Screening for Critical Congenital Heart Disease (CCHD): Global Implementation Efforts

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Anaheim, California
Pulse Oximetry Examined 2002-2007

Oxygen S. A Preliminary

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Objective: To evaluate whether certain newborns with con genital heart disease were diagnosed after discharge. A new criterion was established, an echo was performed on the first day of life, and children with cyanosis were compared with those without.

Methods: Births were performed in 22 hospitals in the United States. A total of 12,824 newborns were included in the study. The incidence of cyanosis was evaluated, and the number of newborns with cyanosis was compared with the number of newborns with normal arterial saturation.

Results: The incidence of cyanosis was 0.4%, and 0.3% of newborns were noted to have cyanosis prior to discharge, which was not statistically significant.

Conclusions: While the incidence of cyanosis was low, the number of newborns with cyanosis was significantly increased in those with a birth weight less than 2500 g. Treatment of cyanosis should be initiated on the first day of life if a diagnosis is made.

Key words: Birth weight, cyanosis, newborns, treatment

The incidence of cyanosis (CHD) is found in up to 0.6% of newborns who are discharged from the hospital within the first days of life. The incidence is highest in newborns with a birth weight less than 2500 g, and the risk of developing cyanosis is higher in newborns with congenital heart disease (CHD).

The incidence of cyanosis is not significantly different among newborns with CHD compared to those without. However, the incidence of cyanosis is significantly increased in newborns with a birth weight less than 2500 g. Treatment of cyanosis should be initiated on the first day of life if a diagnosis is made.

Introduction

The purpose of this study was to evaluate the incidence of cyanosis (CHD) in newborns discharged from the hospital within the first days of life. The incidence of cyanosis is known to be highest in newborns with a birth weight less than 2500 g, and the risk of developing cyanosis is higher in newborns with congenital heart disease (CHD).

The incidence of cyanosis is not significantly different among newborns with CHD compared to those without. However, the incidence of cyanosis is significantly increased in newborns with a birth weight less than 2500 g. Treatment of cyanosis should be initiated on the first day of life if a diagnosis is made.

Conclusion

The incidence of cyanosis is not significantly different among newborns with CHD compared to those without. However, the incidence of cyanosis is significantly increased in newborns with a birth weight less than 2500 g. Treatment of cyanosis should be initiated on the first day of life if a diagnosis is made.
### Table 2

The performance of screening methods in the detection of duct dependent circulation in newborn infants in West Götaland (1 July 2004 to 31 March 2007)

<table>
<thead>
<tr>
<th>Performance</th>
<th>Physical examination alone (n=38374)</th>
<th>Pulse oximetry (n=38429)</th>
<th>Physical examination plus pulse oximetry (n=38429)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (95% CI) (%)</td>
<td>62.50 (35.43 to 84.80)*</td>
<td>62.07 (42.3 to 79.31)</td>
<td>82.76 (64.23 to 94.15)</td>
</tr>
<tr>
<td>Specificity (95% CI) (%)</td>
<td>98.07 (97.93 to 98.21)</td>
<td>99.82 (99.77 to 99.86)</td>
<td>97.88 (97.73 to 98.03)</td>
</tr>
<tr>
<td>Positive predictive value (95% CI) (%)</td>
<td>1.35 (0.65 to 2.47)</td>
<td>20.69 (12.75 to 30.71)</td>
<td>2.92 (1.88 to 4.31)</td>
</tr>
<tr>
<td>Negative predictive value (95% CI) (%)</td>
<td>99.98 (99.96 to 99.99)</td>
<td>99.97 (99.95 to 99.99)</td>
<td>99.99 (99.97 to 100.00)</td>
</tr>
</tbody>
</table>

### Table 3

Pathology found in 69 babies with false positive results from pulse oximetry screening for duct dependent circulation in West Götaland (1 July 2004 to 31 March 2007)

<table>
<thead>
<tr>
<th>Pathology found</th>
<th>No (% of babies)</th>
<th>Stay in neonatal intensive care</th>
<th>≥5 days after screening</th>
<th>&lt;5 after screening</th>
<th>Follow-up only</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other critical congenital heart disease*</td>
<td>4 (6)</td>
<td></td>
<td>6/4</td>
<td>0/4</td>
<td>0/4</td>
<td>6/4</td>
</tr>
<tr>
<td>Other milder congenital heart disease</td>
<td>10 (14)</td>
<td></td>
<td>4/10</td>
<td>1/10</td>
<td>5/10</td>
<td>4/10</td>
</tr>
<tr>
<td>Persistent pulmonary hypertension</td>
<td>6 (9)</td>
<td></td>
<td>3/6</td>
<td>0/6</td>
<td>3/6</td>
<td>N/A</td>
</tr>
<tr>
<td>Transitional circulation†</td>
<td>8 (12)</td>
<td></td>
<td>0/8</td>
<td>3/8</td>
<td>2/8</td>
<td>N/A</td>
</tr>
<tr>
<td>Infections</td>
<td>10 (14)</td>
<td></td>
<td>6/10</td>
<td>0/6</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pulmonary pathology</td>
<td>7 (10)</td>
<td></td>
<td>5/7</td>
<td>1/7</td>
<td>1/7</td>
<td>N/A</td>
</tr>
<tr>
<td>Normal (verified from hospital charts)</td>
<td>24 (35)</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Pulmonary atresia with multiple aortopulmonary collaterals (n=2), tricuspid atresia with pulmonary stenosis and ventricular septal defect (n=1), total anomalous pulmonary venous return (n=1).
†Right to left shunting across foramen ovale without pulmonary hypertension.
United States Efforts

Strategies for Implementing Screening for Critical Congenital Heart Disease

Measurement #1
Pulse Ox on Right Hand (RH) and One Foot After 24 Hours of Age
- FAIL: Pulse ox of 89% or less in either the RH or foot
  Action: Do Not Repeat for Screening, Refer for Immediate Assessment
- RETEST: Pulse ox of 90-94% in BOTH the RH and foot OR a difference of 4% or more between the RH and foot
  Action: Repeat pulse ox measurements in 1 hour
- PASS: Pulse ox of 95% or more in RH or foot AND difference of 3% or less between the two
  Action: Do Not Repeat for Screening, Provide Normal Newborn Care

Measurement #2
Pulse Ox on Right Hand (RH) and One Foot 1 Hr After Measurement #1
- FAIL: Pulse ox of 89% or less in either the RH or foot
  Action: Do Not Repeat for Screening, Refer for Immediate Assessment
- RETEST: Pulse ox of 90-94% in BOTH the RH and foot OR a difference of 4% or more between the RH and foot
  Action: Repeat pulse ox measurements in 1 hour
- PASS: Pulse ox of 95% or more in RH or foot AND difference of 3% or less between the two
  Action: Do Not Repeat for Screening, Provide Normal Newborn Care

Measurement #3
Pulse Ox on Right Hand (RH) and One Foot 1 Hr After Measurement #2
- FAIL: Pulse ox of 89% or less in either the RH or foot
  Action: Do Not Repeat for Screening, Refer for Immediate Assessment
- RETEST: Pulse ox of 90-94% in BOTH the RH and foot OR a difference of 4% or more between the RH and foot
  Action: Repeat pulse ox measurements in 1 hour
- PASS: Pulse ox of 95% or more in RH or foot AND difference of 3% or less between the two
  Action: Do Not Repeat for Screening, Provide Normal Newborn Care
• Norway, Sweden, Poland and Ireland have national recommendations to screen
• Identical screening protocol as used in U.S.
• **Sweden, Norway and Finland used bottom up approach - implementation near 100%**
• Significantly lower screening implementation rates
  - Denmark – claim high prenatal detection rates
  - Iceland - claim lowest infant morality in Europe
BWH screening programme 2010-2013 (40 months)

- Total Livebirths: 25,859
- Most babies screened >12 hrs (mean age 7 hrs)
- Test positive pulse oximetry: 208
  0.8% of all livebirths - Just >1 admission a week

Congenital heart defects identified: 17
  - Critical CHD: 9
  - Serious CHD: 3
  - Significant CHD: 5

2 CCHD missed by all screening procedures


Slide courtesy of Andrew Ewer, MD
Results

• Transitional circulation/mild TTN: 43 (21%)

• No collapse in the postnatal wards

• 165/208 (79%) identified significant clinical condition

• Echos performed for test +ve pulse Ox:
  61/208 (29%)

• Abnormal Echos: 29/61 (48%)


*Slide courtesy of Andrew Ewer, MD*
Impact on Pediatric Cardiologist, Echocardiography and Resource Utilization

- 18,801 infants screened; FP rate 0.13%; sensitivity 80%
- Only 9 echos
- No significant burden on echocardiography resources
- Equally effective tool for improving early diagnosis of other important pathologies –
  - 4 CCHD (TGA, AS, TAPVD, PS)
  - 6 with secondary targets (PPHN, PNE, congenital diaphragmatic hernia, alveolar capillary dysplasia)
Dutch Pilot Study - Home Birth Algorithm

Fig. 1 Flowchart of pulse oximetry screening. The decision tree of the protocol is shown.

Narayen Eur J Pediatr 2014
China: Bigger Numbers, Similar Findings

### Table 3: Detection rate for individual critical congenital heart disease in asymptomatic newborn babies

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pulse oximetry alone</th>
<th>Clinical assessment alone</th>
<th>Pulse oximetry plus clinical assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical pulmonary stenosis</td>
<td>10 (100%)</td>
<td>10 (100%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Tetralogy of Fallot</td>
<td>9 (100%)</td>
<td>9 (100%)</td>
<td>9 (100%)</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>5 (200%)</td>
<td>2 (40%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>Single ventricle</td>
<td>11 (73%)</td>
<td>8 (82%)</td>
<td>10 (91%)</td>
</tr>
<tr>
<td>Pulmonary atresia</td>
<td>30 (100%)</td>
<td>28 (93%)</td>
<td>30 (100%)</td>
</tr>
<tr>
<td>Transposition of great arteries</td>
<td>33 (97%)</td>
<td>29 (88%)</td>
<td>32 (97%)</td>
</tr>
<tr>
<td>Double outlet of right ventricle</td>
<td>9 (89%)</td>
<td>6 (67%)</td>
<td>9 (100%)</td>
</tr>
<tr>
<td>Hypoplastic left heart syndrome</td>
<td>7 (43%)</td>
<td>2 (29%)</td>
<td>4 (57%)</td>
</tr>
<tr>
<td>Critical coarctation of the aorta</td>
<td>7 (43%)</td>
<td>4 (57%)</td>
<td>5 (71%)</td>
</tr>
<tr>
<td>Interrupted aortic arch</td>
<td>5 (40%)</td>
<td>2 (40%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>Critical aortic stenosis</td>
<td>3 (33%)</td>
<td>1 (100%)</td>
<td>3 (100%)</td>
</tr>
<tr>
<td>Total anomalous pulmonary venous connection</td>
<td>17 (82%)</td>
<td>8 (47%)</td>
<td>16 (94%)</td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>84% (122 of 146)</td>
<td>77% (113 of 146)</td>
</tr>
</tbody>
</table>
Comment to Zhao Article

• Optimum timing of screening deserves further consideration:

• U.S. screens 24 hours - lower false positive rate (0.04%) but fewer cases of CCHD identified (NJ 2013 article)

• Need to balance lower false positive rate against likelihood of timely diagnosis (prevent collapse prior to screen)

• Less than 1/3 of positive infants need an echo (if assess for secondary targets first)

Ewer Lancet April 2014
Early screening for critical congenital heart defects in asymptomatic newborns in Mazovia province: experience of the POLKARD pulse oximetry programme 2006–2008 in Poland

Anna Turska-Kmieć, Maria Katarzyna Borszewska-Komacka, Witold Błaż, Wanda Kawalec, Małgorzata Żuk

- 51,698 asymptomatic infants screened from 51 neonatal units (14.2% of total births in Poland)
- 15 cases if CCHD identified by P.O.; 4 false negatives
- Sensitivity – 78.9%; specificity – 99.9%
India

• Post-ductal only; all babies echocardiogram
• 1 in 600 asymptomatic newborns identified with CCHD thru P.O.
Rome, Italy – Two Year Observational Cohort Study

- 5,750 asymptomatic babies; post-ductal only
- P.O screen conducted 48-72 hours 
  (after a physical exam at 24 hours)
- No true positives; 1 false negative CCHD 
  (aortic arch coarctation undetected by both clinical assessment and P.O.)

Zuppa J Mat-Fet& Neo Med 2014
Congenital Heart Disease Screening Program: Health Authority of Abu Dhabi

Implementation Began: January, 2011

Infants Screened: Approx. 23,000

near 80,000

Total Detected:

13 with CCHD Detected

now 34 detected

New screening saves 13 babies in Abu Dhabi

SIMPLE TEST IS NOW MANDATORY IN ALL HOSPITALS IN THE CAPITAL

ABU DHABI

By SAMIHAH ZAMAN
Staff Reporter

A critical shortage of paediatric cardiologists in the emirate of Abu Dhabi is putting the lives of hundreds of babies at risk, especially if a mandatory test to detect serious congenital heart abnormalities is not administered, health experts have said.

The test, which screens for critical congenital heart disease, affecting three in every 1,000 babies worldwide, is important because babies in the GCC could present certain abnormalities that can kill them within the first two months

Happy and healthy

Dr Gerard Martin of the Children’s National Medical Centre, with 8-month-old Jumana and her father Surour Khamis Abdullah.
Please email updates to pulseox@childrensnational.org
European Efforts: Strategizing for a Uniform Recommendation

Torino, Italy 2013 & 2014

THE LANCET

The Lancet, Volume 382, Issue 9895, Pages 856 - 857, 7 September 2013

• France
• Germany
• Italy
• Netherlands
• Spain
• Sweden
• UK

Press release
UK National Screening Committee recommends new test for newborn babies with heart disease

Organisation: Public Health England
Published: 7 May 2014
Giving all children a healthy start in life

Children’s National Heart Institute

Children’s National
European Union – Committee of Experts on Rare Diseases EUCERDS Identified opportunity for improvements in newborn screening

- 2013 Commission Expert Group on Rare Diseases
- Centralized approach - benefits of standardization, registries, COE
- Documented wide practice variation - 2 to 29 disorders
- Prioritizing metabolic and genetic disorders
- Opportunity to consider congenital cardiac defects
Contact Information

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