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The normal range of heart rate at birth in a healthy term neonate: a critical review of the evidence.

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Abstract

The heart rate of a neonate at birth is used to determine whether or not resuscitation is required. The normal healthy range of heart rate is not well established and the method for determining the heart rate is often unreliable and undocumented in the first minute or so after birth. The reasons for the poorly established heart rate norms are discussed and the solution for reliable measurement and documentation of the neonatal heart rate immediately after birth is presented.

Keywords: Neonatal heart rate, Auscultation, Stethoscope, ECG, Doppler ultrasound, Resuscitation.

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Introduction

The heart rate or pulse is one of the most fundamental measures of life and health. During labour the normal range of heart rate of a healthy term fetus is well established and has been validated by hundreds of thousands of well documented recordings of the fetal heart using either Doppler ultrasound or a fetal electrocardiogram (ECG) [1]. The normal range extends from 110 bpm to 160 bpm. Subtle patterns within this normal range can also be recognized, indicating a healthy or unhealthy fetus. With the fetus in utero and obscured from view, the heart rate is the only physiological parameter which can be readily measured. Probably for this reason the ability to measure and document in real-time the fetal heart during routine clinical care has advanced well beyond the ability to measure and document the neonatal heart rate immediately after birth. After birth other parameters of health such as the regularity of breathing, crying, muscle tone and movements of the baby, and the colour of the skin are available to assess the health of the neonate. During transition however the heart rate remains a most important parameter especially in the neonate that is not obviously breathing well or crying. At birth major changes in the circulation have to take place while the fetus transitions from placental respiration to the pulmonary respiration of the neonate. This transition takes place over a few minutes.

Transition at birth

The transition from placental to pulmonary respiration is not instantaneous but takes place over a few minutes after birth [2]. This involves aeration of the lungs and a marked increase in the pulmonary circulation while at the same time a gradual closure of the placental circulation initiated by constriction of the two umbilical arteries. Transition is completed when the umbilical vein closes followed finally by closure of the ductus venosus, foramen ovale and ductus arteriousus. The parallel output of the two sides of the fetal heart is now converted into the serial output of the neonatal heart. The changes in breathing, crying and colour may be obvious but are less objective than the heart rate and, in routine clinical practice, much less easily documented in real-time. A normal heart rate is evidence of good circulation, so as long as we can be confident that the heart rate is within the normal range there is unlikely to be a need for immediate assistance with positive pressure ventilation (PPV) of the lungs in the apparently apnoeic neonate. If the neonate is not breathing during the first minute or so after birth but there is a good circulation, the neonate is likely to be sufficiently oxygenated from the placental circulation [3]. However this decision requires that the heart rate is confidently measured. It also needs to be properly documented for subsequent audit and for medico-legal purposes. What is the normal range of heart rate in a healthy term neonate during the first few minutes after birth?

Physiological range of the neonatal heart rate

The normal range of heart rate in a healthy neonate during transition to pulmonary respiration over the first few minutes after birth is not well agreed and published ranges over the past 30 years can have striking disagreement [4].

For the past five years the most commonly used defined reference range [5] does not begin until the first minute after birth. This was established using oximetry which does not usually register for the first minute. In healthy term infants, needing no medical intervention, the 10th and

90th percentiles are from 68 to 107 bpm one minute after birth. At two minutes the values are from 102 to 173 bpm and at five minutes from 153 to 179 bpm. More recently a further series of healthy babies [6] with routine midwifery care showed the heart rate at one minute, determined by oximetry, was from 38 to 171 bpm, from 54 to 179 bpm at two minutes and from 126 to 169 bpm at five minutes.

The ECG is an effective method of measuring the heart rate during the first minute [7]. This method was used in 1962 by Brady and James [8]. In their small series they found that immediate clamping of the umbilical cord before the onset of respirations was followed by a rapid and profound bradycardia. Even when the cord was clamped as early as 30 seconds the heart rate did not fall below 100 bpm provided they had breathed spontaneously by that time.

Electrical Cardiometry measures impedance across the chest. The impedance changes as the vessels in the chest fill and empty with each heart cycle and can therefore measure cardiac output, heart rate and stroke volume. A small series of healthy term neonates [9] showed that the heart rate (standard deviation) for these neonates at the first minute after birth was (175.9 (15.3), 170.7 (20.4) at two minutes and 168.2 (20.0) at 5 minutes.

Resuscitation

Between 1% and 3% of term babies require assistance [10,11], but how do carers make the decision to intervene to assist the baby who is failing to transition successfully within the first few minutes after birth? Unnecessary intervention to assist breathing with PPV is not without risk of damage to the lungs [12] while delaying such intervention in an already hypoxic neonate may lead to hypoxic injury to the heart or irreversible brain damage [13]. The precise interval before irreversible brain injury occurs depends on the level of hypoxia and acidemia but can never be determined with any accuracy when the information is needed at the moment of birth.

Accurate measurement of the heart rate is the most important measure of health in an apnoeic newborn. The neonatal 2010 International Liaison Committee on Resuscitation (ILCOR) recommendations state that the primary vital sign to judge the need for resuscitation and positive pressure ventilation should remain the heart rate and the heart rate should also provide evidence of the efficacy of the resuscitation. Assessment of the heart rate should be by auscultation of the precordium. The committee considered that there is a high likelihood of underestimating the heart rate with palpation of the umbilical pulse, but this is preferable to other palpation locations [14]. In the ILCOR algorithm the first measurement of the heart rate should take place by 30 seconds after birth. Based on expert opinion, ILCOR recommend that PPV should be initiated if the heart rate is under 100 bpm.

Method of heart rate measurement

The ECG is considered the gold standard for determining the heart rate although it has to be born in mind that an electrical signal does not guarantee any cardiac output. Pulse oximetry provides evidence of both heart rate and significant peripheral circulation as well as oxygen saturation. The equipment allows the output to be documented in real time and would be the ideal but it is unreliable during the first minute after birth when decisions need to be made. Ausculation with a stethoscope is recommended by ILCOR. Stethoscopes are readily available but often not practical especially in assisted vaginal births and at caesarean births when sterility is essential. Midwives do not routinely wear a stethoscope around their neck at birth and its accuracy depends on counting the heart sounds over a timed interval. This only provides a rough measure of the heart rate. It does not provide any real-time documentation. Palpation of the umbilical cord is still the commonest method of initially determining the heart rate in a depressed neonate, and as with auscultation it is not very accurate and provides no real-time documentation. Doppler ultrasound, used during labour to measure and document the fetal heart rate, also works well in the neonate and has the additional advantages of providing an accurate result from the moment of birth, of being low cost, is easily documented. It generates an audible signal which correlates with the strength of cardiac contractions [15,16].

Discussion

The current standard reference range of heart rate at birth was established on neonates who were considered to require no intervention to assist transition, but they all had the umbilical cord clamped soon after birth. This was standard practice at the time of the study. It is notable that there is a marked disparity between the normal healthy range of the fetus and the neonate in the first few minutes after birth. In view of the finding of Brady and James there was concern that the marked bradycardia shown in the standard reference range may be the result of early cord clamping. Early cord clamping before the onset of respiration was shown to cause a marked bradycardia and fall in cardiac output in lambs and the authors state that if there is a long delay between UCC and lung aeration, the infant will be exposed to a hypoxic episode superimposed on top of a period of severely restricted cardiac function. The combined effects of these two adverse events are potentially catastrophic, leading to a severe hypoxic/ischemic event [17].

In the recent study of normal midwifery births where the cord was left intact and the baby placed skin to skin on the mother's chest, the range was very similar to that of the standard reference range [6]. Indeed the bradycardia in the first few minutes was more marked. The babies did however show a significantly better oxygen saturation than those in the standard reference range. The authors attributed the bradycardia to a calming effect of skin to skin on the mother's body. This does not explain why the upper range was still well over 160 bpm. Were these

babies also calmed? Why should the neonatal heart rate in some babies fall so low. The cardiac output in the fetus is highly dependent upon the heart rate so with a heart rate of only 38, the cardiac output must fall to at least one third of the normal.

In the small series using electrical cardiometry, no bradycardia was found. These babies not only had a continuing placental circulation with an intact cord, they remained 10 to 20 cm below the level of the mother's introitus which is likely to have enhanced the rate of redistribution of blood from the placenta into the neonate, and ensure that the preload of the heart is optimized. Although the total volume of the placental transfusion is not affected by placing the neonate on the mother's abdomen immediately after birth, it does reduce the pressure gradient between the placental and the neonatal compartments of the circulation. Elevation onto the mother's abdomen will therefore slow down the rate of redistribution of blood into the baby [18]. With a slower redistribution, preload of the neonate's heart will be reduced during these first few minutes. This could account for a bradycardia in some babies. Rapid redistribution may be critical if there has been any degree of cord compression just before birth [19]. Placing the baby immediately onto the mother's abdomen by the midwife could be considered an intervention [20]. In a natural birth with the mother squatting or on all fours, she would be able to pick up her newborn baby herself when she was ready. This brief pause is long enough to ensure that all babies have optimal opportunity for the redistribution of blood from the placental transfusion. This may explain why Katheria [9] did not find any bradycardia in the babies who remained 10 to 20 cm below the introitus, lying on the soft warm surface (mimicking skin to skin) of the LifeStart trolley [21] for a few minutes after birth.

Virginia Apgar, an obstetrical anaesthetist first recognised the importance of measuring the condition of the neonate at birth to determine which babies required ventilatory assistance [22]. Her scoring system allowed this to be readily documented and is still used universally to this day. Without real-time documentation of a heart rate, subsequent audit provides only the APGAR score which incorporates the precise heart rate into the very broad categories of below 60 bpm, 60 to 100 bpm and above 100 bpm. All the parameters measured by the Apgar score are dependent upon the circulation, which is largely dependent upon the heart rate. While there have been potentially millions of fetal heart rate records with known short term outcomes made over the last 30 years, this is not the case for neonatal heart rates shortly after birth because the neonatal heart rate has been obscured and only documented within the APGAR score. Thus a cohort study of case notes can never be used to define the normal physiological range of neonatal heart rate or outcomes directly related to heart rate alone.

There is thus considerable uncertainly about the normal range of heart rate at birth in a healthy term neonate. With modern electronics there is an opportunity for this to be established with more accuracy. We are not calling for the introduction of yet more technology in normal low risk births. In breathing, crying, baby with good tone and colour, the heart rate is largely academic. However we should be prepared at all births to be able to accurately measure and document the heart rate in a baby that is not breathing and in whom resuscitation intervention is anticipated. For high risk births accurate measurement and documentation is essential and a real-time record of the heart rate should always be made.

The marked bradycardia found in some apparently healthy normal physiological births should be investigated further to determine if immediate elevation onto the mother's abdomen is the underlying cause. This should encourage a normal physiological range of heart rate at birth to be confidently established.

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