

# Point-of-Care Ultrasound and Modernization of the Bedside Assessment

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**W**e live in an era of rapid technological advancement, and as newer diagnostic modalities have emerged, the traditional physical examination has become less central to the clinical assessment of patients. Point-of-care ultrasound (POCUS), ultrasound imaging acquired and interpreted by a treating clinician at the bedside, has emerged as a tool that can augment the diagnostic accuracy of the traditional bedside assessment.<sup>1-3</sup> Emerging evidence shows that the accuracy of certain POCUS applications rivals and sometimes surpasses that of conventional imaging tests.<sup>4-6</sup> Growing literature supports the notion that POCUS can expedite diagnosis as well as reduce the number of imaging tests, patient exposure to ionizing radiation, and overall costs.<sup>7-10</sup> Recently, several low-cost handheld ultrasound devices that generate high-resolution images have entered the market and are being purchased directly by clinicians. Given the increasing availability of POCUS, we discuss its utility from the patient, clinician, and societal perspectives as well as the key barriers to its successful incorporation into graduate medical education.

## Increased Diagnostic Accuracy at the Bedside

Available evidence has suggested that POCUS can improve the detection of many common diagnoses compared to traditional physical examination maneuvers.<sup>3,11-13</sup> Although an exhaustive discussion of all POCUS applications is beyond the scope of this article, we highlight applications that are relevant across multiple specialties, including emergency, family, and internal medicine (TABLE). For patients presenting with dyspnea, POCUS examinations of the heart and lungs have been shown to be more accurate than traditional physical examination techniques in detecting the most common etiologies of this

concern.<sup>2,3</sup> Further, multiple prospective cohort studies have found lung ultrasound to be more accurate than chest x-ray, currently the first-line imaging modality for work up of dyspnea and detection of pleural effusion,<sup>14</sup> pulmonary edema,<sup>15</sup> pneumonia,<sup>4</sup> and pneumothorax<sup>5</sup>—some of the most common causes of dyspnea.

## Reduced Time to Diagnosis and Improved Patient Outcomes

While many of the studies evaluating POCUS have been prospective cohort studies designed to evaluate its accuracy relative to a reference standard,<sup>6,16</sup> more rigorously designed studies intended to evaluate the effect of POCUS on patient outcomes are now emerging. A recent randomized control trial demonstrated that lung ultrasound can diagnose acute decompensated heart failure in patients presenting with dyspnea quicker and more accurately than the standard workup with brain natriuretic peptide and chest x-ray.<sup>17</sup> Two additional randomized control trials have shown that lung ultrasound-guided diuresis in ambulatory patients with heart failure reduces urgent visits.<sup>18,19</sup> In order to further inform best practices in training and use, pragmatic trials are needed to assess patient outcomes and cost associated with POCUS implementation in real world settings.

## Fewer Tests, Less Radiation, Lower Cost

Critics have expressed concerns that POCUS may result in additional testing to evaluate incidental findings. However, evidence is mounting that POCUS has the potential to decrease the use of additional imaging tests and has been associated with lower radiation exposure and fewer follow-up tests with no difference in adverse events in multiple studies.<sup>8-10,20</sup> If these results are broadly reproducible, cost savings and higher value care may be seen as POCUS is implemented across health care systems.

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**TABLE**  
Test Characteristics of Traditional Physical Examination Findings Versus Point-of-Care (POC) Ultrasound Findings for Common Pathologies

| Pathology                            | Physical Exam Finding          | Sensitivity | Specificity | LR+ | LR- | POC Ultrasound Finding              | Sensitivity | Specificity | LR+  | LR-  |
|--------------------------------------|--------------------------------|-------------|-------------|-----|-----|-------------------------------------|-------------|-------------|------|------|
| Pleural effusion                     | Dullness to percussion         | 89%         | 81%         | 4.8 | 0.1 | Pleural fluid visualization         | 93%         | 96%         | 23   | 0.07 |
|                                      | Decreased breath sounds        | 88%         | 83%         | 5.2 | 0.1 |                                     |             |             |      |      |
| Pulmonary edema                      | Crackles                       | 19%–64%     | 82%–94%     | 3.4 | NS  | B lines (bilateral)                 | 94%         | 92%         | 10.4 | 0.06 |
|                                      | Bronchial breath sounds        | 14%         | 96%         | 3.3 | NS  | Consolidation pattern               | 94%–95%     | 90%–96%     | 13.5 | 0.06 |
|                                      | Egophony                       | 4%–16%      | 96%–99%     | 4.1 | NS  |                                     |             |             |      |      |
|                                      | Crackles                       | 19%–67%     | 36%–94%     | 1.8 | 0.8 |                                     |             |             |      |      |
| Elevated LV pressure                 | Fourth heart sound             | 37%–71%     | 50%–70%     | NS  | NS  | PCWP 17 if IVC > 2.0                | 75%         | 83%         | 4.4  | 0.3  |
| Elevated CVP > 8 cm H <sub>2</sub> O | Neck vein inspection           | 47%–92%     | 93%–96%     | 9.7 | 0.3 | For CVP > 10 mm Hg: IVC size > 2 cm | 73%         | 85%         | 4.9  | 0.32 |
| Reduced ejection fraction < 50%      | Third heart sound              | 11%–51%     | 85%–98%     | 3.4 | 0.7 | LV systolic dysfunction             | 84%–91%     | 85%–88%     | 6.5  | 0.14 |
| Congestive heart failure             | Crackles                       | 12%–23%     | 88%–96%     | NS  | NS  | B lines, bilateral                  | 97%         | 95%         | 19.4 | 0.03 |
|                                      | Elevated JVP                   | 10%–58%     | 96%–97%     | 3.9 | NS  | For CVP > 10 mm Hg: IVC size > 2 cm | 73%         | 85%         | 4.9  | 0.32 |
|                                      | Abdominojugular test           | 55%–84%     | 83%–98%     | 8.0 | 0.3 |                                     |             |             |      |      |
|                                      | Edema                          | 10%         | 93%–96%     | NS  | NS  |                                     |             |             |      |      |
|                                      | Bulging flanks                 | 73%–93%     | 44%–70%     | 1.9 | 0.4 | Ascites visualization               | 96%         | 82%         | 32   | 0.04 |
| Ascites                              | Flank dullness                 | 80%–94%     | 29%–69%     | NS  | 0.3 |                                     |             |             |      |      |
|                                      | Shifting dullness              | 60%–87%     | 56%–90%     | 2.3 | 0.4 |                                     |             |             |      |      |
|                                      | Fluid wave                     | 50%–80%     | 82%–92%     | 5.0 | 0.5 |                                     |             |             |      |      |
|                                      | Calf swelling > 2 cm           | 61%–67%     | 69%–71%     | 2.1 | 0.5 | Compression venous ultrasonography  | 96%         | 97%         | 32   | 0.04 |
| Lower extremity DVT                  | Homan's sign                   | 10%–54%     | 39%–89%     | NS  | NS  |                                     |             |             |      |      |
|                                      | Wells score (high probability) | 38%–87%     | 71%–99%     | 6.3 | NA  |                                     |             |             |      |      |

Note: Table adapted from Reference 13 (Bhagra et al 2016).

Abbreviations: NS, not significant; LV, left ventricle; PCWP, pulmonary capillary wedge pressure; IVC, inferior vena cava; CVP, central venous pressure; JVP, jugular venous pressure; DVT, deep vein thrombosis.

## Improved Patient and Clinician Experience

From the patient perspective, POCUS offers advantages that include avoidance of ionizing radiation, immediate availability of results, and most important, greater time with their clinician at the bedside. The available evidence supports the notion that the patient experience is enhanced by the use of POCUS.<sup>21,22</sup> From a clinician's perspective, some of the highest yield POCUS applications include basic cardiac, pulmonary, and vascular ultrasound examinations that are relatively easy to learn and quick to perform.<sup>11,16,23,24</sup>

For these reasons, POCUS stands poised to offer the bedside assessment a renaissance. Many have lamented the waning physical examination skills of clinicians. However, POCUS uniquely brings clinicians back to the bedside, allowing for a more thorough assessment that combines both POCUS and traditional physical examination maneuvers.

## Barriers to Implementation: Past and Present

Given the complexity of POCUS integration into diverse and multi-level health systems, the extent of adoption will likely vary based on a wide range of contextual factors, including the availability of other tests, patient population, and workflow. Below we discuss some of the most prominent barriers within the literature to date.

### Access to Equipment

Until recently, one of the most significant barriers to the adoption of POCUS was access to an ultrasound machine related to cost and portability.<sup>25</sup> Less than 10 years ago, a portable cart-based ultrasound machine with adequate image quality cost between \$40,000 to \$50,000 and had to be wheeled from room to room by a clinician. The surge of affordable handheld ultrasound devices, including some that connect with smartphones or tablets, has greatly mitigated access to an ultrasound machine as a barrier. Currently, handheld ultrasound devices can be purchased for approximately \$2,000 to \$5,000, allowing many clinicians to purchase their own personal devices, greatly increasing access.

### Training

To date, POCUS training has been more widely implemented in undergraduate medical education than in graduate medical education (GME),<sup>26,27</sup> and there is not yet clear consensus regarding what a POCUS curriculum should contain for many specialties. However, following the lead of emergency

medicine, national professional societies that represent specialties like family and internal medicine have now officially endorsed the implementation of POCUS.<sup>28–30</sup> Given this formal support by professional societies and a desire for POCUS training among trainees and residency leadership,<sup>25</sup> many expect that at least some POCUS applications will become required competencies for many specialties. Lack of faculty experts has been recurrently cited as one of the most important barriers to adoption of POCUS by clinicians and residency leadership.<sup>25,31,32</sup> To address the current gap between their society recommendations and actual practice, many specialties have launched training courses meant to provide a pathway to competency.

Although novice POCUS operators can attain basic competency in image acquisition and image interpretation with relatively brief training,<sup>11,33</sup> expert use of any test requires a more complex skill set to integrate test results into clinical decision-making. This higher order skill includes the ability to combine an accurate pretest probability with knowledge of the test characteristics and limitations of the POCUS examination performed to arrive at an accurate posttest probability and appropriate management plan. Because of the complexity of clinical decision-making, POCUS competency, like other clinical skills, will be most consistently achieved with longitudinal mentoring in real world clinical settings. For this reason, faculty expertise is critical for effective integration of POCUS into GME.<sup>25,34,35</sup> Residency leadership interested in developing competency-based POCUS curricula must consider investing in the development of POCUS expertise in their clinical educators as a foundational strategy.

## Conclusions

Given growing evidence of its utility, endorsement by professional societies, and increasing availability, POCUS is poised to modernize the bedside assessment across specialties. Residencies will play a pivotal role in the widespread adoption of POCUS. Development of POCUS expertise among clinical educators is an important first step in creating training curricula that allow for the attainment of competency during residency.

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