Quality Improvement in Screening for Critical Congenital Heart Disease

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Objectives Screening for critical congenital heart disease with pulse oximetry requires healthcare providers to decipher a previously published algorithm, a feature that raises concerns about quality of interpretation of pulse oximetry results. We hypothesized that this method would be prone to error and a computer-based tool would lead to a more accurate interpretation of the screening results.

Study design In this randomized crossover study, healthcare providers with prior experience using pulse oximetry received 2 sets of 10 mock screening scenarios and were asked to interpret the results of each scenario as "pass," "fail," or "retest." Participants were randomized to use either the paper algorithm or computer-based tool for the first set of 10 scenarios and the alternative method for the second set. We used Wilcoxon rank sum tests to compare the accuracy of interpretation using the 2 methods.

Results The 102 participants answered 81.6% of the scenarios correctly when manually interpreting the algorithm vs 98.3% correct when using the computer-based tool ($P < .001$). These differences were most pronounced for the "fail" scenarios (65.4% manual vs 96.7% computer, $P < .001$) and the "retest" scenarios (80.7% manual vs 98.7% computer, $P < .001$), but were also significant for the "pass" scenarios (94.1% manual vs 99.0% computer, $P < .001$).

Conclusions Use of a manual algorithm for the interpretation of results in screening for critical congenital heart disease with pulse oximetry is susceptible to human error. Implementation of a computer-based tool to aid in the interpretation of the results may lead to improved accuracy and quality. *(J Pediatr 2014;164:67-71)*.

In 2011, critical congenital heart disease (CCHD) was added to the US Recommended Uniform Screening Panel. Infant mortality for children with CCHD has slowly been improving over the last 30 years, with infant survival increasing from 67.4% for those born 1979-1993 to 82.5% for those born 1994-2005.[1] Earlier detection of CCHD offers the promise of even further reduced morbidity and mortality for children with CCHD.[2] Unfortunately, 31.3% of children with CCHD are not diagnosed until after the first day of life.[1] Pulse oximetry is a simple, noninvasive, bedside test that can accurately detect the percent of hemoglobin saturated with oxygen; infants with CCHD typically have a low percent saturation even before the onset of symptoms.[3] Of course, not all children with CCHD will be detected via pulse oximetry; screening with pulse oximetry should, thus, be considered an adjunct to the status quo of clinical assessments, not a replacement. Nevertheless, through earlier detection, screening with pulse oximetry holds the promise of improving morbidity and mortality for newborns with CCHD.[1,4] Indeed, newborn screening for many other disorders has proven to significantly improve outcomes for children with those disorders.[5-7]

However, there is a notable difference between screening for CCHD and screening for other disorders in newborns: the need for bedside interpretation of data by the healthcare provider.[8] In the 29 core conditions on the Recommended Uniform Screening Panel that utilize bloodspots, a laboratory blood test is used to detect the presence of the condition.[9] In early detection of hearing loss, bedside devices use automated algorithms to deliver a "pass" or "fail" result; no human interpretation of data is needed.[10]

For CCHD screening, current guidelines recommend that a healthcare professional use a flowchart to interpret the findings from pulse oximetry performed on the right hand and either foot at >24 hours of age (**Figure 1**); these guidelines have been endorsed by the American Academy of Pediatrics, the American College of Cardiology, and the American Heart Association.[11,12] With this algorithm, pulse oximetry is recommended to be performed in asymptomatic term neonates ≥24 hours of age in both the right hand (to obtain a saturation that is typically preductal) and either foot (to obtain a saturation that is postductal). If the saturation in either location is <90%, then the child has a positive screen (fails screening) and further workup such as an echocardiogram is recommended. If the saturation is ≥95% in either location, and the difference between the 2 saturations is ≤3%, then the child has a negative screen (passes screening), and no further screening or workup for CCHD is recommended. If neither of these conditions is met, repeat screening is recommended in 1 hour. If the conditions are still not met upon repeat screening, a third screening is recommended in an hour. If the child does not meet criteria for a negative screen at this third screening, then the child is considered to have a positive screen. To ensure success of any screening program for CCHD with pulse oximetry, appropriate interpretation of this algorithm is necessary.

CCHD Critical congenital heart disease

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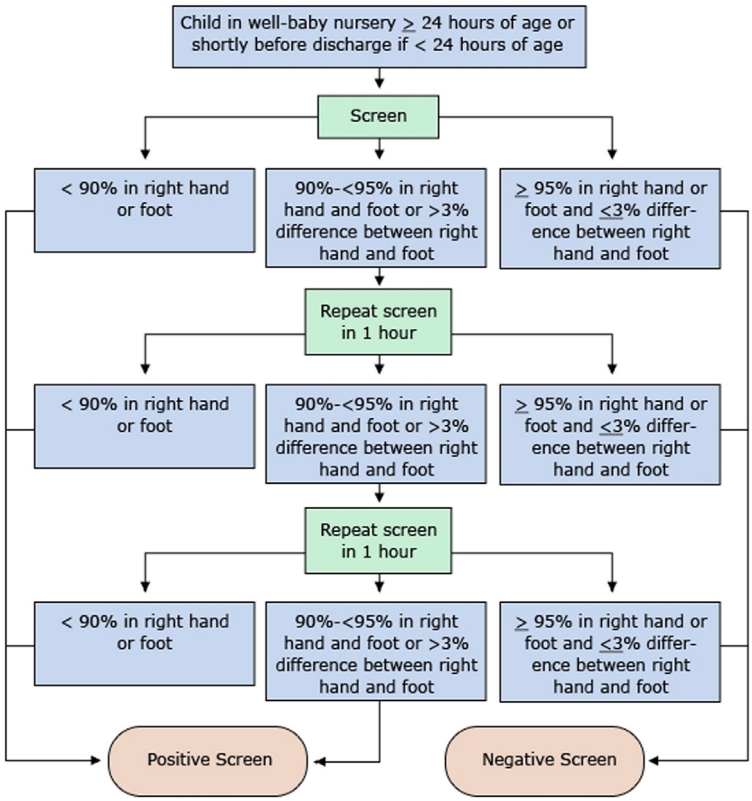

Figure 1. Algorithm for screening for CCHD. Screening protocol endorsed by the American College of Cardiology, the American Academy of Pediatrics, and the American Heart Association (Reprinted from the public domain from the U.S. Centers for Disease Control and Prevention. Available at http://www.cdc.gov/ncbddd/pediatricgenetics/pulse.html).

For hospitals that planned on using human interpretation of an intricate flowchart, we were concerned about whether healthcare professionals would indeed interpret the findings appropriately. The purpose of this study was to assess the accuracy of interpretation of screening results using the paper algorithm vs a computer-based tool. We hypothesized that human interpretation of a paper flowchart would be prone to error and a computer-based tool would lead to more accurate interpretation of the screening results.

Methods

We performed a randomized crossover study at Children's Healthcare of Atlanta in 2012 to compare the performance of a paper algorithm vs a computer-based tool for interpretation of results from screening newborns for CCHD with pulse oximetry. An online computer-based tool was developed in-house for the purposes of this quality initiative. Healthcare providers familiar with how to use pulse oximetry in newborns were eligible for the study. Screening of newborns with pulse oximetry was not part of the standard of care in our facility at the time of this study, but the use of pulse oximetry in symptomatic infants was routine. Each of the participants was given 2 sets of 10 hypothetical screening scenarios and was asked to interpret the results of each scenario as "pass" (negative screen), "fail" (positive screen), or "retest" (repeat screen recommended) by marking the appropriate option for each scenario on the test (**Appendix 1**; available at www.jpeds.com). Unknown to the participants, each set contained 4 "pass" scenarios, 3 "fail" scenarios, and 3 "retest" scenarios. Participants were randomized to use either the paper flowchart or the computer-based tool for the first set of 10 scenarios; each participant then used the alternative method for the second set. When using the paper flowchart, participants received a copy of the flowchart to consult while considering each scenario. When using the computer-based tool (**Appendix 2**; available at www.jpeds.com), participants were asked to input the relevant data into the online tool and then to press a button to submit the data. The computer program then used the algorithm to interpret the submitted data and display the recommended interpretation. After completing the 20 scenarios, participants were asked to give their opinions about the ease of use of the 2 options using a Likert scale (1 = very easy, 2 = easy, 3 = difficult, 4 = very difficult), their likelihood to use a computer option if offered, and their preference for which option to use in practice. Because this was a quality improvement project without the collection of any protected health information, this study was not reviewed by the institutional review board.