

# Critical Care Ultrasonography



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## KEYWORDS

• Critical care • Ultrasonography • Point of care • Resuscitative medicine

## KEY POINTS

- The use of point-of-care ultrasonography (POCUS) has become an integral part of critical care and resuscitative medicine in recent years.
- A major accelerant of the POCUS revolution, across all clinical domains, has been the miniaturization of ultrasonography machines, allowing them to be brought to patients easily, rather than requiring patients to be transported away from their clinical environment to be imaged.
- Whether in a prehospital setting, the emergency department, or the intensive care unit, patients at risk of deterioration and/or death benefit most from the timely, multisystem bedside analysis provided by POCUS.

## INTRODUCTION

Resuscitation scenarios require rapid diagnostic and therapeutic decisions tailored to a patient's underlying condition and evolving physiology. Diagnostic and monitoring tools that can reliably reveal organ failure or life-threatening conditions at the bedside are of the utmost value in these often overwhelming situations.

The use of point-of-care ultrasonography (POCUS) has become an integral part of critical care and resuscitative medicine in recent years. A major accelerant of the POCUS revolution, across all clinical domains, has been the miniaturization of ultrasonography machines, allowing them to be brought to patients easily, rather than requiring patients to be transported away from their clinical environments to be imaged. Nowhere has this paradigm shift been more beneficial to patients and providers than with the critically ill patient. Whether in a prehospital setting, the emergency department (ED), or the intensive care unit (ICU), patients at risk of deterioration

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and/or death benefit most from the timely, multisystem bedside analysis provided by POCUS.

From its origins in the trauma bay in the assessment for hemopericardium<sup>1,2</sup> and hemoperitoneum,<sup>3,4</sup> POCUS for the critically ill patient has a growing list of applications. Some applications are the foundation of resuscitation, such as the cause of shock in the undifferentiated patient, whereas other, newer concepts, like intracranial pressure determination from optic nerve sheath diameter, require more time to determine their clinical value. This article reviews the contemporary applications of POCUS that are most relevant to resuscitation.

Before discussing ultrasonography related to the care of the critically ill, a distinction should be made between what has classically been referred to as critical care ultrasonography as described by the American College of Chest Physicians (ACCP) in 2009 and resuscitative ultrasonography, as discussed here. Critical care ultrasonography has been described as a specific set of skills used in the ICU setting involving thoracic, abdominal, vascular, and cardiac ultrasonography and requiring a minimum standard of competence outlined by the ACCP.<sup>5</sup> Resuscitative ultrasonography encompasses a wide range of practitioners of various skill levels using ultrasonography to assist with resuscitation across a variety of clinical settings. Although resuscitative ultrasonography in the ED is frequently labeled critical care ultrasonography, we therefore favor the more descriptive and nonpartisan term of resuscitative ultrasonography.

## **APPLICATION 1: DIFFERENTIATING SHOCK STATES**

### ***Multisystem Protocols***

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One of the most powerful applications of POCUS is in the rapid differentiation of shock states, which has been an area of intense clinical and academic interest over the past decade with the advent of several multisystem scanning protocols (**Table 1**) for shock published in the literature.<sup>6–11</sup> The published protocols encourage the routine use of a systematic, multiorgan approach when assessing patients with undifferentiated hypotension. Because no single protocol has proved superior to another, it is the common systematic, multiorgan approach they all endorse, rather than the details of their exact execution that should be emphasized. In general, in the face of undifferentiated shock or hypotension, the following ultrasonography examination elements should be executed: focused point-of-care echocardiography, thoracic (lung and pleural) ultrasonography, inferior vena cava (IVC) assessment, abdominal free fluid, and aortic aneurysm assessments. Shock differentiation is fundamental to resuscitative ultrasonography and worthy of further organ-by-organ discussion.

### ***Assessment for Cardiogenic Causes of Shock***

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Evaluation of the heart with POCUS during shock can alter a patient's treatment trajectory in a matter of seconds. In typical goal-directed echocardiography, a phased-array transducer is used to generate 4 standard echocardiographic views of the heart: the parasternal long axis (PLAX) and parasternal short axis (PSAX), the apical 4-chamber (A4C), and subxiphoid (SUBX) views. Each view provides new or complementary information about the relevant cardiac chambers' size and function, gross valvular disorders, as well as the state of the pericardium. Imaging findings are rapidly synthesized to fit in to one of several clinical syndromes. A summary of the clinical syndromes and corresponding imaging details that are of interest in resuscitation are summarized in **Table 2**.

Assessment of the patient's left ventricular function begins with obtaining the PLAX and PSAX views of the heart. The PLAX is often referred to as the scout view of the

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