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Brief Report

Point-of-care pleural and lung ultrasound in a newborn suffering from cardiac arrest due to tension pneumothorax after cardiac surgery

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Abstract We report the case of a 12-day-old newborn affected by coarctation of the aorta and intraventricular defect who underwent coarctectomy and pulmonary artery banding. On post-operative day 7, the patient suffered from pulseless electric activity due to tension pneumothorax. Point-of-care ultrasound was performed during cardiopulmonary resuscitation in an attempt to diagnose pneumothorax. The diagnosis was made without delaying or interrupting chest compressions, and the pneumothorax was promptly treated.

Keywords: Cardiac arrest; pulseless electric activity; ultrasound; tension pneumothorax; paediatric cardiac surgery

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TENSION PNEUMOTHORAX IS A SERIOUS LIFE-threatening complication that may lead to cardiac arrest. Indeed, tension pneumothorax is one of the reversible causes of pulseless electric activity. Pleural and lung ultrasound has been shown to be a powerful tool for bedside early diagnosis of pneumothorax.[1]

Interventions during non-shockable rhythms-associated cardiac arrest are focussed on effective chest compressions and early diagnosis of all reversible causes.[2] Current guidelines on resuscitation support high-quality chest compressions and minimised interruptions for other interventions to optimise coronary and cerebral perfusion.[2] On the other hand, there are several studies showing that point-of-care ultrasonography performed at bedside during resuscitation of adult patients may help early diagnosis of four of the reversible causes of asystole/pulseless electric activity – hypovolemia or pseudo-pulseless electric activity, cardiac tamponade, tension pneumothorax, and pulmonary embolism – without delaying or interrupting chest compressions;[3,5–7] however, studies assessing the impact of point-of-care ultrasonography on outcomes in neonates and children who have suffered from cardiac arrest are lacking.

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Case presentation

We describe the case of a 12-day-old full-term neonate with coarctation of the aorta and intraventricular defect admitted to our cardiac intensive care unit after surgical palliation consisting of coarctectomy with end-to-end anastomosis and pulmonary artery banding. On post-operative day 7, although still mechanically ventilated for acute respiratory distress syndrome, the baby suffered from a pulseless electric activity/asystole-associated cardiac arrest. Cardiopulmonary resuscitation was initiated immediately. Point-of-care ultrasonography was performed in <10 seconds during chest compression interruptions necessary for pulse check, using a Nanomaxx ultrasound device (Sonosite Fujifilm, Bothell, WA, USA). Pleural and lung ultrasound performed with a linear transducer of 13-6 Mhz, showed signs of a left-sided pneumothorax: complete absence of lung sliding on B-mode, absence of B-lines, and there was a

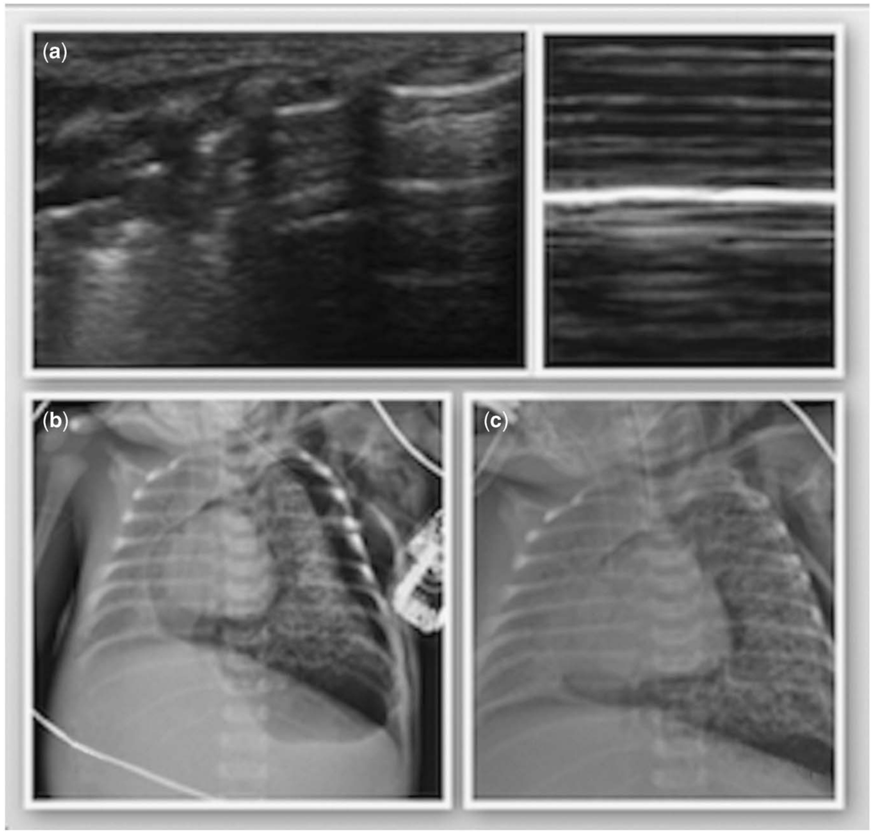

Figure 1.
*(**a**) Lung sonography showing "lung point" on B-mode (left) and "stratosphere sign" on M-mode (right). Lung point is the point on the chest wall where the pneumothorax ends and lung tissue is once again in contact with the pleura. In the B-mode image, on the left, there are some B-lines arising from the pleural line, whereas on the right there are no B-lines but it can be distinguished an A-line pattern. (**b**) Chest X-ray obtained before positioning the pleural drainage and confirming massive left-sided pneumothorax. (**c**) Chest X-ray after successful lung drainage showing improved pneumothorax.*

"stratosphere sign" on M-mode (Fig 1a). Moving the probe cranially, caudally, and laterally, looking for the lung point, we found a huge area of pneumothorax, suggestive of a massive tension pneumothorax. The on-call surgeon was promptly contacted for pleural drainage. Return of spontaneous circulation was obtained after about 30 minutes of resuscitation. Chest radiography obtained just before the positioning of the pleural drainage confirmed the presence of a massive left-sided pneumothorax (Fig 1b). Left lung drainage was successfully placed without complications (Fig 1c).

In the present case, we detected three of the four ultrasound findings useful to diagnose pneumothorax[4] (Fig 1a).

- Absence of lung sliding that allows ruling in pneumothorax with high accuracy[4] (Fig 1a). By turning the ultrasound device from "B-mode" to "M-mode", we obtained typical M-mode pattern of pneumothorax – the "stratosphere sign"[4] (Fig 1a).
- Absence of B-lines, longitudinal artefacts arising from the pleural line, and moving consensually to the pleural sliding. The presence of B-lines ruled out pneumothorax.[4] Absence of B-lines plus the absence of lung sliding are signs of pneumothorax.[4]
- Presence of lung point, the point where the two pleural sheets come back to slide over each other, representing the physical limit of pneumothorax on the chest wall.[4]
- The fourth sign, the absence of lung pulse; in any case, it would not have been detectable because our patient was in cardiac arrest. In fact, the lung pulse refers to the subtle rhythmic movement of the visceral upon the parietal pleura with cardiac oscillations.[4]

Discussion

Since 1988, when paediatric advanced life support was first developed, the original course was focussed on the prevention of cardiac arrest through early recognition and treatment of respiratory failure and shock. Current guidelines support high-quality chest compressions and minimised interruptions for other interventions in order to optimise coronary and cerebral perfusion and blood flow to critical organs.[2] Several simplified

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ultrasound protocols have been well described in the last decade in adults. In 2004, Jensen et al[5] proposed a focussed echocardiographic protocol, performed by non-cardiologists in critically ill adult patients, with the acronym FATE – "focus assessed transthoracic echo protocol" – demonstrating its feasibility in 97% of cases. In 2007, Breitkreutz et al,[6] with the acronym FEER – focused echocardiographic evaluation in resuscitation management – proposed a focussed echocardiographic evaluation integrated into advanced life support algorithm during the pauses for pulse check or during out-of-hospital cardiopulmonary resuscitation manoeuvres without interrupting chest compressions. In 2008, Hernandez et al,[7] adding to the ultrasound evaluation of the heart, pleural and lung ultrasound, to exclude pneumothorax, proposed the CAUSE protocol – Cardiac Arrest UltraSound Exam. This protocol suggests the use of the convex transducer for both subxyphoid evaluation of the heart and for pleural and lung ultrasound. Niendorff et al[8], in 2005, analysed a consecutive series of adults who suffered from asystole/pulseless electric activity arrest and concluded that ultrasound could be successfully integrated into the advanced cardiovascular life support algorithm. In this study, the duration of chest compression interruptions was not longer than 10 seconds – that is, the time necessary for pulse check.[8] In 2010, Breitzkreutz et al[3], in a prospective trial conducted in adult patients, found an increased survival when a reversible cause could be identified with ultrasound.

Compared with adults, given the small size of newborns and children, ultrasound allows optimal visualisation of the pleura and lungs. In an unstable patient with haemodynamic shock or cardiac arrest, the absence of any movement of the pleural line, either respiratory (lung sliding) or cardiac (lung pulse), associated with the absence of B-lines allows the diagnosis of a pneumothorax requiring a chest tube placement. This case exemplifies the utility of point-of-care ultrasonography in identifying a reversible cause of cardiac arrest. We suggest that point-of-care ultrasonography be incorporated into the paediatric advanced life support algorithm at each pause for pulse check if necessary. Each examination must take <10 seconds. Using a linear and/or a microconvex transducer, the operator should obtain four scans: parasternal view of the pleural line by placing the probe perpendicular to two consecutive ribs along the parasternal line on both sides to rule out pneumothorax; coronal view of the lung bases by placing the probe perpendicular to two ribs between the middle and anterior axillary line just above the diaphragm on both sides to exclude massive haemothorax; subxyphoid view of the heart to exclude cardiac tamponade and evaluate cardiac contractility, to rule out suspicion of massive pulmonary embolism, and to evaluate inferior vena cava collapsibility in order to assess volume status; and compressive ultrasound performing a transversal scan of femoral veins on both sides to exclude deep venous thrombosis.

Our case and published evidence suggest that ultrasound assists in early diagnosis and prompt treatment of reversible causes of asystole/pulseless electric activity obtaining rapid return of spontaneous circulation. Therefore, is it time to implement new resuscitation guidelines with simplified ultrasound protocols in non-shockable rhythms in neonates and children? We believe that there is a great need for randomised controlled trials to assess the impact of point-of-care ultrasonography on outcomes of children who have suffered from a cardiac arrest.

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Conflicts of Interest

None.

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