Pulse oximetry screening for critical congenital heart defects

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Congenital heart defects (CHD) are the most common congenital malformations and remain a major cause of neonatal mortality and morbidity in the developed world.[1] Critical congenital heart defects (CCHD) are the most serious form of CHD (**FIGURE 1**) with an incidence of between 2 and 3 per 1,000 live births.[2] Infants with a CCHD are at risk of cardiovascular collapse, acidosis and death in the first few days of life following closure of the ductus arteriosus and therefore early diagnosis is essential to reduce the possibility of these complications and to improve outcome following cardiac surgery.[1]

Currently most infants are screened for CCHD using antenatal ultrasound scanning and postnatal physical examination. However, both of these procedures have a relatively low detection rate and up to a third of infants may be discharged from hospital with an undiagnosed critical defect.[3]

Pulse oximetry (PO) measures blood oxygen saturations and is a well-established, accurate, non-invasive method of detecting low oxygen levels (hypoxaemia).[1] The rationale for using PO to screen for CCHD is that hypoxaemia is present in the majority of cases of CCHD, but this is often comparatively mild and may be clinically undetectable. Therefore, the addition of PO screening may detect infants with unidentified CCHD before they collapse.[1] This concept was first described over ten years ago[4] but it is only relatively recently that several large European studies[5-9] have provided sufficient robust evidence of test accuracy that can reliably inform the introduction of routine PO screening.

In 2012, a systematic review of all available evidence (including nearly 230,000 screened infants) concluded that PO screening was a moderately sensitive, highly specific test for detection of CCHD that met the criteria for universal screening.[10] In 2014, the world's largest PO screening study involving over 120,000 infants in China[11] demonstrated similar findings, which essentially removed any remaining uncertainties about the performance of PO screening.[12]

The addition of PO screening reduces the 'diagnostic gap'[7] (ie those infants with CCHD who are not detected by current screening methods) and when PO screening is combined with antenatal ultrasound scanning and the newborn physical examination, over 92% of infants with CCHD are identified.[10] In addition to test accuracy studies, further work, both in the UK and the USA, has shown PO screening to be cost-effective[13,14] and acceptable to both parents and staff.[15]

All infants with hypoplastic left heart, pulmonary atresia with intact ventricular septum, simple transposition of the great arteries or interruption of the aortic arch.

All infants dying or requiring surgery within the first 28 days of life with the following conditions: coarctation of the aorta; aortic valve stenosis; pulmonary valve stenosis; tetralogy of Fallot; pulmonary atresia with ventricular septal defect; or total anomalous pulmonary venous connection.

FIGURE 1 Definition of critical congenital heart defects.

Screening pathways (or algorithms) for PO screening within the published studies are variable.[4,10,16] The main differences are:

1. the use of a single (post-ductal) saturation measurement or measuring both pre- and post-ductal saturations, and
2. the timing of screening (before or after 24 hours of age).

Algorithms that use only single measurements seem quicker and easier, but careful comparison of the data from these studies and those using both pre- and post-ductal saturations show that using only a single post-ductal measurement may miss a small number of infants with CCHD. With large populations this number may become significant and the benefits of using two measurements seem to outweigh the potential disadvantages.[16-18]

As with any screening test it is important to consider the number of false positives (those infants who test positive but do not have CCHD) and the timing of the screen affects the number of false positive screens. Later screening (>24 hours) has a lower rate of false positive tests,[10] however, between 30 and 80% of false positive infants have a significant respiratory or infective condition or non-critical CHD.[10,16,19] Earlier screening is mandatory in countries such as the UK where the majority of infants are discharged within 24 hours of birth. In addition, later screening may result in up to 50% of those with CCHD presenting before screening can take place, sometimes with an acute deterioration.[15] These factors must be considered carefully; although a lower number of false positives is advantageous in a screening test, if the majority of false positives have a serious non-cardiac condition that requires urgent treatment this is clearly a significant additional benefit.[19] In addition, later screening (after 24 hours) may lead to more infants with CCHD becoming seriously

unwell before testing takes place, which defeats the purpose of screening.[16,17]

Screening infants born at home presents particular challenges; homebirth rates are increasing and midwifery staff often leave mother and baby shortly after birth, which means that testing must take place within a couple of hours. However, screening infants in this situation has been shown to be both feasible and acceptable in a small UK study[20] and further evidence from a larger Dutch study will soon be available.[21]

In recent years several countries (including Switzerland, Ireland and Poland) have recommended routine PO screening and in 2011, the US Health and Human Services recommended that screening for CCHD be added to the uniform newborn panel, thus establishing PO screening as national US Government policy.[16] Recently, clinicians from the Nordic countries also recommended PO screening[22] but uptake in the rest of Europe has been relatively slow. In the UK, the National Screening Committee instigated a national consultation in 2013 and the following year recommended a national pilot study, which completed at the end of 2015. The results of this pilot will inform the decision on UK policy.

A multinational group of clinicians has been working towards a Europe-wide implementation of PO screening[23] and, in a recent symposium at the World Congress of Perinatal Medicine in Madrid, the group recommended that no further research on the test accuracy of PO screening is necessary and that routine screening should be considered across Europe. Senior representatives from many important European societies, including the European Society for Paediatric Research and the Union of European Neonatal and Perinatal Societies, endorsed these findings. Currently many countries are undertaking further feasibility pilot studies and the progress in this area is very exciting. Data from these national studies may allow further refinement of screening algorithms, although local factors are likely to play an important role in this.

In summary, PO screening is feasible, cost-effective, and acceptable, and reduces the diagnostic gap for CCHD. A universal programme of PO screening in newborns will increase the detection of CCHD, however, it has also been shown to be useful in detecting other potentially life-threatening clinical conditions, which is an important additional advantage. When defining the most appropriate screening algorithm a balance must be struck between detection of serious illness and limiting false positive results – local circumstances may have an influence in this respect. Finally, it is also important to remember that PO screening is not a perfect test and infants with CCHD may still be missed. Therefore PO screening should be used as an adjunct to existing screening methods and healthcare professionals and parents need to be aware of the limitations of the test.

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