Cardiac arrest with pulseless electrical activity rhythm in newborn infants: a case series

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ABSTRACT

The 2015 neonatal resuscitation guidelines added ECG to assess an infant’s heart rate when determining the need for resuscitation at birth. However, a recent case report raised concerns about this technique in the delivery room. We report four cases of pulseless electrical activity during neonatal cardiopulmonary resuscitation in levels II–III neonatal intensive care units in Canada (Edmonton [n=3] and Winnipeg [n=1]). Healthcare providers should be aware that pulseless electrical activity can occur in newborn infants during cardiopulmonary resuscitation. We propose an adapted neonatal resuscitation algorithm to include pulseless electrical activity. Furthermore, in compromised newborns, heart rate should be assessed using a combination of methods/techniques to ensure accurate heart rate assessment. When ECG displays a heart rate but the infant is unresponsive, pulseless electrical activity should be suspected and chest compression should be started.

INTRODUCTION

Heart rate (HR) is the most important clinical sign to evaluate compromised newborn infants and to guide resuscitation efforts in the delivery room.1 Increase in the newborn’s HR remains the most reliable indicator of adequate ventilation.1 Until recently, HR in newborn infants at birth was assessed using: (1) palpation of the umbilical cord, (2) auscultation of the precordium and/or (3) pulse oximetry.1 In 2015, the neonatal resuscitation guidelines changed their recommendation to suggest using ECG to assess an infant’s HR immediately after birth.12 However, this weak recommendation was based on low-quality evidence, that is, observational data and small randomised trials.2–5

A recent case report of a newborn infant with hydrops fetalis raised concerns about the reliability of ECG.6 In addition, two case reports reported pulseless electrical activity (PEA) in newborn infants. One followed placement of a central catheter resulting in cardiac tamponade7 and the second occurred during neonatal resuscitation.8 Furthermore, we have reported two animal studies with cardiac arrest with PEA rhythm, where ECG displayed an HR ranging between 15/min and 80/min in 23/549 and 22/3010 asphyxiated piglets. The occurrence of cardiac electrical activity with no associated mechanical activity is called cardiac arrest with PEA rhythm. Depending on the electrical origin, PEA can be classified as sinus, atrial, junctional or ventricular.11 Furthermore, PEA is categorised as narrow QRS complex (70% of cases) or wide QRS complex.11 Narrow QRS complex PEA might be due to cardiac tamponade, pulmonary embolism, tension pneumothorax or mechanical lung hyperinflation,11–13 while wide QRS complex PEA is more likely due to electrolyte disturbances, tachydysrhythmias, cardiomyopathy or cardiac ischaemia.11–13 In adults, PEA occurs in approximately 35%–40% of in-hospital arrests and 22%–30% of out-of-hospital cardiac arrests and is associated with a 2%–5% survival to discharge rate.14 Cardiac arrest with PEA rhythm has not previously been reported in newborn infants. However, since the 2015 guidelines changes, the authors of this case series have witnessed several newborn infants presenting with cardiac arrest with PEA rhythm.

What is already known on this topic?

► The 2015 neonatal resuscitation guidelines recommended ECG as a method to assess an infant’s heart rate when determining the need for resuscitation at birth.
► A recent piglet study reported cardiac arrest with pulseless electrical activity rhythm in 23/54 asphyxiated piglets raising concerns about the reliability of ECG in newborn infants during cardiopulmonary resuscitation.
► A case of pulseless electrical activity in a newborn infant has been described after placement of a central catheter resulting in cardiac tamponade.

What this study adds?

► While ECG usually provides a rapid and accurate display of the heart’s electrical activity, it does not prove the presence of effective cardiac function.
► Pulseless electrical activity can occur during neonatal resuscitation in the delivery room.
► During the management of the compromised infant, healthcare providers should not rely solely on ECG, and rather use a combination of tools to assess heart rate.

CASE PRESENTATIONS

The authors have observed several cases at their respective institutions (The Royal Alexandra Hospital, Edmonton [n=3] and The Health...
A premature infant with a birth weight of 1045 g was born vaginally with history of premature rupture of membrane for 8 weeks. At the initial assessment after birth, the infant’s HR on the ECG was 40–50/min. However, auscultation detected no HR. This clinical picture indicated cardiac arrest with PEA rhythm. After mask ventilation, MR. SOPA and intubation the infant’s HR remained 0/min, while the ECG continued to display 40–50/min. Despite chest compressions and two doses of epinephrine, the infant’s HR did not improve, and care was withdrawn at approximately 20 min after birth.

**DISCUSSION**

This case series describes four newborn infants presenting with cardiac arrest associated with PEA on ECG. This is concerning as initiation of chest compressions might be delayed if clinicians rely solely on ECG display of HR. In these cases, hypoxia/asphyxia, hypovolaemia due to antepartum haemorrhage and tension pneumothorax were the most likely causes for cardiac arrest with PEA. These examples are consistent with reports of cardiac arrest with PEA after hypoxia/asphyxia in newborn piglets and in human neonates after placement of a central catheter.
The neonatal resuscitation programme (NRP) algorithm was developed for use in the delivery room to accommodate the specific physiological events that take place during transition. With the incorporation of ECG monitoring in the most recent edition, palpation of the umbilical cord and auscultation of the precordium may be overlooked.4 13 Due to the possibility of cardiac arrest with PEA rhythm, relying solely on ECG is problematic, and other methods of clinical assessment should be implemented alongside ECG to ensure accurate assessment of cardiac function. Therefore, the NRP algorithm should be revised to distinguish between asystole, bradycardia and cardiac arrest with PEA rhythm. We propose this adapted algorithm:

**Step 1: assess infant’s HR using auscultation or palpation**
Immediately after birth, the infant’s HR should be assessed using auscultation or palpation (Figure 1). The neonatal resuscitation guidelines state that ‘Auscultation’ is performed by placing a stethoscope on the newborn’s chest, and palpation is done by placing the umbilical cord between the thumb and the index finger1. The HR is assessed by listening or feeling the pulse for 6s then multiplying this value by 10 to obtain a HR in beats per minute (beats min⁻¹).1 2 We recognise that both methods have their pitfalls and are less accurate compared with pulse oximetry or ECG.13 14 Clinical assessment underestimates the true HR with a mean difference (SD) between auscultation and palpation and ECG HR of −14 (21) and −21 (21)/min⁻¹, respectively.3 Both techniques are faster in obtaining an initial HR compared with pulse oximetry or ECG.13 14 Newer techniques including Doppler ultrasound and digital stethoscopes might be useful; however, neither has been examined in asphyxiated infants.15 16

**Step 2: attach pulse oximeter and ECG to continuously monitor HR**
The neonatal resuscitation guidelines state that ‘A pulse oximeter should be attached to the right hand/wrist17 and ECG-leads on clean areas of the skin on the chest’.1 2 Several studies have demonstrated that ECG measures HR faster and more reliably than pulse oximetry.5 13 14 18

**Step 3: assess HR prior to starting and during chest compressions**
Before starting, and periodically during ongoing resuscitation, evaluation of the HR should include a combination of methods (Figure 1). If PEA is suspected, auscultation and/or palpation should be the cornerstone of HR assessment as pulse oximetry and ECG may be unreliable. In addition, point-of-care ultrasound to check for myocardial activity could aid in the diagnosis of PEA.16 18 If bradycardia is detected on clinical examination, ECG may be used to monitor HR.

**CONCLUSION**
Neonatal resuscitation guidelines have changed to suggest the use of ECG in the delivery room and in most cases ECG provides a fast and accurate measurement of a newborn’s HR. However, clinicians need to be aware of PEA, during which clinicians may be falsely reassured that cardiac output is adequate. In general, auscultation and palpation are not as accurate as ECG or pulse oximetry, but they remain important clinical tools for HR assessment during cardiopulmonary resuscitation of newborn infants. We believe that each technique has a role and should be combined to allow adequate assessment of an infant’s HR.

**REFERENCES**