



Case Report

Utility of point-of-care ultrasound for guidance of ultrafiltration goal in a patient with end stage renal disease and acute hypoxic respiratory failure following 2 weeks on mechanical ventilation

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ABSTRACT

Point-of-care ultrasound is a bedside tool that is increasingly being used as part of the physical examination to evaluate fluid status. Cardiac ultrasound for assessment of volume status focuses on evaluating left ventricular ejection fraction, presence of pericardial effusion, right ventricular size, inferior vena cava size and collapsibility, and stroke volume measurement at the left ventricular outflow tract. Another way in which POCUS can be used to assess for fluid overload is the use of mitral inflow doppler to measure early diastolic transmitral flow velocity (E) and tissue doppler to measure early diastolic mitral annular velocity (e'). The ratio of E/e' is then used as an estimation of left ventricular filling pressure. This is a case where a 54-year-old female with end stage renal disease presents with hypoxic respiratory failure and is found to have diffuse bilateral airspace opacities on chest radiograph. E/e' was used to determine the etiology of the patient's undifferentiated pulmonary infiltrates and guide fluid removal through ultrafiltration. Ultrafiltration was performed with subsequent improvement in E/e' and the patient was successfully weaned off mechanical ventilation.

1. Introduction

Point-of-care ultrasound (POCUS) has emerged as a diagnostic tool to determine volume status and guidance for fluid removal [1]. The ratio of early diastolic transmitral flow velocity to early diastolic mitral annular velocity (E/e') as an estimation of left ventricular filling pressure is one way in which doppler may be used in the assessment of hemodynamic congestion [1]. This case highlights the use of POCUS for assessment of fluid status for guidance of ultrafiltration in a patient with fluid overload.

2. Case presentation

A 54-year-old African American female with past medical history of end stage renal disease secondary to systemic lupus erythematosus presented with shortness of breath and cough for 2 weeks. She has a history of cocaine abuse. Her medications include prednisone and plaquenil. She denies any fever, productive cough, or chest pain. On presentation to the ER, she was in acute respiratory distress and was intubated for acute respiratory failure. Examination in the ICU revealed a pulse rate of 88 bpm, respiratory rate of

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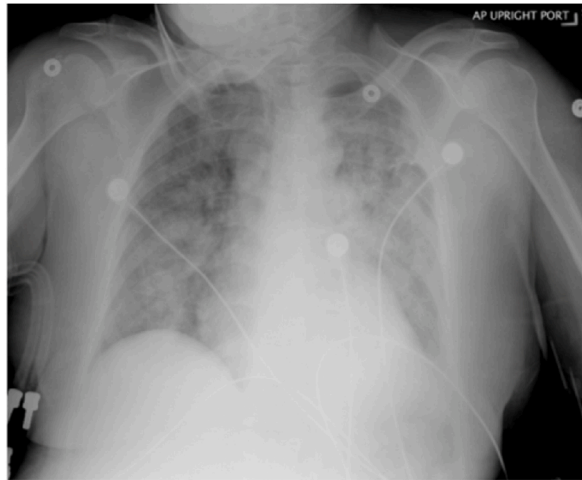


Fig. 1. Chest radiograph on admission.

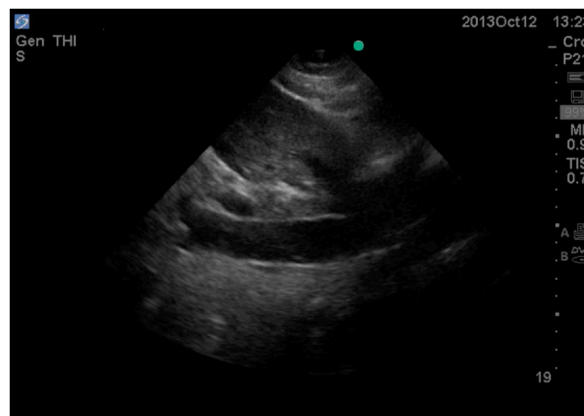


Fig. 2. Ultrasound of IVC prior to fluid removal.

24/minute, and blood pressure of 110/70 mmHg. Patient was intubated and sedated. Examination was remarkable for bilateral inspiratory crackles and bilateral lower extremity edema. Chest radiograph on admission showed diffuse bilateral airspace opacities (Fig. 1). The differential diagnosis included: diffuse alveolar hemorrhage secondary to capillaritis, diffuse alveolar damage due to pneumonia and possibly from cocaine inhalation, and acute pulmonary edema from fluid overload. Complete echocardiogram showed normal ejection fraction. POCUS showed IVC was larger than 2 cm without respiratory variability (Fig. 2). Mitral inflow doppler was used to measure early diastolic transmitral flow velocity (E) and tissue doppler was used to measure early diastolic mitral annular velocity (e') (Fig. 3). The ratio of E/e' was calculated and found to be 15.6 which was indicative of elevated filling pressure, consistent with pulmonary edema. Ultrafiltration (UF) was done with removal of 8 kg of fluid during a prolonged dialysis treatment. Repeat measurement of E/e' following UF showed reduced ratio to 7.5 (Fig. 4), which is consistent with a normal filling pressure. IVC was collapsed on repeat POCUS after UF. PaO_2/FiO_2 ratio improved from 190 to 400. Patient was successfully weaned off ventilator the following morning.

3. Discussion

This case highlights the utility of E/e' in assessing fluid status to guide fluid removal. In this case of hypoxic respiratory failure with multiple possible etiologies, POCUS was crucial in determining fluid overload as the cause. The measurement of E/e' was useful in conjunction with IVC size and variability to determine the presence of pulmonary edema. The goal of fluid removal was to lower the left ventricular (LV) filling pressures (E/e') < 8 , and improve the PaO_2/FiO_2 ratio. Following ultrafiltration, these measures quantitatively improved in addition to the clinical improvement leading to extubation. POCUS-driven assessment and E/e' was helpful to determine left atrium (LA) filling pressure and guide fluid removal in the setting of circulatory overload.

The ratio of early diastolic transmitral flow velocity to early diastolic mitral annular velocity (E/e') has been found to be a reliable estimation of LV filling pressure. The diastolic phase of the cardiac cycle consists of isovolumetric relaxation, early rapid ventricular filling, diastasis, and atrial contraction. During systole, the myocardium is contracted and before the end of LV ejection, myocardium relaxation begins, which is measured by e' . LV pressure rapidly decreases during isovolumetric relaxation and produces a pressure

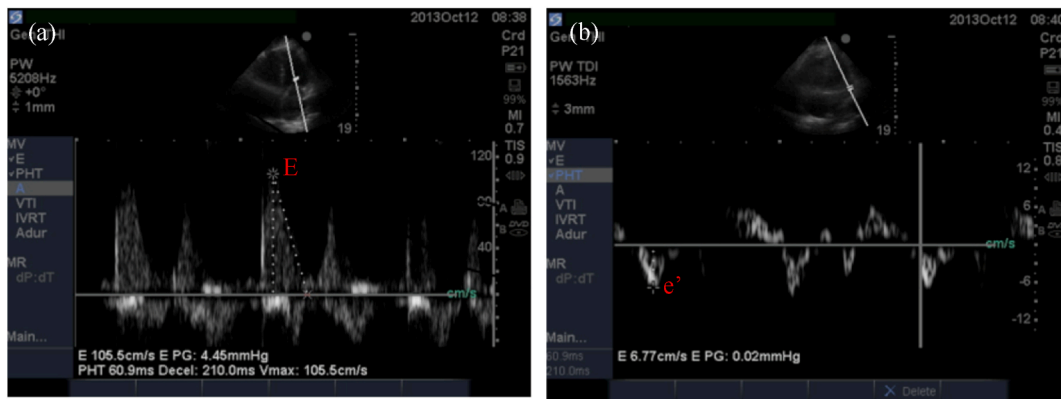


Fig. 3. Before ultrafiltration

(a) Mitral inflow doppler measuring early diastolic transmitral flow velocity (E)
 (b) Tissue doppler measuring early diastolic mitral annular velocity (e').

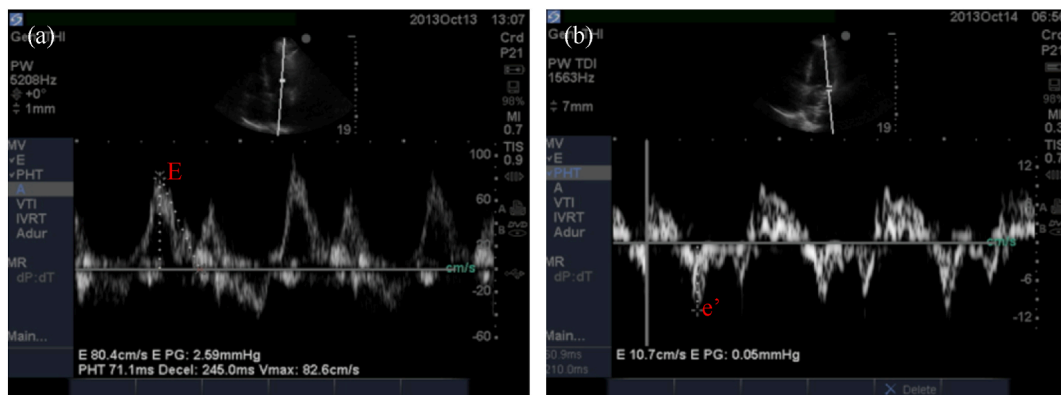


Fig. 4. After ultrafiltration

(a) Mitral inflow doppler measuring E
 (b) Tissue doppler measuring e'.

gradient between the LA and LV that leads to rapid LV filling. This is then followed by LV passive filling, which is measured by E. $E/e' > 15$ predicts abnormal filling pressure (and elevated pulmonary capillary wedge pressure) while $E/e' < 8$ predicts normal filling pressure and LA pressure [2]. For intermediate values, evaluation of other parameters is needed to estimate LA pressure [3]. Increase in E velocity is seen with sodium and water retention, while e' velocity is unrelated to the patient's volume status as it measures myocardial relaxation. Therefore, elevated E/e' ratio is seen in volume overload due to elevation of LA pressure. Subsequently, E/e' decreases following ultrafiltration as E decreases, with reduction in circulating volume, while e' remains relatively unchanged [4]. E/e' was found to have a stronger correlation with pulmonary capillary wedge pressure than brain natriuretic peptide [5]. Elevated E/e' is especially indicative of elevated LV filling pressure when other echocardiogram parameters are consistent with increased LV filling pressure [6]. However, tissue doppler may be unreliable in the setting of advanced decompensated systolic heart failure especially with large LV volumes, poor visualization of a dilated mitral valve annulus, mitral annular calcification, severe mitral regurgitation, mitral stenosis, tachycardia, atrial fibrillation, constrictive physiology, or regional wall motion abnormalities [3,6–8].

4. Conclusion

We present a case where a patient with hypoxic respiratory failure secondary to undifferentiated pulmonary infiltrates was determined to have elevated left ventricular filling pressures through use of POCUS. E/e' ratio was used to guide fluid removal through ultrafiltration, resulting in improvement in E/e' ratio and patient outcome. This case highlights the practical application of POCUS in clinical decision making in the setting of circulatory overload.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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