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Case Report

Three-view bedside ultrasound for the differentiation of acute respiratory distress syndrome from cardiogenic pulmonary edema

Abstract

Bedside ultrasound is being increasingly used by emergency physicians (EPs) for the differentiation of acute dyspnea in critically ill patients [1]. Lung ultrasound is emerging as a highly sensitive tool in diagnosing alveolar interstitial edema with the presence of diffuse "B-lines" arising from the pleural line [2]. However, when used independently, lung ultrasound is unable to differentiate between cardiogenic and noncardiogenic causes of pulmonary edema [3]. This case report describes a rapid 3-view or "triple scan" sonographic examination to differentiate acute respiratory distress syndrome (ARDS) from cardiogenic pulmonary edema.

A 42-year-old man was brought in by ambulance after being found unresponsive. He was altered, hypotensive, and in respiratory distress. Paramedics reported a critically elevated blood glucose (>500 mg/dL) and a lack of response to intravenous naloxone. Upon arrival in the emergency department (ED), the patient was nonverbal, tachypneic, and in severe respiratory distress. His lungs were clear to auscultation, and there was no evidence of elevated jugular venous pressure or peripheral edema. The vital signs were blood pressure, 90/48 mm Hg; pulse rate, 81 beats per minute; respirations, 28 breaths per minute; rectal temperature, 91.4°C; and Sa_{O_2} 100% on a nonrebreather face mask. A venous blood gas demonstrated a pH of 6.67, and serum chemistries were significant for a HCO_3 of 3.3 mmol/L, potassium of 8.0 mmol/L, creatinine of 3.58 mg/dL, and β-hydroxybutyrate of 17.27 mmol/L. The initial portable radiograph was read by the attending radiologist as "focal area of haziness in the left lower lung."

The patient was aggressively treated per the institutional diabetic ketoacidosis protocol. Over the course of 7 hours, the patient was intubated for airway protection, started on a Levophed drip, and received more than 7 L of isotonic sodium chloride solution. Eight hours into the patient's course, he was noted to be increasingly difficult to oxygenate even while receiving 100% oxygen via the confirmed endotracheal tube. A repeat portable anteroposterior chest radiograph was obtained (Fig. 1) and read as "consolidation in both lung fields, most likely representing pulmonary edema." Intravenous fluids were stopped because of concern for iatrogenic fluid overload, and a bedside ultrasound examination was performed. Using a 5- to 2-MHz curvilinear transducer (Philips HD11XE, Andover MA), the EP noted a hyperdynamic heart, diffuse B-Lines in both anterior lung fields, and a collapsed inferior vena cava (IVC) (Figs. 2, 3, and 4). A central venous catheter was placed yielding a central venous pressure (CVP) of 6 mm Hg and subsequent arterial blood gas after intubation revealed a Pa_{O_2}/fraction of inspired oxygen of 104.5 mm Hg, helping to define the diagnosis of ARDS. The providers restarted intravenous fluids knowing with confidence that the patient's hypoxia was not a result of cardiogenic pulmonary edema.

Accurate diagnosis of the cause of acute dyspnea in the ED is often challenging. On sonographic lung examination, B-lines or "lung comets" are vertical artifacts

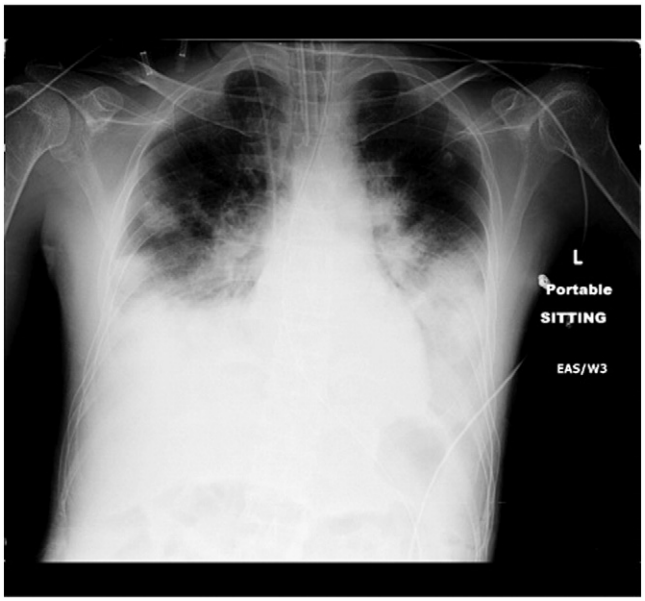

Fig. 1 Chest radiography showing bilateral infiltrates consistent with pulmonary edema.

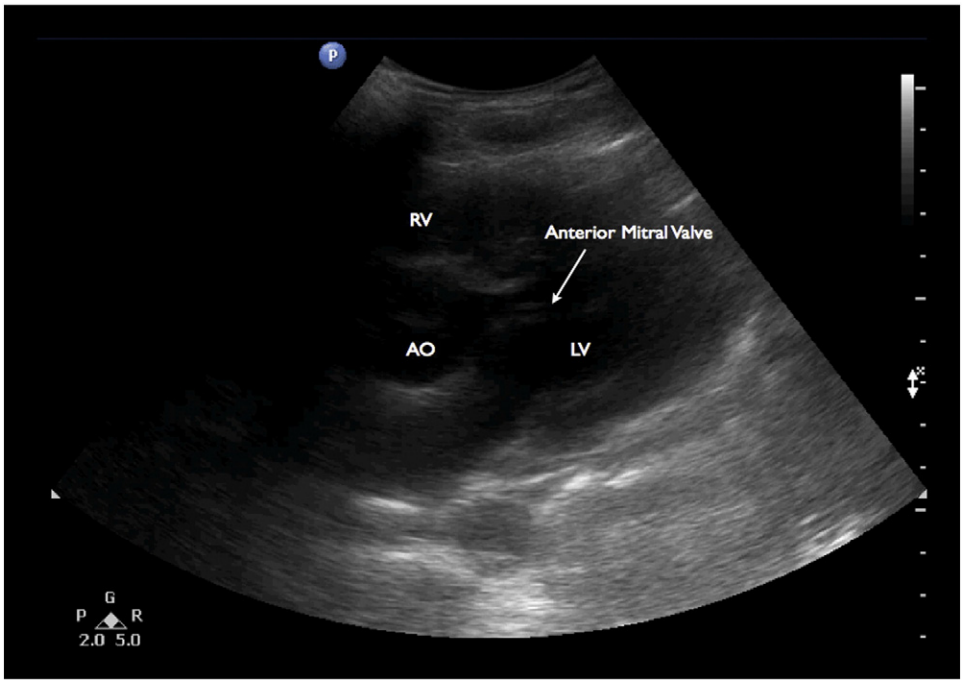

Fig. 2 Bedside echocardiography/parasternal long view. RV indicates right ventricle; LV, left ventricle; AO, aorta. Cardiac cycle demonstrated a hyperdynamic heart with the anterior leaflets of the mitral valve striking the interventricular septum.

generated by an air-fluid mixture at the pleural line that are highly sensitive for alveolar-interstitial syndrome (AIS) including cardiogenic pulmonary edema, ARDS, interstitial pneumonia, and pulmonary fibrosis [4]. Previous studies comparing lung ultrasound with computed tomographic scan as a gold standard have demonstrated that the presence of diffuse B-lines is 85.7% to 100% sensitive and 92% to 93% specific for AIS [5]. However, the presence of diffuse B-lines alone cannot distinguish between cardiogenic and noncardiogenic causes of

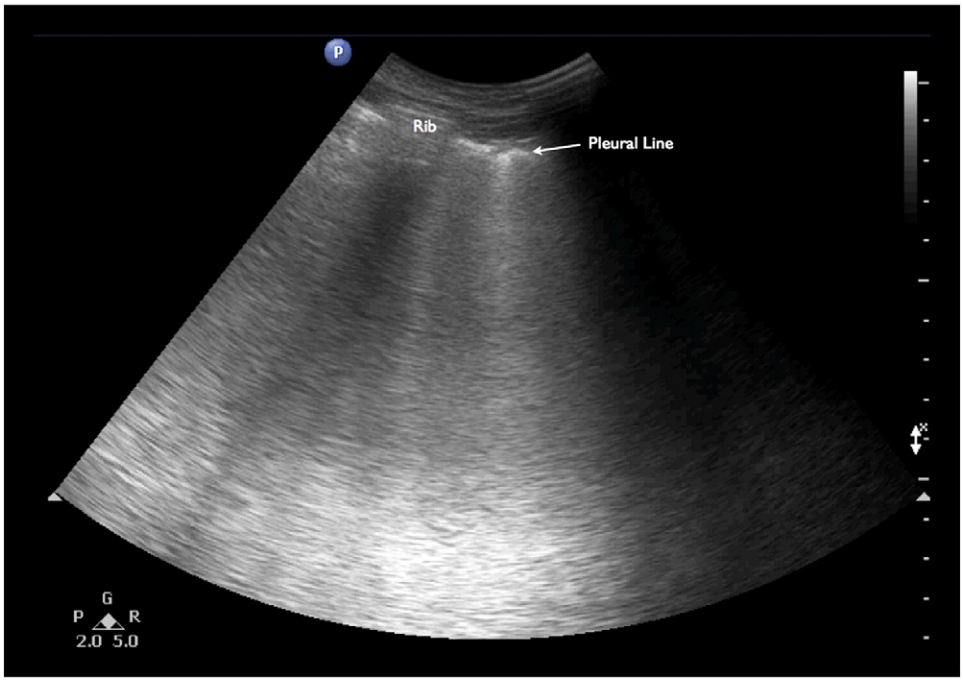

Fig. 3 Lung ultrasound. Diffuse B-lines arising from the pleural line bilaterally, pathognomonic for AIS that includes cardiogenic pulmonary edema, ARDS, or interstitial pneumonia.

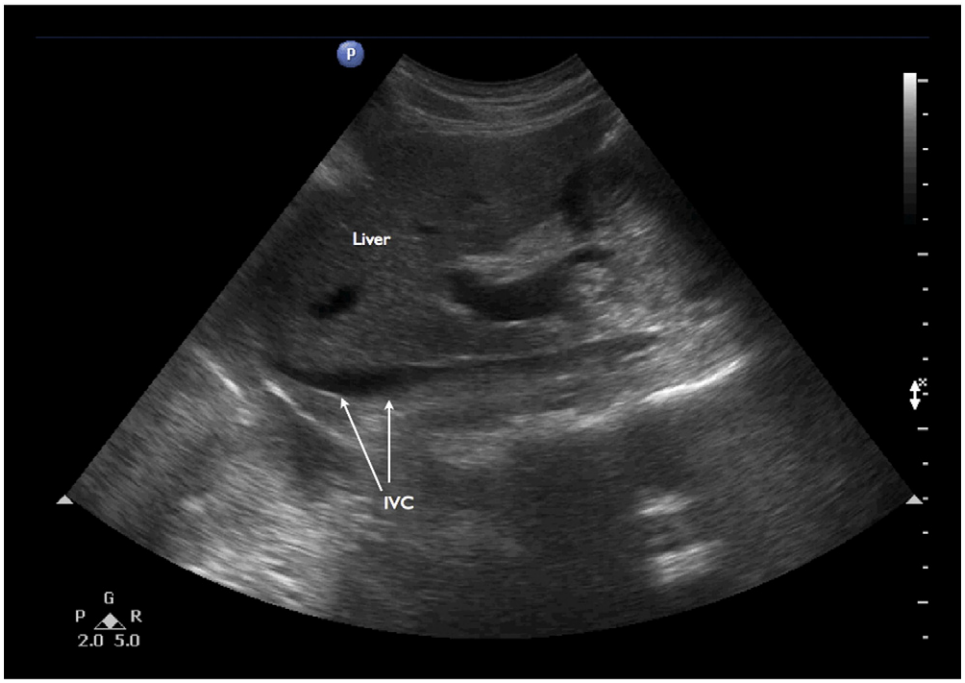

Fig. 4 Inferior vena cava diameter collapses during the respiratory cycle suggesting low CVP.

pulmonary edema, which have different treatment strategies [6]. Bedside transthoracic echocardiography performed by EPs has been shown to be accurate in predicting left ventricular ejection fraction [7]. Potential limitations of bedside echocardiography by EPs include failure to identify isolated diastolic or valvular heart failure or solely relying on the presence of a poor left ventricular ejection fraction to diagnose acute decompensated heart failure [8]. In addition, EPs have studied the use of sonographic determination of IVC size and collapsibility as a predictive marker of right-sided cardiac pressures and/or CVP [9,10]. A recent study demonstrated a strong correlation between a caval-index greater or equal to 50% (high collapsibility) and measured CVP less than 8 mm Hg, with a sensitivity of 91% and specificity of 94% [10].

In our patient, the repeat bedside ultrasound was critical in his management. The patient's hyperdynamic heart, diffuse B-lines, and collapsed IVC indicated noncardiogenic pulmonary edema. Aggressive fluid resuscitation continued while central venous access was obtained, confirming a CVP less than 8 mm Hg. The limited ultrasound examination took less than 3 minutes to perform and was instrumental in the decision to continue volume resuscitation. At our institution, we routinely combine a rapid ultrasound examination (echo for gross ejection fraction, both anterolateral lung fields to assess for B-lines, and IVC for respirophasic variation) for undifferentiated dyspnea and examination we refer to as the *triple scan*. Although pulmonary ultrasound, limited cardiac ultrasound, and assessment of the IVC have each independently shown promise as predictors of various cardiopulmonary states, they have not been evaluated in combination. In conjunction with clinical signs and symptoms, this multiapplication ultrasound protocol may aid in the evaluation of the acutely dyspneic patient.

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