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Pulse oximetry screening for critical congenital heart defects in newborn infants: Should it be routine?

Andrew K Ewer

Correspondence to
Dr Andrew K Ewer, Neonatal Unit, Birmingham Women's Hospital, Edgbaston, Birmingham B15 2TG, UK; a.k.ewer@bham.ac.uk

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ABSTRACT

Screening with pulse oximetry for critical congenital heart defects is the subject of much recent debate. This review will explore the recent evidence for screening and discuss how implementation of screening might be best achieved.

BACKGROUND

The detection of life-threatening, critical congenital heart defects (CCHDs) in newborn babies—before they present with acute cardiovascular collapse or death—presents an important clinical challenge. CCHDs occur in 1–3 per 1000 live births (depending on the definition used) and routine clinical examination and antenatal ultrasound still miss a significant proportion of cases.[1–3] Collapse of babies with undiagnosed CCHD before surgery results in a worse outcome, from a cardiovascular and a neurodevelopmental perspective.[2 3]

Based on the rationale that most newborn babies with CCHD have a degree of hypoxaemia, the use of pulse oximetry to screen asymptomatic babies for CCHD was first explored over 10 years ago.[4 5] Further initial studies, mainly in single centres, with relatively few babies and a low prevalence of CCHD were then undertaken.[2 6] Although demonstrating proof of concept, the data were insufficient to recommend universal screening.[2 6]

CURRENT EVIDENCE

Recently, several large European studies[7–11] have strengthened the case and demonstrated that pulse oximetry as an adjunct to existing screening can increase CCHD detection rates to well over 90%.[12] Importantly, most studies also report detection of secondary targets, that is, test positive babies who have either non-critical congenital heart defects (CHD) or serious non-cardiac illness such as congenital pneumonia, early-onset sepsis and pulmonary hypertension. In recent studies, between 30% and 70% of the false positives fell into this category.[12] As some of these conditions are potentially as lethal as a CCHD if undiagnosed (eg, group B streptococcal pneumonia), this is a key additional advantage of the test.

Pulse oximetry screening is simple, quick and painless, has been shown to be acceptable to parents and clinical staff and does not increase anxiety even in the parents of babies with a false-positive result.[3 13] A recent systematic review and meta-analysis of 13 studies of almost 230 000 babies concluded that pulse oximetry was a highly specific (specificity 99.9%, 95% CI 99.7 to 99.9), moderately sensitive (sensitivity 76.5%, 95% CI 67.7 to 83.5) test that meets the criteria for universal screening.[14]

HOW SHOULD SCREENING BE PERFORMED?

Several issues continue to be debated, including when to screen, site(s) of saturation monitoring and the impact on clinical and echocardiographic services, particularly if the false-positive rate is high.[12 14 15]

Screening pathways in published studies have significant heterogeneity.[6 14] The main differences relate to the timing of screening and whether to measure post-ductal saturation only, or both pre- and post-ductal saturation. The false-positive rate is much lower when screening is performed after 24 h.[14] However, this must be carefully balanced against the increasing tendency to discharge apparently healthy newborns within 24 h and the risk of collapse in babies with CCHD before screening is done.[12 15] Approximately half of the babies with CCHD screened after 24 h present with symptoms prior to screening[8 9] and up to 10% of those may present with collapse in hospital.[8]

Although a meta-analysis of measuring post-ductal versus pre- and post-ductal saturation showed no difference in sensitivity,[14] studies that measured pre- and post-ductal saturation have consistently identified CCHDs that would have been missed using post-ductal saturation alone.[8 10 12 15]

IS PULSE OXIMETRY SCREENING COST-EFFECTIVE?

Most published data suggest that neonatal pulse oximetry screening is likely to be cost-effective.[2 3 8 16 17] The model-based economic evaluation using data from the PulseOx study estimated an incremental cost-effectiveness ratio of £24 000 per timely diagnosis when compared with clinical examination alone.[17] However, this estimate is likely to reflect a 'worse case scenario' for several reasons: an antenatal detection rate of 50% for CCHD was assumed, but the figure is often lower; also the false-positive rate was relatively high (0.8%) and the model assumed that all test positives would undergo an echocardiogram by a consultant paediatric cardiologist at a cardiac centre. In practice, test positives often present with a clear alternative diagnosis (eg, respiratory disorder or transitional circulation) obviating the need for echocardiogram and those that are performed are often done by in-house neonatologists or paediatricians with an interest in cardiology. If echocardiography expertise is unavailable, dialogue with the cardiac centre or even telemedicine scanning may identify those babies who need urgent referral.

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As a result, it is likely that the actual cost will be lower.[15]

Importantly, cost-effectiveness analyses which do not adopt a lifelong, societal perspective may underestimate the benefits of preventing disability. Pulse oximetry can prevent death and disability through earlier diagnosis of CCHD and non-cardiac problems such as pneumonia and early-onset sepsis. The long-term impacts on hospital and community healthcare, community services, special education, increased welfare payments, unemployment and lost parental and child productivity have not been assessed.

SHOULD PULSE OXIMETRY SCREENING BE ROUTINE IN ALL NEWBORNS?

This concept has recently gathered considerable international momentum among clinicians.[18–20] Increasingly, pulse oximetry screening is being adopted by individual hospitals and as national policy. In 2011, after a comprehensive analysis by the CCHD Work Group of evidence from parents, professionals and relevant agencies,[21] the US Health and Human Services Secretary recommended that pulse oximetry screening be added to the Recommended Uniform Screening Panel.[22] Most infants in Switzerland[12 23] and Abu Dhabi are routinely screened, and the Polish Ministry for Health[11 12] and the Royal College of Physicians of Ireland[24] have recommended pulse oximetry screening. Recently, it has been suggested that more European National Bodies and Professional societies should be encouraged to formulate policy statements on CCHD screening.[25]

In the UK, in 2010, only 7% of maternity units undertook routine screening[26] but by 2012 this increased to almost 20% and around 70% of the non-screening units considered its introduction.[20] There remains, in the UK, a wide variation in practice owing to the lack of national guidance and consensus. Justifiable concerns have been raised about the lack of echocardiography services to cope with the increased demand.[20] In the USA, screening is recommended after 24 h to reduce the false-positive rate and the necessity to transfer infants over long distances for diagnostic echocardiography. This is unlikely to be practicable in countries such as the UK where early discharge is the norm. Also, earlier diagnosis of CCHD and serious non-cardiac illness reduces the risk of infants collapsing before diagnosis. As all test positives are, by definition, babies with lower oxygen saturations, clinicians are unlikely to be willing to discharge them. Repeat tests in otherwise healthy babies with moderately reduced saturations are likely to allow those babies with 'transitional circulation' to become normoxaemic, obviating the need for additional intervention.[12 15] Those with persistently lower saturations warrant further investigation, but an echocardiogram may not be necessary in those with a clear alternative explanation for hypoxaemia (such as congenital pneumonia). Careful clinical assessment is essential in all cases. Local data suggest that more than four times as many babies undergo echocardiography as a result of abnormal clinical examination than following abnormal pulse oximetry screening.[27]

LIMITATIONS OF PULSE OXIMETRY SCREENING

Pulse oximetry screening is not a perfect test; with a sensitivity of around 75% for CCHD,[14] it is clear that about a quarter of babies with these defects will not be detected. However, in combination with other routine screening procedures the vast majority will be identified.[12] The commonest lesions missed by pulse oximetry are those causing obstruction to the aorta (eg, coarctation and interrupted aortic arch), which unfortunately are also frequently missed by antenatal ultrasound and routine examination.[12 15] This was highlighted in a UK report of 10 years of pulse oximetry screening where three out of the four babies discharged with undiagnosed CCHD after passing all screening procedures, including pulse oximetry, had aortic obstruction.[28] Staff should be aware of these limitations and parents appropriately informed.

NEXT STEPS

For individual hospitals, neonatal networks or countries considering routine pulse oximetry screening, what is the best plan for developing a reliable screening algorithm? What is the optimal timing? Should measurements be post-ductal or pre- and post-ductal? Should all test positives undergo echocardiogram? For the detection of CCHD, any form of pulse oximetry screening is superior to no pulse oximetry. The specific algorithm should be adapted to suit local circumstances. If babies are not routinely discharged until well after 24 h and postnatal nurseries are well staffed and babies closely observed prior to discharge, then it may be reasonable to delay screening until after 24 h to reduce false positives. However, increasingly babies are being discharged earlier and reduced staffing levels on postnatal wards may mean that earlier screening will facilitate early discharge and ensure that babies with critical problems do not collapse before screening. Repeat testing in apparently well babies is also likely to reduce the false-positive rate.[8 15] Pre- and post-ductal screening is likely to identify slightly more babies with CCHD than post-ductal screening alone,[12 15] and when scaled up nationally, this number may become important. However, post-ductal screening will identify many more babies than no screening at all. The hotly debated subject of echocardiography for test-positive cases can be resolved by a pragmatic approach. Rather than suggesting that all test-positive cases automatically undergo echocardiography, this should be reserved for babies with an abnormal cardiovascular examination and no satisfactory explanation for persistent hypoxaemia.[15] In practice, following these guidelines, the numbers of additional echocardiograms performed is likely to be relatively small, certainly fewer than those currently undergoing this investigation as a result of abnormal clinical examination.[27]

CONCLUSIONS

Given the simplicity of the test and underlying principles, it is hard to argue against routine pulse oximetry screening. A recent *Lancet* editorial asked '…why should such screening not be introduced more widely'.[19] Most paediatricians will agree with the fundamental maxim that 'no baby should have unexplained, persistent hypoxaemia'. Clinicians assess newborn babies with low oxygen saturations in every maternity hospital almost every day. The early identification of these babies by screening, before they become unwell can rapidly and easily become routine practice. National organisations and societies should be encouraged to consider policy statements after a thorough review of the evidence.

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