Technical Pitfalls in Sonography of the Inferior Vena Cava: Beware the Diaphragm

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We recently cared for a 52-year-old man in our emergency department who presented with progressive shortness of breath over several days. On examination, he was found to have bibasilar crackles, jugular venous distention, and mild lower extremity edema. A chest radiograph revealed a borderline cardiac size and prominent interstitial lung markings, and his electrocardiogram revealed sinus tachycardia without acute ST- or T-wave abnormalities.

On the basis of these findings, we made a preliminary diagnosis of decompensated heart failure and performed point-of-care cardiac sonography to further assess his condition. The patient was found to have an enlarged left ventricle, a severely reduced left ventricular ejection fraction, biatrial enlargement, and a trace pericardial effusion (Video 1). The resident physician performing the study reported that the inferior vena cava (IVC) appeared dilated but that it showed normal collapse with inspiration (Video 2).

Given this apparent inconsistency, we obtained additional views of the IVC. The distal (caudal) portion was observed to have little to no change with respiration (Video 3). However, the more proximal segment immediately adjacent to the cavoatrial junction, including the portion at the hepatic vein inlet, continued to show apparently normal inspiratory collapse. The resident, dutifully observing current guidelines specifying that the IVC diameter be measured at this level, again interpreted the study as displaying normal IVC respiratory variation. However, when taking the entire structure into account, it was apparent that the IVC was indeed dilated, with minimal to no inspiratory collapse. The patient was treated with diuretics and admitted to the hospital, where formal echocardiography confirmed the above findings. He ultimately had a diagnosis of nonischemic cardiomyopathy and made a slow improvement during his hospitalization.

We believe this case brings to light two important pitfalls that should be kept in mind when evaluating the IVC as an indicator of central venous pressure. In the first clip, the anterior wall of the IVC is crisp, distinct, and relatively echogenic compared to the adjacent liver tissue; however, the posterior wall seems to blend in with the soft tissue immediately behind it. This appearance results from the transducer moving slightly off axis such that the sound beam passes obliquely through the IVC rather than directly through its central diameter and thus ends up intercepting adjacent diaphragmatic tissue as the patient breathes spontaneously.[1] This error in technique can also be observed during the "sniff" test.[2] It can usually be recognized by noting a "hazy" appearance of the posterior wall in the far field and corrected by adjusting the transducer such that the posterior IVC wall is seen as a thin echogenic linear structure that is distinct from the surrounding soft tissue.

In the second clip, our resident corrected the above issue but now faced an additional technical challenge. The distal portion appears dilated and does not collapse with inspiration, whereas the proximal portion nearer to the cavoatrial junction seems to collapse approximately 50% with passive breathing. In this case, the posterior aspect of the dome of the diaphragm moves into the scanning plane and falsely creates the appearance of a collapsing IVC (Figure 1). In many cases, no amount of transducer manipulation or patient repositioning can completely do away with this phenomenon, so the sonographer must be careful not to be drawn in by the motion of the hemidiaphragm and instead focus on the true IVC lumen, which can only be clearly seen several centimeters distal to the level of the hepatic vein inlet. Of note, we have observed that this issue is often more pronounced when the patient's breathing is labored, a common occurrence in decompensated congestive heart failure.

Most research from the critical care and emergency medicine arenas, as well as current guidelines from the

Figure 1. Computed tomogram revealing the position of the posterior aspect of the dome of the right hemidiaphragm (arrow). Inspiration causes anterior motion into the scanning plane and may falsely create the appearance of IVC collapse on sonography.

American Society of Echocardiography, emphasize the importance of IVC respiratory variability in determining an estimation of central venous pressure.[3–8] Thus, we believe that a familiarity with the above pitfalls is essential, especially when IVC collapsibility as judged by sonography is inconsistent with the patient's overall clinical picture. In particular, the 2010 American Society of Echocardiography guidelines[3] specify that the IVC be measured at the level of the hepatic vein inlet, which unfortunately is exactly the location where it is vulnerable to the phenomena described above. Thus, the diligent sonographer should keep in mind that he or she may need to be flexible when deciding where to assess the IVC for inspiratory collapse. Finally, although some may believe that using M-mode sonography allows for more precise quantification of the degree of IVC collapsibility, it should be recognized that the M-mode trace is derived from the same underlying 2-dimensional image and thus is vulnerable to the same pitfalls.

In summary, we recommend the following approach to avoid incorrectly identifying normal inspiratory collapse in patients with distended IVCs: (1) Ensure that the walls of the IVC are crisp, thin, echogenic, and distinct from the adjacent soft tissue; this process confirms proper transducer positioning and ensures an on-axis measurement. (2) Consider assessing the IVC at a level where the true lumen is well visualized, which may be father away from the right atrium than what is recommended by traditional guidelines, rather than rigidly adhering to measurements taken at specific anatomic landmarks. As sonographic assessment of IVC dimensions is being used increasingly to guide management at the point of care, we hope these technical considerations will help providers make accurate estimations of central venous pressure.

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