Image Acquisition Method for the Sonographic Assessment of the Inferior Vena Cava

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Abstract

Over the past several decades, clinicians have incorporated several applications of diagnostic point-of-care ultrasound (POCUS) into medical decision-making. Among the applications of POCUS, imaging the inferior vena cava (IVC) is practiced by a wide variety of specialties, such as nephrology, emergency medicine, internal medicine, critical care, anesthesiology, pulmonology, and cardiology. Although each specialty uses IVC data in slightly different ways, most medical specialties, at minimum, attempt to use IVC data to make predictions about intravascular volume status. While the relationship between IVC sonographic data and intravascular volume status is complex and highly context-dependent, all clinicians should collect the sonographic data in standardized ways to ensure repeatability. This paper describes standardized IVC image acquisition including patient positioning, transducer selection, probe placement, image optimization, and the pitfalls and limitations of IVC sonographic imaging. This paper also describes the commonly performed anterior IVC long-axis view and three other views of the IVC that can each provide helpful diagnostic information when the anterior long-axis view is difficult to obtain or interpret.

Introduction

Over the last several decades, the accessibility of point-of-care ultrasound (POCUS) has increased dramatically. Providers across medical disciplines can now integrate POCUS into their bedside exams and more readily identify important contributors to patients' conditions[1]. For example, in acute care settings, one of the most important areas of focus is the assessment and management of volume status[2]. Inadequate fluid resuscitation can result in tissue hypoperfusion, end-organ dysfunction, and severe acid-base abnormalities. However, overzealous fluid administration is associated with worsened mortality[3]. The determination of volume status has primarily been accomplished using the combination of physical exam findings and dynamic hemodynamic measures, including pulse pressure variation, central venous pressure, and/or fluid challenges *via* either passive leg-raise testing or intravenous fluid boluses[4]. With the growing availability of POCUS devices, some providers are seeking to use ultrasound imaging to supplement these measures[5]. The sonographic assessment of the anterior-to-posterior dimension of the IVC and the respirophasic change in that dimension can assist in the assessment of right atrial pressure and, possibly, intravascular volume status[6,7,8,9].

Notably, however, the relationship between IVC parameters (i.e., size and respirophasic change) and volume responsiveness is distorted in many common situations, including but not limited to, the following: (1) passively ventilated patients receiving either high positive end-expiratory pressure (PEEP) or low tidal volumes; (2) spontaneously breathing patients making either small or large respiratory effort; (3) lung hyperinflation; (4) conditions impairing venous return (e.g., right ventricular dysfunction, tension pneumothorax, cardiac tamponade, etc.); and (5) increased abdominal compart pressure[10].

While the utility of IVC sonography as a standalone measure for assessing the intravascular volume status is debated[5,10,11,12], there is no debate about the fact that its use as a diagnostic tool requires imaging in standardized ways and the ability to utilize alternative views when a single vantage point proves to be inadequate[2]. Toward this end, this manuscript defines the four sonographic views of the IVC, illustrates common sonographic pitfalls and how to avoid them, and provides examples of both typical and extreme IVC sonographic states. There are four views in which the IVC can be adequately visualized by transabdominal sonography: anterior short-axis, anterior long-axis, right lateral long-axis, and right lateral short-axis. The protocol below describes a standardized method of image acquisition.

Protocol

All procedures performed in the studies involving human participants were conducted in accordance with the ethical standards of the Duke University Health System Institutional Research Committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The protocol was performed using input from several peer-reviewed papers in the academic literature[2,13,14,15]. Imaging was performed on the authors themselves for the normal images and as part of routine educational ultrasound scans done for teaching purposes for the positive images, with preceding verbal consent obtained as per institutional standards. The patients were selected based on certain criteria. Specifically, the inclusion criterion was any patient with hypotension, and the exclusion criterion was patient refusal to undergo an ultrasound exam.

1. Safety procedures

1. Utilize nonsterile nitrile or latex gloves depending on the patient's allergies. Additional safety precautions may be required based on the clinical context. Please refer to the respective institution's infection control policies, and follow any precautions in place.

2. Probe selection

1. For infants (i.e., children younger than 1 year of age), perform the sonographic evaluation of the IVC with either a low-frequency or high-frequency (>5 MHz) ultrasound transducer, depending on the infant's body size.
   NOTE: IVC evaluation in infants is a specialized pediatric topic beyond the scope of this review. The remainder of this review solely focuses on imaging the IVC in individuals over 1 year of age.

2. For individuals over 1 year of age, visualize the IVC with any low-frequency (≤5 MHz) ultrasound transducer, such as a linear phased-array sector arc probe or curvilinear probe.

NOTE: The linear phased-array sector arc probe is commonly referred to as a phased-array probe. This term is misleading, since all modern ultrasound transducers use phasing to steer the ultrasound beam[16,17]. However, for the sake of brevity, throughout this review, we will use the term phased-array probe instead of linear phased-array sector arc probe.

    1. The phased-array probe is the optimal probe for both main types of external cardiac ultrasound: transthoracic echocardiography (TTE) and focused cardiac ultrasound (FoCUS)[18]. When performing either TTE or FoCUS to evaluate the heart, continue using the phased-array transducer for the IVC portion of each exam rather than switching to another low-frequency probe.

3. Machine preset

1. Set the machine to the cardiology convention by using the **Cardiac Preset** function, which sets the indicator to the left of the screen. Set the screen refresh rate to >20 Hz.

NOTE: The IVC evaluation can be performed in the Abdominal Mode. However, for the same points mentioned in step 2.2.1, it is far more convenient to utilize the same presets for both a FoCUS exam and a POCUS IVC exam.

2. Set the mode to B-Mode (2-dimensional grayscale). Set the depth to 6-20 cm, depending on the depth of the IVC in each patient.

4. Scanning technique

1. Apply ultrasound gel to the transducer.
2. Obtain the anterior IVC short-axis (ANT IVC SAX) view.
    1. Position the patient in the supine position with both hips flexed, if tolerated by the patient.
    2. Place the ultrasound probe centered on the patient's anterior midline just caudal to the xiphoid process in the coronal plane, with the transducer indicator mark pointing toward the patient's left (**Figure 1**).
    3. Adjust the depth so that the IVC and aorta appear in the middle third of the screen and the spine is visible (**Video 1**).
    4. For setting the axis, fan the ultrasound beam cranially or caudally until both the IVC and the abdominal aorta appear in the short-axis cross-section as rounded structures (**Video 1**).
    5. Decrease the gain until the blood in the IVC is either completely black or just a few specks of grey are visible (**Video 1**).
    6. Once all the settings are done, click on **Acquire**.
3. Obtain the anterior IVC long-axis (ANT IVC LAX) view.
    1. Position the patient in the supine position with both hips flexed, if tolerated by the patient.
    2. Position the probe for obtaining the ANT IVC SAX view as described in step 4.2, center the view on the IVC, and rotate the ultrasound probe 90° counterclockwise, without translating the probe, such that the probe's indicator faces cranially at the end of the rotation (**Figure 2**).

3. Adjust the depth so that the IVC appears in the middle third of the screen and the liver tissue is visible deeper than the IVC (**Video 2**).

4. For setting the axis, fan the ultrasound beam toward the patient's left or right until the IVC appears as a rectangular, intrahepatic structure spanning from cranial to caudal on the screen. (**Video 2**).

5. Decrease the gain until the blood in the IVC is either completely black or just a few specks of grey are visible (**Video 2**).

6. Once all the settings are done, click on **Acquire**.

7. Optional: Quantify the IVC anterior-to-posterior (AP) diameter (**Figure 3**).

    1. With a live image of the IVC optimized as per step 4.3.6, click on **Freeze**. Click on **Caliper** or **Measure**, depending on the machine's measurement button.

    2. Move the trackball to the anterior wall of the IVC approximately 1-2 cm caudal from the hepatic vein confluence. Click on **Select**.

    3. Move the trackball to the posterior wall of the IVC opposite the point in step 4.3.7.2, such that the line between the two points is roughly perpendicular to the long axis of the IVC. Click on **Select**, and then click on **Acquire**.

4. Obtain the right lateral IVC long-axis (RL IVC LAX) view.

    1. Position the patient in the supine position with the legs flat and the right arm moved away from the patient's side, either overhead or outstretched laterally, so as to allow access to the right flank.

    2. Place the probe transducer in the coronal plane with the indicator pointing cranially in the sixth or seventh right intercostal space just anterior to the right mid-axillary line (**Figure 4**).

    3. Adjust the depth so that the IVC appears in the middle third of the screen and the liver tissue is visible deeper than the IVC (**Video 3**).

    4. For setting the axis, fan the ultrasound beam anteriorly or posteriorly until the IVC is visualized as a rectangular, intrahepatic structure spanning from cranial to caudal on the screen (**Video 3**).

    5. Decrease the gain until the blood in the IVC is either completely black or just a few specks of grey are visible (**Video 3**). Click on **Acquire**.

5. Obtain the right lateral IVC short-axis (RL IVC SAX) view.

    1. Continue positioning the patient supine with the legs flat and the right arm moved away from the patient's side, either overhead or outstretched laterally, so as to allow access to the right flank.

    2. Continue positioning the probe in the position used for obtaining the RL IVC LAX view (see step 4.4), center the view on the IVC, and rotate the ultrasound probe 90° clockwise, without translating the probe, such that the probe's indicator faces anteriorly at the end of the rotation (**Figure 5**).

    3. Adjust the depth so that the IVC appears in the middle third of the screen and the liver tissue, aorta, and spine are all visible deeper than the IVC (**Video 4**).

    4. For setting the axis, fan the ultrasound beam cranially or caudally until the IVC and abdominal aorta are visible in the short-axis view as rounded structures (**Video 4**).

5. Decrease the gain until the blood in the IVC is either completely black or just a few specks of grey are visible (**Video 4**). Click on **Acquire**.

Representative Results

Adequate exam

There is no single caliber or respirophasic behavior of the IVC that can be considered universally normal in all circumstances. For instance, the IVC seen in **Videos 1-4** and **Figure 3** was imaged in a healthy, hydrated male experiencing no acute illness. However, notably, this patient's "normal" IVC has a relatively large AP diameter, >2 cm in the ANT IVC LAX view, and shows minimal respirophasic change. This exact same IVC appearance in other circumstances could be considered pathological (e.g., if there is suspicion of any of the following: congestive heart failure, chronic renal disease, pulmonary hypertension, right heart dysfunction, cardiac tamponade, and/or pneumothorax causing high intrathoracic pressure)[13,14,19,20]. Similarly, the finding of >50% change in IVC caliber is considered normal in asymptomatic patients[14] but has been associated with hypovolemic shock and with a higher risk of hypotension during the induction of general anesthesia[21,22]. Additionally, the relationships between IVC parameters (size and respirophasic change) and intravascular volume status are known to break down in any of the following situations[10]: (1) positive pressure ventilation with either small tidal volumes or large PEEP; (2) spontaneous ventilation with either shallow or vital capacity breathing; (3) hyperinflated lung states (e.g., obstructive lung disease); (4) states of impaired venous return (e.g., pulmonary hypertension, right heart dysfunction, cardiac tamponade, tension pneumothorax); and (5) states of increased intraabdominal pressure .

Since the clinical interpretation of the IVC caliber and respirophasic change is highly context-dependent and this paper is centered on IVC image acquisition, we define an adequate exam as one that permits the visualization of the IVC (**Figure 3**) and an inadequate exam as one that does not show the IVC or shows it transiently, thus preventing the assessment of the maximal caliber of the vessel, its respirophasic change, or both. As an example of a complete adequate exam, **Videos 1-4** each permit IVC visualization and, thus, interpretation.

Inadequate exams

There are two common pitfalls leading to inadequate exams: 1) the abdominal aorta being misidentified as the IVC, and 2) the IVC lateral displacement being mistaken for IVC respirophasic change. In **Figure 6** and **Video 5**, the operator mistakenly obtained a clip of the abdominal aorta in long-axis rather than of the IVC. Since the two vascular structures lie in close proximity to one another and run in parallel[23], the misidentification of one for the other is common.

In non-peer reviewed teaching, an often cited way of identifying the IVC is to visualize the vascular structure draining into the right atrium[24,25]. However, the long-axis view of the abdominal aorta often falsely appears to show the cranial portion of the aorta as contiguous with various cardiac chambers, commonly the RA (see **Video 5**). Without being aware of this pitfall, in the authors' experience, trainees often misidentify the abdominal aorta as the IVC when this criterion is used.

To help distinguish between the two reliably, certain heuristics are helpful. Specifically, the IVC has the following sonographic features: (1) it is located to the right of the midline and is intrahepatic; (2) it is thin-walled; (3) it lacks pulsatility (except in severe tricuspid regurgitation); and (4) it can vary in shape over the course of the respiratory cycle

Conversely, the abdominal aorta has the following sonographic features: (1) it is located to the left of the midline and is retro-hepatic; (2) it has thick echogenic walls; (3) it is pulsatile (except in cardiac arrest and in the presence of non-pulsatile ventricular assist devices); and (4) it is generally constant in shape throughout the respiratory cycle.

The shape of the pressurized aorta remains generally cylindrical throughout the respiratory cycle, whereas the IVC, which has lower internal pressure, is more easily distorted by external forces. Specifically, changes in intrathoracic pressure are transmitted to the IVC in complex ways, resulting in dynamic changes in the IVC caliber over the course of the respiratory cycle. These changes have been termed IVC respirophasic changes[15].

Depending on the mode of ventilation, the pattern of IVC respirophasic change varies. When a spontaneously breathing patient inspires, the diaphragm contracts and moves caudally, generating negative intrathoracic pressure that promotes venous return to the right heart[26]. As a result, the IVC collapses in response to this negative inspiratory pressure and expands during expiration (see **Video 6**).

Intuitively, the opposite is true for mechanically ventilated patients. With mechanical ventilation, positive pressure is generated down the bronchioalveolar trees, thus expanding the lungs and creating positive intrathoracic pressure[26]. This positive pressure impedes venous return and distends the IVC during inspiration. Subsequently, the pressure release during expiration allows a proportional decrease in the caliber of the IVC.

The presence of respirophasic change can be a marker of both normal and abnormal physiology, depending on the context[18,21,22,27,28,29,30,31]. In either case, to detect respirophasic change, the maximal dimension of the IVC must remain in the 2-dimensional plane of the ultrasound beam throughout a clip. However, the IVC and aorta can move laterally during the respiratory cycle, regardless of the mode of ventilation[15]. In the long-axis views of either structure, this lateral movement may falsely appear to be a respirophasic change. Differentiating this pseudo-collapsibility from true collapsibility is best performed by supplementing long-axis views with short-axis views, in which the lateral displacement can be viewed directly, while simultaneously assessing for true compression or expansion during respiration.

An example of IVC lateral displacement is shown in **Video 7**. In this video, the IVC's seeming collapsibility is due to its movement relative to the ultrasound transducer. This relative movement would prevent a clinician from assessing the true respirophasic change in IVC size. Therefore, the clip shown is inadequate for IVC assessment.

Figure 1: Anterior IVC short-axis view. To obtain the anterior IVC short-axis view, the probe is placed just caudal to the xiphoid process in the coronal plane, with the indicator mark pointing toward the patient's left. Please click here to view a larger version of this figure.

Figure 2: Anterior IVC long-axis view. To obtain the anterior IVC long-axis view, first the anterior IVC short-axis view is obtained. Then, the IVC is centered, and the probe is rotated 90° counterclockwise so that the probe's indicator mark faces cranially and the probe is aligned with the long axis of the patient's body. Please click here to view a larger version of this figure.

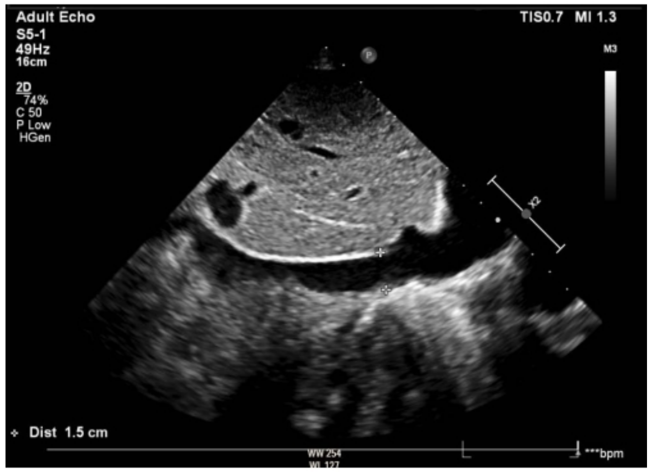

Figure 3: Anterior IVC long-axis view AP measurement. Still image of the anterior IVC long-axis view showing where the standardized measurement of the antero-posterior diameter of the vessel should be made (i.e., 1-2 cm caudal to the hepatic vein confluence, where the hepatic veins empty into the IVC). Please click here to view a larger version of this figure.

Figure 4: Right lateral IVC long-axis view. To obtain the right lateral IVC long-axis view, the ultrasound probe is placed just anterior to the mid-axillary line along the left flank, with the ultrasound beam in the coronal plane and the indicator mark pointing cranially. Please click here to view a larger version of this figure.

Figure 5: Right lateral IVC short-axis view. To obtain the right lateral IVC short-axis view, first the right lateral IVC long-axis view is obtained. Then, the IVC is centered, and the probe is rotated 90° clockwise so that the probe's indicator mark faces anteriorly, perpendicular to the long axis of the patient's body. Please click here to view a larger version of this figure.

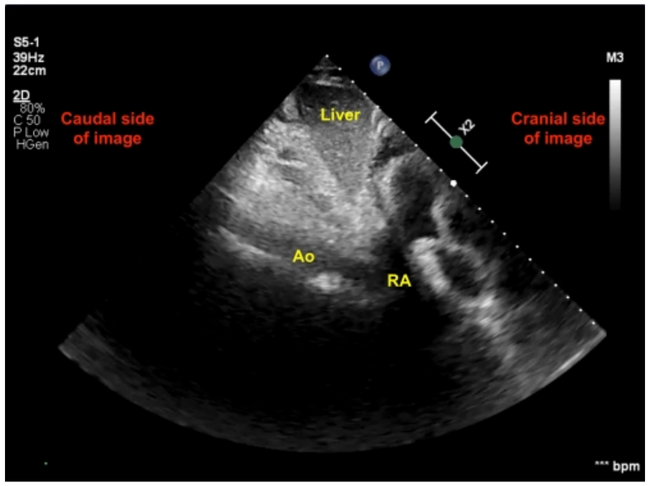

Figure 6: Anterior abdominal aorta long-axis view: This is a labeled still image of **Video 5**. This view was obtained by searching for the anterior IVC long-axis view whilst angling the ultrasound beam slightly toward the patient's left. In this image, the aorta appears to be contiguous with the right atrium (RA), a frequent finding that undermines the utility of looking for drainage into the RA as a way of distinguishing between the IVC and the abdominal aorta. Please click here to view a larger version of this figure.

Video 1: Anterior IVC short-axis view. Video and accompanying still image showing the typical sonographic appearance of the anterior IVC short-axis view. In this view, the intrahepatic nature of the inferior vena cava (IVC) can be easily appreciated. In this view, the IVC is surrounded by liver anteriorly and posteriorly. In contrast, under normal circumstances, the abdominal aorta (AO) lies posterior to the liver. Further, the anterior IVC short-axis view typically allows the visualization of the spine, which is located deeper than both the IVC and abdominal aorta. The cartoon schematic seen at the beginning and end of this clip was reprinted with permission from www.countbackwardsfrom10.com. Please click here to download this Video.

Video 2: Anterior IVC long-axis view. Video and accompanying still image showing the typical sonographic appearance of the anterior IVC long-axis view. In this view, the IVC is seen in its long-axis cross-section as a rectangular structure within the liver extending from the diaphragm cranially to the caudal portion of the screen. Other structures often seen in this view include the spine and a portion of the supradiaphragmatic space. The cartoon schematic seen at the beginning and end of this clip was reprinted with permission from www.countbackwardsfrom10.com. Please click here to download this Video.

Video 3: Right lateral IVC long-axis view. Video and accompanying still image showing the typical sonographic appearance of the right lateral IVC long-axis view. In this view, the IVC is seen in its long-axis cross-section as a rectangular structure within the liver extending from the diaphragm cranially to the caudal portion of the screen. Other structures often seen in this view include the abdominal aorta (seen in long-axis in this view) and the diaphragm. Notably, in most patients, the IVC lateral-to-medial (L/M) diameter is on average about 4 mm greater than the antero-posterior (A/P) IVC diameter[32]. However, despite this discrepancy in the absolute size, the respirophasic change is similar in both directions for a given IVC. Accordingly, there is evidence that the two views can be used interchangeably for some purposes[32]. The cartoon schematic seen at the beginning and end of this clip was reprinted with permission from www.countbackwardsfrom10.com. Please click here to download this Video.;

Video 4: Right lateral IVC short-axis view. Video and accompanying still image showing the typical sonographic appearance of the right lateral IVC short-axis view. The superficial portion of this view contains structures in the right flank, such as the liver. The deep portion of this view contains structures located near the midline of the body, such as the spine, IVC, and abdominal aorta (AO). Both the IVC and aorta are seen in this view in their short-axis cross-sections (i.e., as relatively round structures). The cartoon schematic seen at the beginning and end of this clip was reprinted with permission from www.countbackwardsfrom10.com. Please click here to download this Video.

Video 5: Anterior aorta long-axis view. Video and accompanying still image showing the abdominal aorta (AO) in long-axis view. This view was obtained by searching for the anterior IVC long-axis view whilst angling the ultrasound beam slightly toward the patient's left. In this clip, the aorta appears to be contiguous with the right atrium (RA), a frequent finding that undermines the utility of looking for drainage into the RA as a way of distinguishing between the IVC and abdominal aorta. Please click here to download this Video.

Video 6: Anterior IVC long-axis view respirophasic change. This video clip shows an anterior long-axis view of the IVC in a spontaneously breathing patient. Normally, as seen here, a large negative pressure breath or sniff lowers the intrathoracic pressure significantly, creating a large enough gradient for venous return to increase from the abdomen into the thorax and, thus, causing an increase of >50% in the IVC's antero-posterior dimension. Please click here to download this Video.

Video 7: Anterior IVC long-axis view pseudo-collapsibility. This video clip shows an anterior long-axis view of the IVC in a spontaneously breathing patient. However, the IVC is seen moving in and out of the plane of the ultrasound beam, as evidenced by the disappearance and reappearance of the hepatic veins draining into the IVC, which have a fixed position relative to the IVC itself. Cases like this of lateral IVC displacement are, in our experience, commonly misinterpreted by trainees as IVC collapsibility, which results in the potential for treatment error. To minimize the chances of committing this error, we recommend always complementing long-axis views of the IVC with supplementary short-axis views. Please click here to download this Video.

Video 8: Anterior IVC in long-axis view that is narrow and collapsible. This video clip shows an anterior long-axis view of the IVC in a spontaneously breathing patient, with findings suggestive of grossly low right atrial pressure: an IVC anterior-posterior dimension <1 cm and >50% collapse of the IVC diameter with respiration. IVC parameters this extreme are typically a sign of intravascular hypovolemia and, in the setting of hypotension, can be used as a justification for administering a fluid challenge. Please click here to download this Video.

Video 9: Anterior IVC in long-axis view that is distended. This video clip shows an anterior long-axis view of the IVC in a spontaneously breathing patient, with findings suggestive of grossly elevated right atrial pressure: an IVC anterior-posterior dimension of ~2.5 cm and essentially no respirophasic change. IVC parameters this extreme are typically a sign of intravascular normovolemia to hypervolemia. In cases of hypotension, these IVC findings suggest that something other than hypovolemia is likely primarily driving the hypotension. Please click here to download this Video.

Discussion

Even when properly imaged, information garnered from the IVC should not be the sole data point used for guiding treatment. The exact same IVC size and respirophasic changes can be seen in both normal states and in pathologic conditions. Therefore, the clinical context is critically important for guiding how to interpret the IVC data. Further, when using ultrasound to assess a patient's intravascular volume status, the published literature is mixed as to what thresholds of IVC size and respirophasic change accurately predict the subsequent cardiac output increase in response to an intravascular volume challenge (i.e., volume responsiveness)[5,11,18,27]. This should not be surprising, as IVC size and respirophasic changes are closely correlated with central venous pressure (CVP)[14], which itself has not been found to be a reliable marker of volume responsiveness[33].

To acknowledge the limitations of sonographic IVC parameters and still extract useful information from them, Lee et al.[11] proposed a helpful pragmatic approach involving using the IVC and lung ultrasound to sort hypotensive patients into one of three broad categories regarding the volume status: 1) volume resuscitate when the IVC is <1 cm in AP diameter (**video 8**) and the lungs on ultrasound appear free of edema; 2) volume restrict when the IVC is >2.5 cm in AP diameter (**video 9**) and there is sonographic evidence of pulmonary edema; and 3) volume trial when the sonographic appearance of the IVC and the lungs falls between the extremes identified in categories (1) or (2).

Expounding on the approach by Lee et al.[11], we propose utilizing another concept that is underemphasized in the IVC interpretation literature: pre-test probabilities. For instance, in cases where the pre-test (pre-ultrasound) probability of hypovolemia is high, intermediate IVC and lung ultrasound findings (category 3 above) are more likely to predict hypovolemia than in the general population. Patients who should be considered to have a high pre-test probability of hypovolemia include, but are not limited to, the following: acute polytrauma victims; recipients of open abdominal surgery in the past 24 h; patients being weaned from cardiopulmonary bypass; and patients in early (<24 h) septic shock. In contrast, patients who should be considered to have a lower pre-test (pre-ultrasound) probability of hypovolemia include the following: intensive care unit patients 1 or more days after initial fluid resuscitation or patients for whom another form of shock (i.e., other than hypovolemic shock) is being considered.

With the increased availability of sonographic capabilities across medical facilities in the United States, more providers are turning to POCUS to guide diagnosis and treatment. Inconsistent and inaccurate imaging can confound patient management and exacerbate intra-operator variability. To avoid these pitfalls, providers should follow a standardized protocol to obtain IVC images and learn to supplement the commonly performed anterior IVC long-axis view with the other views described in this paper. For instance, the anterior long-axis view is frequently inadequate or challenging in at least two situations, including severe hypovolemia and respiratory distress, when the IVC moves laterally in the body in relation to the ultrasound transducer, thus creating the illusion of collapsibility (i.e., pseudo-collapsibility) in the long-axis view. In both scenarios, the anterior IVC short-axis view can help by allowing providers to locate the IVC more easily in times of IVC collapse and by helping to differentiate true collapsibility from pseudo-collapsibility. Further, even both anterior views may be inadequate or impossible in any situations where dressings, drains, air-filled loops of bowel, or thick tissues (obesity or pregnancy) lie between the ultrasound transducer and the IVC. In these situations, the lateral views may provide the only glimpse of the IVC possible. In all cases, combining at minimum one long-axis view and one short-axis view can improve medical providers' 3-dimensional understanding of IVC size and respirophasic behavior to guide management appropriately.

Disclosures

The authors have nothing to disclose.

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