

Modification of Critical Congenital Heart Disease Screening Practices at Moderate Altitude

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CCHD Newborn Screening at Altitude

- Challenges of Pulse Oximetry Screening at Altitude
- Delayed Transition in infants born at Altitude
- Expected 4-5% infants to fail CCHD newborn screening

Feasibility of Critical Congenital Heart Disease Newborn Screening at Moderate Altitude

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KEY WORDS

pulse oximetry, critical congenital heart disease, altitude, neonate, infant, screening

ABBREVIATIONS

AAP—American Academy of Pediatrics
CCHD—critical congenital heart disease

Dr Wright conceptualized and designed the study, coordinated and supervised data collection and data entry, and drafted the initial manuscript; Dr Kohn organized and helped coordinate nursery participation and participated in data collection; Dr Nierneyer was the secondary mentor on the project, helped design the data collection instruments and logistics of data acquisition, and critically reviewed the manuscript; Dr Rauch was the primary mentor on the project and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: The American Academy of Pediatrics (AAP) and other organizations have recommended critical congenital heart disease (CCHD) pulse oximetry screening. Small studies have revealed lower saturations at higher altitude, but this effect on CCHD screening is unknown. The AAP requested additional studies at altitude to help clarify the dilemma.



WHAT THIS STUDY ADDS: The AAP has endorsed higher-altitude studies of CCHD screening. This observational prospective study revealed a higher positive screen rate at moderate altitude than at sea level. These findings suggest that current national recommendations may result in increased screening failures at moderate altitude.

abstract

BACKGROUND AND OBJECTIVE: Consensus guidelines have recommended newborn pulse oximetry screening for critical congenital heart disease (CCHD). Given that newborn oxygen saturations are generally lower at higher altitudes, the American Academy of Pediatrics and others recommend additional evaluation of the screening algorithm at altitude. Our objective was to evaluate the feasibility of newborn pulse-oximetry CCHD screening at moderate altitude (Aurora, CO; 1694 m). We hypothesized the overall failure rate would be significantly higher compared with published controls.

METHODS: We enrolled 1003 consecutive infants at ≥ 35 weeks' gestation in a prospective observational study. The nationally recommended protocol for CCHD screening was adhered to with the exceptions of no reflex echocardiograms being performed and providers being informed of results only if saturations were less than predefined critical values.

RESULTS: There were 1003 infants enrolled, and 998 completed the screen. The overall failure rate for completed screenings was 1.7% (95% confidence interval: 0.6%–2.0%). The first 500 infants had 1.8% fail, and the last 503 infants had 0.6% fail. Among infants who failed screening, 73% failed secondary to saturations $< 90\%$, whereas saturations between 90% and 94%, persistently $> 3\%$ difference, and multiple criteria were each responsible for 9% of failures. Overall, 1.8% of all infants had incomplete screening and had not passed at the time the test was stopped.

CONCLUSIONS: Pulse oximetry screening failure rates at moderate altitude are significantly higher than at sea level. Larger studies with alternative algorithms are warranted at moderate altitudes. Pediatrics 2014;133:e561–e569

- Implemented sea-level protocol at moderate altitude of 5557 feet (1694 m)
- Proportion of infants failing: 1.1%
 - First 500 infants: 8 of 500 (1.6%) failed
 - with 18 of 500 (3.6%) either failing or having incomplete screening.
 - Last 503 infants: 3 of 503 infants (0.6%) failed
 - 9 of 503 (1.8%) either failed or had incomplete screening.

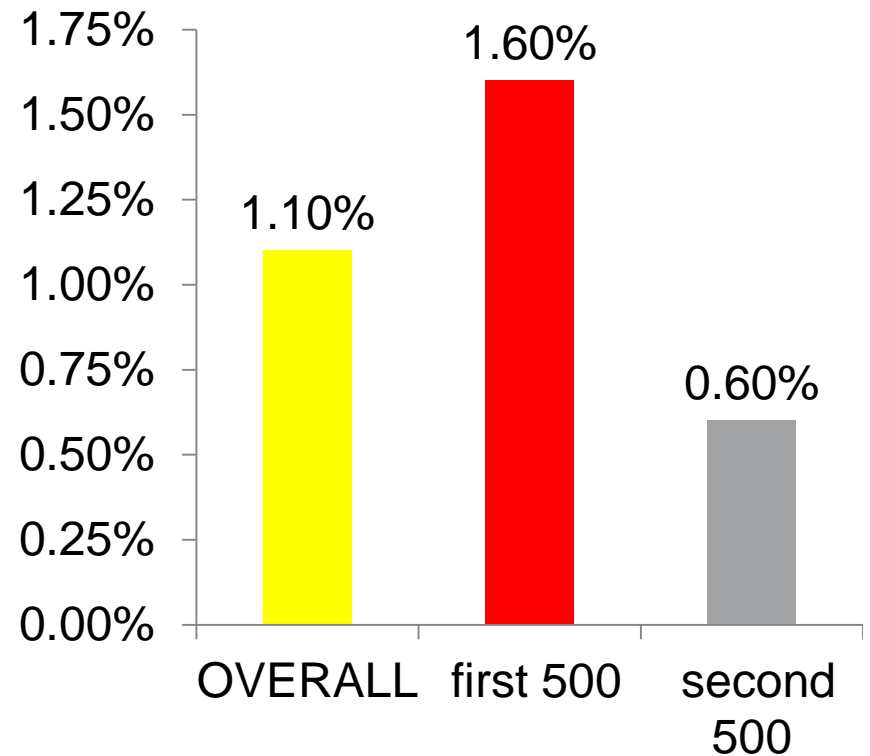
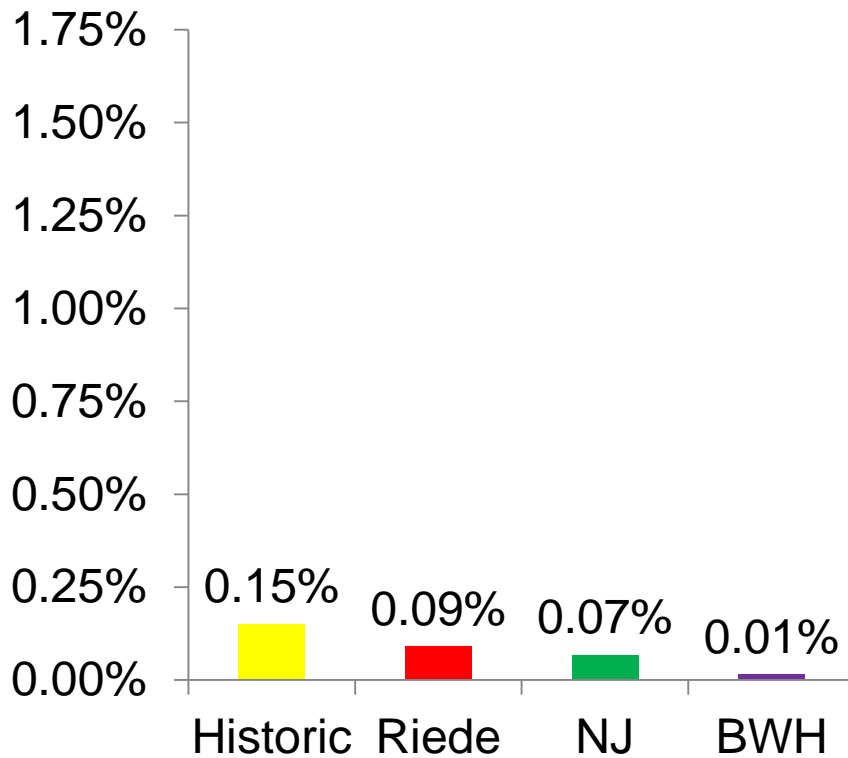
Experience at Highest Altitudes in Colorado

- Vail Valley Medical Center at 8,100 feet elevation
- Participation in a multi-site national study
- Preliminary data showing an over 30% false positive screen rate on well newborns.
- All the positive screens had negative cardiac echocardiograms (no CCHDs detected)

Colorado CCHD Newborn Screening Status

- Recommendations are dependent upon altitude:
 - Proportion failing pulse oximetry screening is greater than sea-level
 - *Tolerable (<1%) at hospitals <7000 feet*
 - *Not tolerable (>30%) >8,000 feet*
 - *Not enough data in hospitals between 7,000 and 8,000 feet*
- Colorado is moving forward with CCHD newborn screening with staggered recommendations based on altitude

What can we do to decrease the percent of false positives?



Thangaratinam, et al *Lancet* 2012.

Riede et al *Eur.J.Pediatr.* 2010.

Garg, et al *Pediatrics* 2013.

Johnson, et al *Pediatrics*, 2014.

Implementation of CCHD Screening

- University of Colorado Hospital
- Following the feasibility study, CCHD screening was implemented as standard of care (9/2012)



Modifications to the protocol based on Hospital Practices

- Newborns screened at 24 hours during standard '24-hour makeover'
- Standard protocol and cutoffs used (Kemper 2012)
- Newborns who failed the screen
 - Careful observation
 - Ordered echocardiogram
 - Repeated pulse oximetry every 4 hours
 - *They have a passing pulse ox valu*
 - *They have an ECHO performed*

Adjustments to AAP/Kemper protocol

- Fail: Pulse Ox ≤ 84 in either preductal or postductal limb
- Pass: Pulse Ox ≥ 95 in either limb and a difference between limbs ≤ 3
- Re-Screen:
 - $85 \leq (\text{Pulse Ox for both limbs}) < 95$
 - Difference between limbs ≥ 4

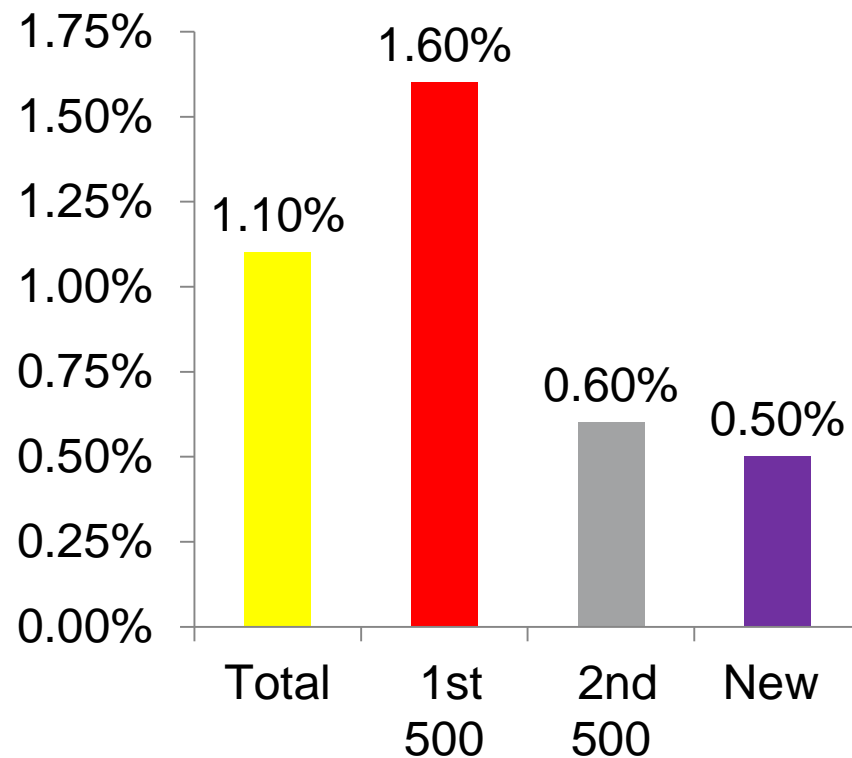
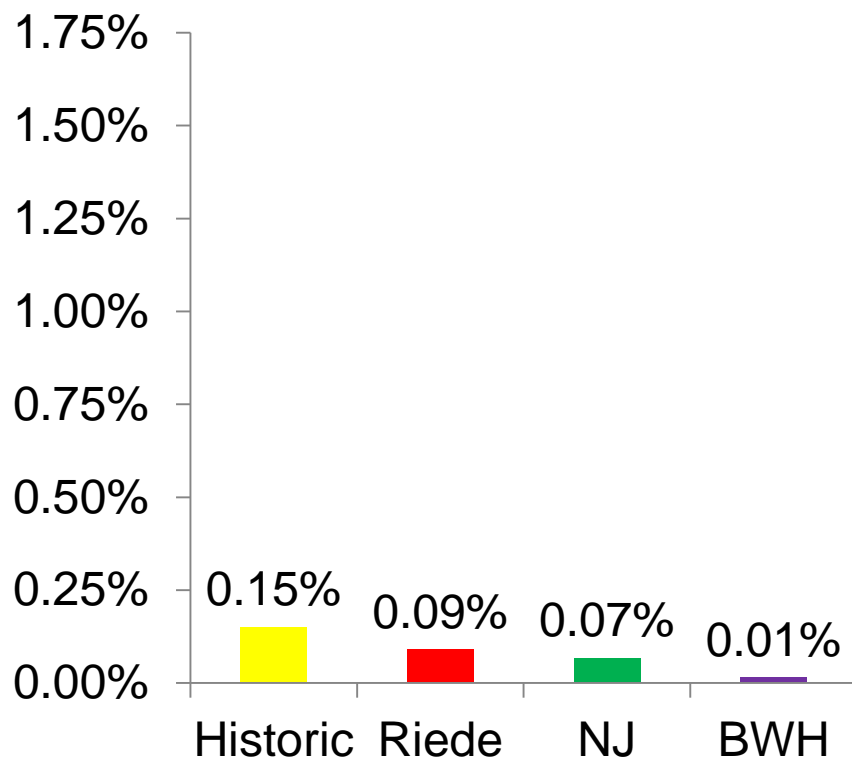
Demographics

Total Infants	2383
Male gender	1107 (50.9%)
Gestational Age	39 weeks (IQR 38-40 weeks)
Birth weight (mean)	3253 grams (std dev 470 grams)

Screening results

- Using the modified Colorado approach the overall failure rate is $2/2383 = 0.503\%$ Incomplete rate would be: $(55+5)/2383 = 2.52\%$
- Non-passing values by the end of the 3rd screen
 - Echos completed: 5 (0.21% of the study population)
 - Remaining infants had repeat pulse oximetry
- Implementing AAP/Kemper Protocol: 29/2383 (1.22%)

False positives are improving



Thangaratinam, et al *Lancet* 2012.

Riede et al *Eur.J.Pediatr.* 2010.

Garg, et al *Pediatrics* 2013.

Johnson, et al *Pediatrics*, 2014.

Other hospitals, other approaches

- Modifications vary throughout hospitals, implementing under standard of care
 - Later screening (30-36 hours)
 - Oxygen hood to simulate sea level oxygen
- Current mechanisms to compare outcomes are lacking
- Mandate for screening and data collection will lead to ability to compare data and refine algorithms.

CCHD Screening at Altitude

- Modified CCHD algorithm may decrease the false positive CCHD screening results
- Additional modifications to the high altitude algorithm are needed
- Screening at moderate altitude is possible, however additional modifications may be needed.

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