found a sensitivity of 94.1% and a specificity of 92.4% for using B-lines to diagnose acute cardiogenic pulmonary edema, compared with the final clinical diagnosis.[12] Al Deeb et al. examined 226 patients and found similar sensitivity (95.3%) and specificity (88.2%) for diagnosing acute cardiogenic pulmonary edema when nurses were trained to evaluate for bilateral B-lines in dyspneic patients admitted to the hospital, also compared with the adjudicated final diagnosis.[13] Carlino et al. evaluated dyspneic patients using a 3-minute pocket-sized device scan of the heart, lungs, and inferior vena cava and found that no single view offered a substantial improvement in diagnostic accuracy; however, the combination of bilateral B-lines and/or pleural effusion and either a dilated left atrium or left ventricular ejection fraction (LVEF) of <40% had a very high diagnostic accuracy (AUC 0.97).[14] Russell et al. performed a secondary analysis of a prospective observational study of patients with dyspnea and found that a simple three-view scanning protocol looking for the presence of B-lines on the right and left anterior superior lung zones and an LVEF of <45% took an average of 1 minute and 32 seconds to perform and had 100% specificity for ADHF if all three were positive.[15] Another recent systematic review and meta-analysis of six studies and 1,827 patients found a sensitivity of 88% (CI 75%-95%) for lung POCUS, compared with a chest radiography at a sensitivity of 73% (70%-76%) for the diagnosis of ADHF.[16] All these studies suggest that improving the diagnosis of ADHF does not require complex echocardiographic views and is probably more feasible and accessible than many expect.

SUMMARY
POCUS continues to show promise for evaluating patients with dyspnea. It is clear that adding a few POCUS examination maneuvers to a provider's toolbox, such as looking for B-lines and overall cardiac function, can improve the evaluation of dyspneic patients. However, POCUS enthusiasm should not outpace

the evidence. The studies discussed in this update highlight an important need for additional research in HM settings and patient populations. Most of the studies were conducted in non-HM patients, with sonographers varying widely in experience, which highlights the importance of proper training. In addition, future studies should investigate outcome measures such as mortality, length of stay, and cost efficacy. Furthermore, those employing POCUS must remember that improved sensitivity for detecting certain conditions can come at the expense of adequate specificity. POCUS findings, although potentially powerful, must always be synthesized with other clinical findings and considered within the larger clinical context for individual patients.

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