SONO case series: a 63-year-old male with shortness of breath

CASE PRESENTATION

A 63-year-old, undomiciled male, who has been out of care for many years presents with shortness of breath for the last 3 days. He has also had 3 days of constant, substernal chest tightness which is not pleuritic, positional or exertional. He has a chronic cough with some worsening yellow sputum production but no fevers. He denies leg swelling. He is an active smoker with a 40 pack-year history. He has a history of alcohol abuse and methamphetamine abuse. His EKG does not show any acute ischaemia.

INITIAL VITAL SIGNS

BP 135/96, pulse 121, RR 28, temperature 36.3, oxygen saturation 95% on room air.

The patient is tachypnoeic. His heart sounds are notable for tachycardia without murmurs, gallop or rubs. His lung sounds are notable for both wheeze and rales at the bases. His abdomen is soft and non-distended and non-tender, and his extremities are warm and well perfused without any oedema.

INDICATIONS FOR ULTRASOUND

In this patient, and the acutely dyspnoeic patient in general, the differential is broad, including but not limited to acute coronary syndrome, congestive heart failure, chronic obstructive pulmonary disease, pneumonia and pulmonary embolus. These various diagnoses have different diagnostic tests and treatments and ultrasound can assist with rapidly narrowing the differential to help immediately guide management.

CARDIAC ULTRASOUND

For cardiac ultrasound, using the phased array probe, obtain four views including the parasternal long, parasternal short, four chamber apical view and subxiphoid view.

In the parasternal long view (figure 1, online supplementary video 1), the left ventricular ejection fraction (LVEF) can be estimated visually to obtain an overall assessment of cardiac squeeze. In this patient, the squeeze is diminished. Another proxy that can be used for LVEF is the E-point septal separation (EPSS) (figure 2).[1]

To calculate EPSS, the distance from the tip of the anterior mitral valve leaflet to the septal wall is measured when it is closest to the septal wall in diastole and a distance >7 mm can indicate poor LVEF. Notably, there are certain conditions that can limit its accuracy including valvular diseases that affect mitral valve movement (example, mitral stenosis, aortic insufficiency), severe left ventricular hypertrophy and abnormal septal anatomy.

In the parasternal short view, again a visual assessment of LVEF can be made (figure 3, online supplementary video 2). Also, an assessment of left versus right ventricle size can be performed. Typically, the right ventricle is about two-thirds the size of the left, and an enlarged right ventricle can be concerning for right heart pathology (example, pulmonary embolism, pulmonary hypertension, etc).

The four-chamber apical view allows comparison of ventricular size as well as an overall assessment of cardiac squeeze and wall movement (figure 4, online supplementary video 3).

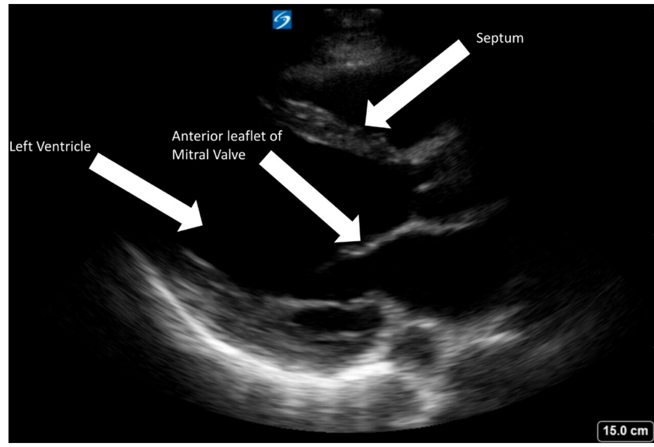

Figure 1 Parasternal long view.

The subxiphoid view (figure 5, online supplementary video 4) along with the other views allows for an assessment of pericardial effusion and can also give an assessment of overall cardiac function.

IVC ULTRASOUND

From the subxiphoid view, rotating the probe marker to the patient's head and moving rightward allows for a sagittal view of the inferior vena cava (IVC) (figure 6). The IVC can give an assessment of volume status, and particularly in patients where there is concern for poor cardiac output, it can be used for assessment of volume overload.[2 3] The diameter of the IVC is measured within 1 to 2 cm of the right atrium (RA), and the patient is asked to perform an inspiratory manoeuvre, such as sniffing, and the amount of collapse from exhalation to inspiration noted. A normal IVC diameter is measured at less than 2.1 cm. Respiratory variation can be calculated as the difference between the two numbers divided by the maximum. In one study,[2] patients with congestive heart failure had an average variation of 9 per cent compared with 46 per cent in the control group.

In our patient, the IVC is dilated (>2.1 cm) and had little respiratory variation suggesting volume overload.

There has been controversy over the best way to measure the IVC on ultrasound as well as the accuracy of IVC ultrasound.

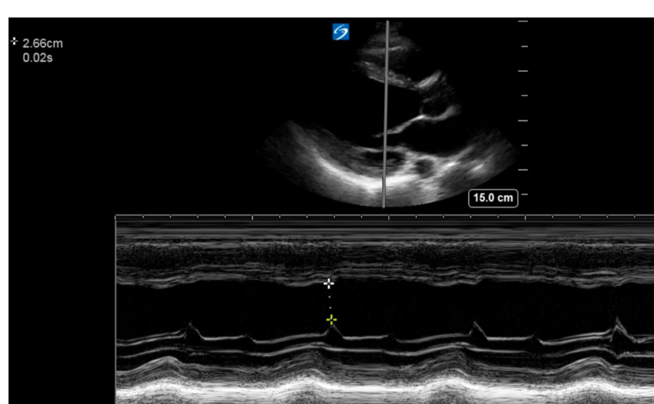

Figure 2 E-point septal separation.

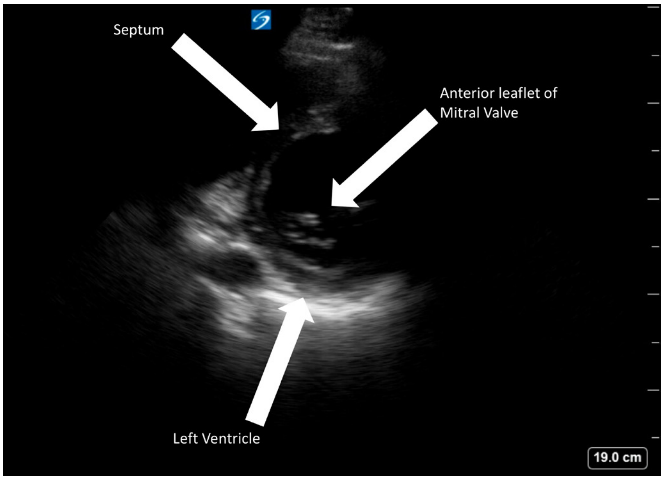

Figure 3 Parasternal short view.

HOW TO MEASURE THE IVC?

Historically, the IVC is measured in the long axis with the probe indicator towards the patient's head, angled through the liver, identifying both the RA-IVC junction and hepatic vein. Identifying both these junctions helps avoid mistaking the IVC for the abdominal aorta. Obtaining this view can be difficult due to body habitus, intestinal gas and discomfort. The American College of Emergency Physicians suggests the midaxillary long axis as an alternative view. The transducer is placed on the mid axillary line with the transducer marker pointed cephalad. Fanning the transducer posteriorly captures a long axis view of the IVC passing though the liver and diaphragm.

Most studies used to validate IVC diameter have only been done with the subxiphoid view and not with the midaxillary approach. A pitfall with both methods is that an off-axis image generates an oblique view of the IVC resulting in a falsely small diameter.[4] Some suggest measuring the IVC in the short axis, finding the maximum diameter and then rotating into the long axis to ensure a non-oblique view.

WHERE TO MEASURE THE IVC?

After obtaining an ideal IVC image, the next question is where to measure the maximum diameter? The IVC does not collapse uniformly. Most studies measure the IVC just distal to the hepatic vein. The locations of the IVC measurements differ across studies.[2 5–8] Wallace *et al* warned against measuring at the junction of the right atrium and IVC, which showed the most difference compared with other sites.[8] This variation is likely

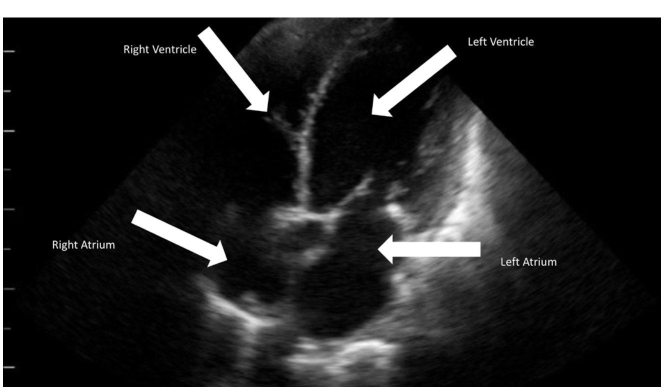

Figure 4 Four-chamber apical view.

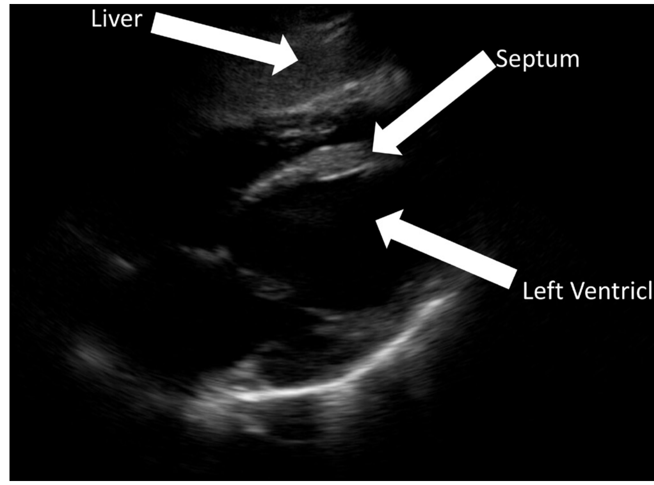

Figure 5 Subxiphoid view.

because the muscular portion of the diaphragm attaches at this location and creates a falsely positive appearance of IVC collapse.[9] To avoid this error, sonographers must recognise where the diaphragm attaches and not be drawn to the motion of the hemidiaphragm and instead focus distally on the true lumen of IVC. This phenomenon can be more pronounced when a person is in respiratory distress with laboured breathing.

IVC AS A MARKER FOR FLUID STATUS VERSUS RESPONSIVENESS?

IVC is used as a surrogate for central venous pressure (CVP). It is well known that CVP does not correlate with fluid responders. CVP cannot predict the response to a fluid challenge.[10] Thus, IVC diameter alone is not adequate to predict how a volume bolus will affect cardiac output. In spontaneous breathing patients, a meta-analysis did show that the IVC diameter at extreme values correlates better with fluid status.[11–13] IVC diameter is lower in patients in haemorrhagic shock and severely dehydrated patients.[11–13] IVC diameter less than <9 mm correlated well with severe hypovolaemia. Intermediate numbers are equivocal.[14] Large IVC diameters greater than 2 cm in both spontaneous and ventilated patients are associated with elevated right atrial pressure and fluid overload.[15] It is important to consider that other pathologies create plethoric IVC other than intravascular volume overload, such as cardiac tamponade, right heart strain in pulmonary embolism, mitral regurgitation or aortic stenosis or large intra-abdominal pressures. In diagnosing the cause of a

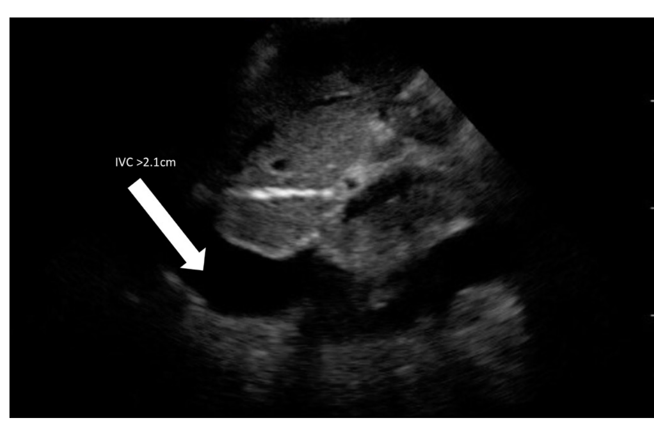

Figure 6 Sagittal view of inferior vena cava (IVC).

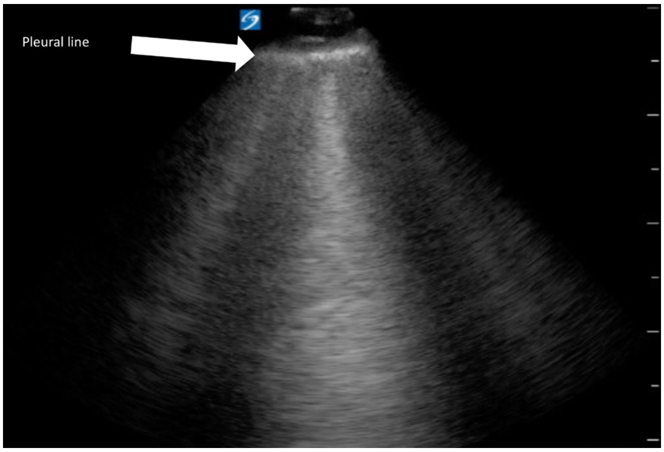

Figure 7 Lung ultrasound.

plump IVC, one needs to consider the clinical picture and incorporate both cardiac and lung images.

LUNG ULTRASOUND

As part of the ultrasound evaluation for patients with concern for dyspnoea, the lungs can also be examined. Using a low frequency curvilinear probe, with the probe marker toward the patient's head, examine at minimum the anterior lung fields as well as the posterior lung fields of each lung.

In this patient's lung ultrasound (figure 7) there are multiple B-lines, which are vertical lines within each rib space extending from the pleura to the bottom of the screen. This can be a sign of interstitial/pulmonary oedema, and fluid overload in patients with acute dyspnoea.[16 17] One systematic review and meta-analysis found a positive likelihood ratio of 12.4 (95% CI=5.7 to 26.8), and negative likelihood ratio of 0.06 (95% CI=0.02 to 0.22)[18] for B-lines in diagnosing acute decompensated congestive heart failure.

There is controversy over defining the number of B-lines required for diagnosis of interstitial oedema. Indeed, inter-rater agreement on number of B-lines has been shown to vary depending on zone of lung imaged and number of B-lines.[19] Thus, making diagnoses on B-lines alone, especially if there are not an extreme number can be problematic.

CASE CONCLUSION

Taking the ultrasound images as a whole, the patient has poor cardiac output on cardiac ultrasound, evidence of overall fluid overload on IVC ultrasound and signs of pulmonary oedema on lung ultrasound. These findings suggest a diagnosis of congestive heart failure. Given these ultrasound findings, the patient is immediately started on treatment with diuresis, and a cardiology admission is requested. By the time the patient's laboratory results and x-ray confirm this diagnosis, he is already feeling better with improved vital signs. He had an echocardiography study performed the next day as an inpatient which showed LVEF <20%, felt to be due to long-term alcohol use and methamphetamine use along with possible ischaemic disease given age. He was discharged with medical management and plan for implantable cardioverter defibrillator placement.

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