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Pulse Oximetry Screening for Critical Congenital Heart Disease: Bringing Evidence Into Practice[1,2,3]

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Knowledge translation

Congenital heart disease is the most common and serious type of infant birth defect. Pulse oximetry screening has been supported in the literature as a valuable tool to aid in the prompt detection of critical defects. Pulse oximetry is easily accessible, inexpensive, and noninvasive, and can be readily performed by clinical nurses at the infant's bedside; however, it remains a technology that is underutilized in newborns. Nurses can be leaders in addressing the need to translate knowledge into practice to improve the morbidity and mortality rates in the newborn population.

CONGENITAL HEART DISEASE (CHD) is the most common and serious type of infant birth defect. It is also the leading cause of perinatal and infant mortality (Ewer, 2012; Thangaratinam, Brown, Zamora, Khan, & Ewer, 2012), affecting approximately 8–9 in every 1,000 infants born in North America (Mahle et al., 2009). Of these infants, approximately 25% (depending on the definition used) will have what is termed critical congenital heart disease (CCHD) (Mahle et al., 2009). Early detection of CCHD is challenging; however, screening using pulse oximetry has been strongly supported by recent literature as a highly valuable tool to aid in the prompt detection of infants with CCHD (Chang, Rodriguez, & Klitzner, 2009; Mahle, Martin, & Morrow, 2012; Thangaratinam et al., 2012). In 2012, Thanagaratinam and colleagues conducted a vastly comprehensive systematic review with meta-analysis, which included data on 229,421 newborn infants. This broad review concluded that robust evidence exists for the practice of pulse oximetry screening to be implemented into clinical practice and practice guidelines. Pulse oximetry is easily accessible, inexpensive, and noninvasive, as well it can be readily performed by clinical nurses at the infant's bedside; nevertheless, it continues to be underutilized in the newborn population.

In aiming to promote improved population health status and early disease recognition, screening programs are a valuable method of secondary prevention. Pulse oximetry screening tests are not intended to be diagnostic. The purpose, like other types of screening, is to aid in prompt identification of infants that may be at risk of CCHD. These infants can then be referred on for further evaluation, diagnosis and treatment prior to acute cardiovascular collapse or death (Ewer, 2014). In 2011, pulse oximetry screening was endorsed by the American Heart Association, the American Academy of Pediatrics, and the American College of Cardiology Foundation (Mahle et al., 2012). Following these strong recommendations, in September, 2011, the United States Department of Health and Human Services (HHS) has further recommended that pulse

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oximetry screening for CCHD be added to the universal newborn screening panel (Mahle et al., 2012). New innovations have led to the advancement of pulse oximetry technology; however, Canada continues to remain behind other developed countries in regards to widespread implementation of this promising practice. Raising awareness regarding program implementation strategies for evidenced based change can be beneficial to improving the detection rates of CCHD during the neonatal period and lead to improved patient outcomes. The role of the nurse needs to be made a fundamental part of program development. Nurses are the individuals who perform the majority of pulse oximetry screening, yet most discussion to date has been presented in medical, not nursing, literature. Nurses should have a key role in program development during all stages or development and implementation in order enhance program success and sustainability. Through knowledge dissemination regarding pulse oximetry screening, nurses will be better suited to urge for practice changes regarding screening for CCHD.

Background

As defined in the literature, CCHD can be any potentially life-threatening duct-dependent defect in which infants will die or require surgical repair/intervention within the first 28 days of life (Ewer, 2012; Prudhoe, Abu-Harb, Richmond, & Wren, 2013; Thangaratinam et al., 2012). Pulse oximetry is effective in early identification of CCHDs which have a hypoxemia component (often referred to as cyanotic heart disease) including hypoplastic left heart syndrome (HLHS), pulmonary atresia with intact septum, tricuspid atresia, total anomalous pulmonary venous connection (TAPVC), Tetralogy of Fallot (TOF), transposition of the great arteries (TGA), and truncus ateriosus (Mahle et al., 2009; Ramjattan & Allen, 2013). Relating to the unique attributes of fetal circulation, approximately 1–1.8/1000 infants will be born with a duct dependent circulation, requiring patency of the ductus arteriosus for survival (de-Wahl Granelli et al., 2009). In most healthy infants the ductus arteriosus will begin constricting or closing shortly after birth as part of normal physiological transition from intrauterine to extrauterine life. The timing of this closure explains why infants with CCHD are at particularly high risk of profound circulatory compromise shortly after hospital discharge (Mahle et al., 2009). With the increasing trend for early discharge (Ewer et al., 2011), as well as an increased number of planned deliveries occurring outside of tertiary settings, infants with CCHD may be at an exceptionally higher risk to remain undiagnosed until the ductus begins to close (Kuehl, Loffredo, & Ferencz, 1999). Of note, approximately 10–30% of infants who die from CCHD do not have their cardiac condition diagnosed before autopsy (de-Wahl Granelli et al., 2009).

Through early detection and stabilization, neonatal outcomes for infants with duct dependent defects can be greatly improved (Riede et al., 2010). Diagnosis of CCHD within a timely manner allows for a care team to be organized and the infant to be stabilized until surgical or catheter intervention can be performed (Brown et al., 2006; Mahle et al., 2009; Thangaratinam et al., 2012). Preoperative condition is optimized by early diagnosis. An infant who presents in good preoperative condition is at a decreased risk of operative and postoperative morbidity and mortality (Brown et al., 2006). Undiagnosed and late detection can lead to an infant presenting in profound circulatory compromise and end organ dysfunction, greatly impacting the long-term morbidities and risk of mortality (Brown et al., 2006; Chang et al., 2009; Ewer, 2012), the most significant being ischemic brain injury (Mahle et al., 2009).

Adding pulse oximetry screening to current screening practices can improve rates of early diagnosis and treatment, potentially limiting the number of infants who present in critical condition (Ewer et al., 2011) as well as infant deaths within the community. The authors of a Swedish study have found that introducing pulse oximetry screening programs should at least be cost neutral in the short term, as each additional case detected early saves at least as much as each case that is missed (de-Wahl Granelli et al., 2009). Looking further, there is great potential for long-term health care cost reductions due to the probable prevention of serious neurological morbidity in patients that have survived following an undiagnosed CCHD (de-Wahl Granelli et al., 2009). In addition, pulse oximetry screening has also been found to be effective in detecting other potentially life-threatening conditions beyond congenital heart disease, such as early onset neonatal sepsis and respiratory disorders that may have otherwise gone undetected until significant complications arise (Ewer, 2012; Meberg et al., 2008). Improved rates of early detection of these conditions in addition of CCHD, generates further recommendation for routine use of pulse oximetry screening in the newborn population.

Pulse Oximetry

Pulse oximetry is a non-invasive, clinically well-established and accurate method of objective testing for oxygen saturation measurements (Ewer, 2012). Pulse oximetry has become such a routine nursing skill in the clinical settings that blood oxygen saturations are now often considered the "fifth" vital sign (Popovich, Richiuso, & Danek, 2004). Pulse oximetry monitors measure the amount of functional oxygen saturation in the infant's blood (de-Wahl Granelli et al., 2009). To measure oxygen saturations, a small sensor is secured on the right upper limb for a preductal reading (most commonly around either the palm/wrist of the right hand) or on either of the lower limbs (the sole of either foot) to obtain a postductal measurement (Figure 1). This result is then recorded as a percentage of oxygen saturation, and this measurement informs the nurse of the percentage of hemoglobin that is available to transport oxygen in the blood (Popovich et al., 2004). Due to the non-invasive, painless, and relatively quick measurement that is obtained with pulse oximetry it is an