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NEUROCRITICAL CARE SOCIETY

LESSONS LEARNED

Acute Hypoxia in a Patient with Neuromuscular Weakness

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The Case

A middle-aged woman was brought to the emergency department with acute onset of shortness of breath and generalized weakness. Her history included myasthenia gravis, which was managed with prednisone, thymectomy, and pyridostigmine. Her neurological examination included generalized weakness with hyporeflexia with intact cranial nerve examination. Shortly after arrival, she had acute respiratory distress requiring intubation, following which she was admitted to the neurointensive care unit.

Initial Course

On arrival to the unit her first arterial blood gas was appropriate on volume-controlled ventilation, and she was tolerating without distress. As a part of initial workup, the patient had a 2D echocardiogram with bubble study done, which was reported unremarkable (Video 1). The apical four chamber view is not shown, but Video 1 shows the corroborated subcostal four chamber view of the heart during the bubble study, showing grossly normal biventricular function, appropriate right ventricular size, tricuspid annular excursion, and no evidence of right to left shunt. Other admission laboratory data were only notable for mild leukocytosis. An internal jugular apheresis catheter was placed, and plasmapheresis was initiated.

After several hours of plasmapheresis, the patient had a brief episode of hypoxia with a peripheral O_2 saturation of 90% and ventilatory settings of fraction of inspired oxygen (FiO2) of 40% and positive end-expiratory pressure of 6 cm H_2O. Blood gas confirmed hypoxemia (pH/pCO_2 (mmHg)/pO_2 (mmHg)/Bicarb (mEq/L) 7.32/48/72/24.1).

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In this Patient, What is the Differential of Hypoxemia and What Further Information Would You Obtain?

Vitals during this episode were as follows: blood pressure (BP), 95/44 mmHg; mean arterial pressure (MAP), 60 mmHg; heart rate, 72 bpm; and temperature, 37.2 °C.

Likely differentials here could be pneumonia, pneumothorax following dialysis catheter placement, mucus plugging, derecruitment of alveoli, and, less likely but possibly, new right to left shunt or angiotensin convertase enzyme (ACE) inhibitor-induced hemodynamic collapse during plasmapheresis [1].

Case Continued

The patient received 1 L of balanced crystalloid, and ventilator settings were increased to FiO2 of 50% and positive end-expiratory pressure of 8 cm H_2O. The patient recovered with a BP of 134/59 mmHg, an MAP of 84 mmHg, a heart rate of 78 bpm, and saturation of oxygen (SpO2) of 96%. After nearly 12 h of stability, the patient had a similar episode of hypoxia (SpO2 91%) and hypotension (BP 86/47 mmHg; MAP 59 mmHg). Norepinephrine was started with a target MAP > 65 mmHg.

How Would You Proceed?

Given recurrent hypoxemia, an increased A-a gradient, and hypotension, let's discuss the aforementioned differentials, collectively considered as undifferentiated shock. Although accompanying sepsis was a possible etiology given mild leukocytosis, neuromuscular weakness, and possible aspiration prior to arrival, the patient was afebrile, and her lactic acid level was normal. A chest X-ray following apheresis catheter placement did not show any pneumothorax (Fig. 1). Hypoxemia did not improve after the recruitment maneuver. The patient was not on any ACE inhibitor, as confirmed by family.

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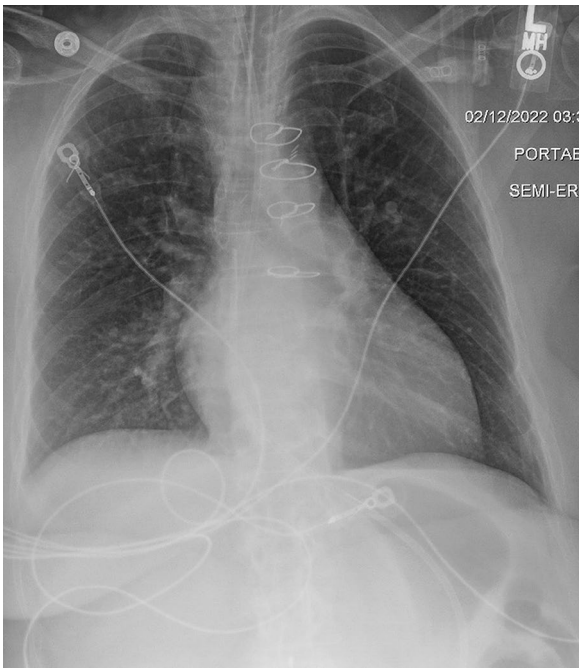

Fig. 1 Chest X-ray showing sternotomy wires because of thymectomy and otherwise unremarkable appearance

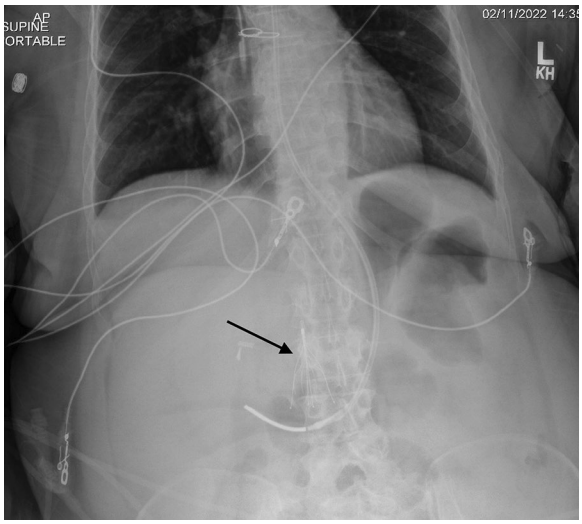

Fig. 2 Abdominal X-ray showing retained inferior vena cava filter against L3-L4 spine

With a Normal Chest X-Ray, Hypotension, and Hypoxemia, What Could You do to get More Diagnostic Information at the Bedside?

After eliminating some of the differentials, a point-of-care ultrasound (POCUS) focused on cardiac views was performed to look for clues to undifferentiated shock.

As shown in Video 2, there was a remarkable change in cardiac function on POCUS on the subcostal four chamber view. Other views were of poor quality. The right ventricle appeared significantly dilated with decreased function when compared to a previous echocardiogram performed on admission. A possible atrial septal defect was also noted. The bubble study confirmed a new right to left shunt not seen previously. Further views were obtained to assess inferior vena cava (IVC) collapsibility obtained in the longitudinal axis along the IVC (Video 3). The IVC appeared distended, and there was no collapsibility.

The new information obtained from POCUS changed the differential diagnoses significantly. The patient had a new right ventricle enlargement, decreased tricuspid annulus excursion, and intracardiac right to left shunt indicating higher right atrial pressure. This pathophysiologic phenomenon can only occur when there is obstruction of the forward flow from the right atrium to the right ventricle and from there to the pulmonary artery and lung parenchyma. Given the acuity of the situation, pulmonary embolism (PE) was the most likely diagnosis. The patient underwent chest computed tomography with contrast, which confirmed the suspicion (Video 4). Of note, POCUS of the lung parenchyma showed normal lung sliding, A lines, and absence of B lines, which made pneumonia a less likely diagnosis.

After ruling out contraindications to recombinant tissue plasminogen activator (rt-tPA), a 50-mg intravenous rt-tPA infusion was given [2, 3]. Over the next few days, the patient's hemodynamic status improved, and norepinephrine was discontinued. The patient completed the remaining plasmapheresis treatments and was eventually successfully extubated.

POCUS provided valuable information, which helped quick, focused assessment and timely intervention. Regarding the PE, this patient did not have any known risk factor, including prolonged immobility (only in the intensive care unit for 24 h), deep vein thrombosis (DVT), coagulation disorder, or malignancy. When an X-ray of the abdomen taken on admission was reviewed, there was an IVC filter noted (Fig. 2), and the family later recalled a remote DVT diagnosed after treatment with intravenous immunoglobulin (IVIg). The patient was lost to follow-up, and the IVC filter was never retrieved.

We performed POCUS again after 1 week of treatment, which is shown in Video 5, without and with a bubble study, showing complete resolution of the right heart strain pattern and of right ventricular dilation and reversal of the right to left shunt on the bubble study.

Lessons Learned

1. The patient had a normal echocardiogram on admission, but after hemodynamic deterioration, our POCUS showed a significant change in cardiac dynamics, including opening of a silent intracardiac shunt due to reversal of the pressure gradient between the right and left atria. Hemodynamics is a constantly changing parameter in critically ill patients. An echocardiogram only reflects cardiac function at the time of performance; therefore, it should be repeated if there is a clinical change in hemodynamics or oxygenation to aid diagnosis. POCUS is an efficient tool in the neurocritical care unit to be used as an adjunct to gold standard tests. Even with limited views, such as in this case, it can still provide valuable information [4].
2. A lung ultrasound can help detect or rule out pneumonia/pneumothorax and other pulmonary etiologies for hemodynamic collapse or hypoxia.
3. Central lines allow direct installation of agitated saline into the right atrium; however, peripheral IV lines can also be used. Emphasis should be placed on performing a bubble study whenever possible because it can provide insight into relative pressure gradients and intracardiac shunts.
4. An IVC filter is indicated in preventing propagation of lower extremity DVT toward the heart and decreases risk of PE. However, a retained IVC filter beyond its duration of intended use or failure to retrieve the filter can result in aggregation of clots on the filter, and it can become a source of distal pulmonary emboli [5, 6].
5. In certain high-risk populations, IVIg may lead to increased risk of venous thromboembolism due to resultant hyperviscosity. Careful history and monitoring are necessary when administering IVIg in a high dose or at a rapid rate [7].

Supplementary Information
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Author's Contribution
JK: drafting and revising the manuscript, acquisition, and analysis of ultrasound data. CSWA: revising the manuscript and addition of critically important intellectual content. WW: revising the manuscript and addition of critically important intellectual content. OS: revising the manuscript and addition of critically important intellectual content. ES: drafting and revising the manuscript, addition of critically important intellectual content, and final approval of the manuscript.

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None.

Declarations

Conflict of interest
All authors report no conflict of interest.

Ethical Approval/Informed Consent
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