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Case Report
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The Use of Cardiac Point-of-Care Ultrasound in Improving Outcomes of Resuscitations

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Abstract

Point-of-Care Ultrasound (POCUS) is being used more frequently today in pediatric emergency medicine departments. It has become an important adjunct for clinical diagnosis and procedural guidance. We present a case report of a patient who presented to our Pediatric Emergency Department (PED) and was diagnosed with myocarditis using cardiac ultrasound at the start of her resuscitation. Point-of-care ultrasound was found beneficial in making a crucial diagnosis of myocarditis at the initial stage of resuscitation. POCUS directed the quick management and eventual connection of the patient to Extracorporeal Membrane Oxygenation (ECMO) which contributed to the better outcome of the resuscitation.

Case Presentation

A 15 months old female child was referred to the PED of a tertiary care, university-affiliated, urban facility, due to 4 days of vomiting, restlessness and high fever. Apart from atopic dermatitis, the child was previously healthy and fully immunized.

Parents reported that 3 days prior to her presentation, she developed fever and shortness of breath. She was prescribed antibiotics by her pediatrician for pneumonia.

On the day of presentation to the PED, the pediatrician did not see any improvement in her condition and referred her to our PED since she appeared pale and lethargic.

On arrival to the PED she was obtunded, in severe respiratory distress and pale. Her vital signs were as follows: Oxygen saturation of 70%, heart rate160 bpm, blood pressure 85/58 mmHg, temp 37.30°C and a capillary refill time of 4 sec.

Further examination revealed clear lung sounds bilaterally, rapid heart sounds with no murmurs and no jugular vein distention. Her abdomen was soft, non-tender, with no enlargement of the liver or spleen. Peripheral pulses were felt very weak on palpation.

From triage, the child was transferred immediately to the resuscitation room. While attempts were being made to establish an IV access, the PED, POCUS trained, attending performed a POCUS examination following the "RUSH" protocol – Rapid Ultrasound for Shock and Hypotension. Cardiac echo revealed severely poor cardiac function (Figure 1) with an enlarged IVC and multiple B-lines (Figure 2) in both lung fields. Based on these findings, the child was deemed to be suffering from myocarditis with severe cardiac failure. She was connected to fluids and given a small bolus of 10 ml/kg with normal saline and later, due to poor response, inotorpe treatment was initiated.

Her initial blood tests revealed leukocytosis of 26,000 cells/µl with 34% neutrophils, hemoglobin 9.7 g/dL and thrombocytosis of 543,000 cells/µl sodium level was 137 meq/L, potassium 7.6 meq/L, albumin 3.8 g/dL, uric acid 13.7 mg/dL, LDH 1024 U/L with a slight elevation in liver function tests. C-Reactive Protein (CRP) level was 0.4 mg/dL, venous blood gases demonstrated a pH of 6.9 with pCO_2 34 mmHg, pO_2 32 mmHg and HCO3 of 8.4 mmol/L.

Despite all efforts undertaken, blood pressure was not restored and after consultation with the Cardiac Intensive Care Unit (CICU) team, the child was intubated and put on an Extracorporeal Membrane Oxygenation (ECMO) machine in the PED resuscitation room. Once connected, blood pressure stabilized and the child was transferred to the CICU.

At the CICU the infant remained connected to the ECMO machine for a period of 8 days with gradual improvement of her cardiac function. After two weeks, she was weaned off from mechanical

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Figure 1: Parasternal long image of the heart. The image has been taken at the maximal opening of the mitral valve.

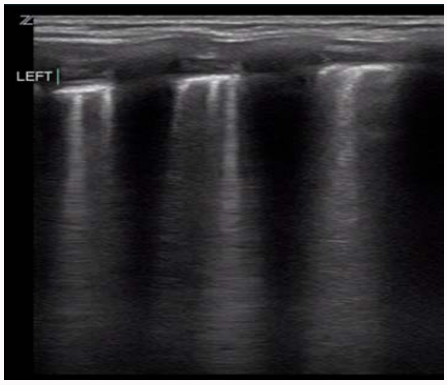

Figure 2: Multiple B lines are visible on lung ultrasound.

ventilation. Her nasopharyngeal swab culture subsequently revealed influenza A.

An echocardiogram prior to discharge showed mild dilation with low systolic function of the left ventricle and mild mitral regurgitation. The child was neurologically intact at discharge.

In the following months, the child was admitted twice to our emergency department. She was found to be with poor cardiac function and was later diagnosed with dilated cardiomyopathy.

Ultrasound Technique

The RUSH protocol assesses three main components: the pump - i.e. the cardiac system; the tank – i.e. volume status; and the pipes – i.e. the vascular system. A useful acronym in order to remember the exam components by is HI-MAP: Heart, IVC, Morrison's pouch (FAST), Aorta and Pneumothorax.

Since aortic aneurysm or deep vein thrombosis are rare in children our exam focused on cardiac evaluation and volume status as reflected by the IVC and pulmonary edema.

The cardiac exam looks at the heart in four views:

1. Subxiphoid – the transducer is placed underneath the xiphoid with the probe marker directed to the right of the patient. The transducer is directed to the patient's left shoulder.

2. Parasternal long – the transducer is placed to the left of the manubrium with the probe marker towards the patient's right shoulder.

3. Parasternal short – while maintaining the same position as for the parasternal long view, the transducer is rotated 90º towards the patient's right hip.

4. Four chamber views – the transducer is placed at the point of maximal impulse, probe marker towards the patient's right and the transducer is angled towards the patient's right shoulder.

These views enable a gross assessment of cardiac function – normal, moderately decreased, severely decreased. In addition, the heart is inspected for pericardial effusion.

The IVC is examined by placement of the transducer beneath the xiphoid, probe marker towards the patient's right and the transducer is perpendicular to the xiphoid. The diameter of the IVC is compared to the aorta where the normal ratio would be 0.8 to 1.2.

The lungs are examined by placement of the transducer in a mid-clavicular line with the probe marker towards the patient's head, over the right and left lung. Finding of lung gliding would rule out a diagnosis of pneumothorax. Finding of multiple B lines may suggest pulmonary edema.

Review of the Literature

Several studies have reported on the benefit of rapid use of ultrasound in the emergency department as a tool which influences the decision on how to manage a patient in an unstable condition [1-3].

Ultrasound assessment of patients in shock is becoming the standard of care in emergency and critical care settings worldwide. One of the most common protocols used for this assessment is the Rapid Ultrasound in Shock (RUSH) examination.

The RUSH exam, a rapid evaluation of cardiac function, key vascular structures, and likely sources of hypotension, represents a comprehensive algorithm for the integration of bedside ultrasound into the care of the patient in shock. By focusing on a stepwise approach for evaluation the cause of shock defined here as "Pump, Tank, and Pipes", clinicians will gain crucial anatomic and physiologic data to better care for these patients [4].

Bagheri-Hariri et al. [5] reported an overall sensitivity of the RUSH exam of 88% and specificity of 96% [5] with no significant difference between the emergency physician and radiologist as operators of this protocol [6].

The value of using the RUSH protocol has been reported in two case files of patients, one with hypotensive shock and the other with cardiac tamponade, who presented to the emergency department in shock and were managed promptly using the RUSH protocol during resuscitation [7].

ECMO is used in cases of cardiopulmonary failure to reestablish cardiac output and organ perfusion so that permanent end-organ injury, while awaiting reversal of cardiac and other organ disease processes, is prevented. An overall survival rate of 51% was seen in children who were supported with rapid-response ECMO after suffering from in-hospital cardiac arrest that did not respond to conventional CPR [8].

The use of Extracorporeal Membrane Oxygenation (ECMO) is still limited owing to low availability, especially in emergency departments. Nevet et al. [9] reported two children with acute myocarditis successfully treated with ECMO in the emergency department of a tertiary pediatric medical center. Given the urgency

of their condition and its presumably reversible (viral) etiology, treatment with ECMO was initiated in the department's resuscitation room. The outcome was excellent, and cardiac function remained normal throughout the 6 and 10 months follow-up.

Myocarditis among pediatric patients varies in severity from mild disease to a fulminant course with overwhelming refractory shock and high mortality. Because the disease is potentially reversible, it is reasonable to use ECMO to bridge patients until recovery or transplantation. Nahum et al. [10] reported on the course and outcome of 12 children with acute fulminant myocarditis who were managed by ECMO due to refractory circulatory collapse. They demonstrated that ECMO can be safely and successfully used for children with acute fulminant myocarditis without a need for heart transplantation.

The new PALS recommendations from 2015 emphasize the advantage of connecting the patient to ECMO during cardiopulmonary resuscitation. These recommendations rely on evidence from 4 observational studies of pediatric IHCA that have shown no overall benefit to the use of CPR with ECMO compared to CPR without ECMO, but have shown better outcomes when used during cardiac arrest in children with underlying cardiac disease [11].

While ECMO has been recognized in the latest PALS guidelines, ultrasound was not mentioned in the PALS section and only noted in the adult advanced cardiovascular support section, where the authors recommend that “Ultrasound (cardiac or non cardiac) may be considered during the management of cardiac arrest, although its usefulness has not been well established".

We believe that due to the noninvasive nature of ultrasound and its ability to provide rapid and repeated assessment of physiology during resuscitation, this modality should move to the front line of emergency care. Integration of POCUS techniques such as the RUSH exam has the potential to augment the clinical evaluation and guide resuscitation to improve the patients outcomes.

Conclusion

This case illustrates the potential clinical impact of POCUS in the management of shock in the pediatric emergency department. The use of POCUS at the very start of resuscitation enabled the treating team to arrive to the diagnosis of severe myocarditis, and the early initiation of the complicated, drastic, yet lifesaving therapeutic option of ECMO, which ultimately improved the child’s prognosis. It is reasonable to think that the rapid intervention enabled by the POCUS examination contributed to the good neurologic outcome in such a severe case.

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