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Car Seat Safety for Preterm Neonates: Implementation and Testing Parameters of the Infant Car Seat Challenge

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Abstract

Background—The American Academy of Pediatrics (AAP) recommends that all preterm neonates undergo a period of observation in a car safety seat before discharge, known as the Infant Car Seat Challenge (ICSC), to monitor for respiratory immaturity and the risk of adverse cardiopulmonary events in the upright position. However, no universal guidelines exist to define appropriate cutoffs for failure of the ICSC. We sought to evaluate regional neonatal intensive care unit (NICU) implementation of the ICSC and to evaluate variation in failure criteria.

Methods—We contacted level II and III nurseries/NICUs in New York/New England (n = 119) to determine if each performed ICSCs, their inclusion criteria, duration of testing, and failure criteria.

Results—We contacted 119 institutions and had an 87% response rate (n = 103). Of the institutions that responded, 89% (n = 89) perform ICSCs. Of these 89 with current protocols, 17% did not follow AAP guidelines to test all neonates born <37 weeks' gestation, and 45% did not follow guidelines for test duration. Despite wide variation, most units use thresholds for bradycardia of <80 bpm and desaturation of <90% to determine failure.

Conclusions—Despite AAP guidelines, implementation of ICSCs for preterm neonates is not universal in the region studied. Variation in definition of ICSC failure means that neonates are receiving differential care, not on the basis of their clinical characteristics, but on which institution performs the test. We propose standardizing the test to all infants born at <37 weeks' gestation to a duration of at least 90 minutes, along with a failure threshold for bradycardia of <80 bpm for >10 seconds, and for saturation <90% for >10 seconds.

Keywords

car seat testing; Infant Car Seat Challenge; premature infants

According to the National Highway Traffic Safety Administration (NHTSA), the proper use of child safety seats is 71% effective in reducing the risk of infant death.¹ Because of this,

the American Academy of Pediatrics (AAP) Committee on Injury and Poison Prevention began recommending universal use of car safety seats for all infants in 1974 and subsequently formalized this recommendation as an AAP policy.²⁻⁵ In the mid-1980s, researchers began to note that preterm neonates were having positional problems while in their car safety seats, leading to significant desaturation events.⁶⁻⁸ The AAP therefore began recommending that all preterm and at-risk newborns be observed for a period of time in their car safety seat before discharge to monitor for episodes of apnea, brady-cardia, and oxygen desaturation.³⁻⁵ This observation period is known as the Infant Car Seat Challenge (ICSC), and its primary purpose is to identify those infants that will have cardiorespiratory problems when placed in their upright car seats.

Since the AAP made their initial formal recommendation to perform ICSC testing in the early 1990s, it has become a routine predischARGE screening procedure for preterm infants in the United States.³⁻⁵ The most recent guidelines from 2009 recommend screening all infants born at <37 weeks' gestation for a period of 90 to 120 minutes or the duration of the car ride home, whichever is longer.⁹ In the United States, up to 500,000 infants qualify for some form of ICSC annually.¹⁰ Despite these recommendations, implementation is not universal in neonatal intensive care units (NICUs) or in nurseries that care for late preterm infants. The most recent attempt to evaluate implementation practices showed that only 91% and 81% of level II and III NICUs, respectively, and as few as 22% of level I well-baby nurseries were performing a predischARGE ICSC on preterm infants as of 2003.¹¹

There are no universal parameters to define ICSC failure. Besides the inclusion criterion of preterm birth and the testing duration, there are no other formal guidelines for performance of this test. Each individual institution is left to determine its own definition of a significant bradycardia or desaturation event that constitutes a failure. And despite its widespread implementation, the validity of the ICSC to fulfill its intended purpose of identifying infants at risk for adverse cardiopulmonary events when in the semiupright position in a car safety seat has never been proven. Validation of the ICSC will require prospective investigation, but the absence of national or even regional standardization of ICSC testing leads to variability in interpretation and implementation, making investigations of this test difficult. Consensus regarding specific aspects of testing would allow decreased arbitrary assignment of failure criteria and increased generalizability of the outcomes of studies of ICSC testing.

The primary aim of this survey was to characterize ICSC testing practices and to identify which testing factors demonstrated relative consensus across NICUs in New England and New York. We hypothesized that the majority of centers would include desaturations less than 90% as the primary failure criterion.

Methods

We identified all existing level II and III NICUs in New England (including Connecticut, Maine, New Hampshire, Rhode Island, and Massachusetts) and New York using the 2011 AAP Section on Perinatal Pediatrics Directory of Newborn Intensive Care Units. Because there is very little information available on ICSC practices in the United States in general, we chose to focus on a narrow geographic area to assess regional agreement in testing

parameters. We focused on level II and III nurseries because the literature has shown that greatest number of ICSC are performed at these nurseries and they may be more likely to have current ICSC protocols.¹¹ We identified a total of 119 institutions. Each institution was contacted via e-mail or phone to determine whether they had a standard ICSC policy. We spoke with a charge nurse, nurse practitioner, and/or physician familiar with each institution's ICSC policy. NICUs with written ICSC policies were asked to e-mail or fax the policy. Lack of receipt of policies within a 2-week time period prompted reminder calls or e-mails every 2 weeks for a maximum of 4 attempts. NICUs without written policies were asked to provide a detailed verbal description, and this description was verified through follow-up phone verification with a nurse, nurse practitioner, and/or physician familiar with the policy.

We then categorized available ICSC policies on the basis of the inclusion criteria for testing (gestational age, weight) and duration of the test. We also identified failure criteria, including bradycardia and occurrence of oxygen desaturation.

Descriptive statistics were used to evaluate NICU characteristics and each of the testing variables and failure criteria. Data are reported as frequency (range).

Results

The survey was conducted between December 2011 and May 2012. Of the 119 qualifying institutions, 103 (87%) responded to our requests for information about their ICSC policy. Of the 103 responding institutions, 11 (11% of respondents) did not perform ICSC testing. This included 4 level II units (14% of level II units that responded) and 7 level III units (9% of level III units that responded). We found that 3 sites performed ICSCs but were in the process of updating their policy and did not have current information to release, and the remaining 89 institutions did perform predischarge ICSC testing and had a current protocol. In order to identify current testing parameters, we evaluated the protocols of these 89 institutions.

Inclusion Criteria: Gestational Age

Of the 89 institutions with an available policy, the majority (83%) followed the AAP guidelines, which recommend testing all infants born at <37 weeks' gestation. However, the remaining 17% used a range of birth gestational ages from <32 weeks to <36 weeks (Figure 1).

Inclusion Criteria: Birth Weight

AAP guidelines do not currently recommend birth weight as an inclusion criterion for screening, but a number of institutions were found to include this in their individual ICSC policies. We were therefore interested in determining how commonly this was implemented. A majority of the 89 institutions with a current policy (51%) either did not use birth weight as a criterion for testing or did not include it in their policy/protocol. Only 45% of these NICUs (n = 40) specifically tested low birth weight (LBW) infants who were born weighing <2500 g, while the remaining 4% used a lower birth weight cutoff, ranging from <1500 to <2300 g.

Testing Duration

AAP guidelines recommend the ICSC last for 90 to 120 minutes or the duration of car ride home, whichever is longer. Of the 89 institutions with current ICSC policies, only 55% (n = 49) had tests that lasted a minimum of 90 minutes, consistent with the AAP guidelines (Figure 2). Thirty-one percent of institutions tested for 60 to 89 minutes (n = 28), 6% tested for 30 to 59 minutes (n = 5), and 2% tested for <30 minutes (n = 2). Five institutions (6%) tested for only the duration of the car ride home.

Failure Criteria: Bradycardia

The definition of bradycardia that was significant enough to constitute a failure of the ICSC varied widely among the 89 institutions. Most (70%) used a heart rate of less than 80 bpm, but the values used ranged from <75 to <120 bpm (Figure 3). Of those that used <80 bpm as their criterion for failure, the duration of time that qualified as a failure ranged widely from no minimum duration to a minimum duration of 60 seconds. Only 3 of the policies made no mention of using bradycardia in their determination of failure of the ICSC.

Failure Criteria: Oxygen Desaturation

Saturation thresholds to determine failure of the ICSC were the least consistent across the 89 NICUs. Failure saturations used at the institutions ranged from <80% to <93% (Figure 4). The most commonly cited threshold was <90%, which was used by over a third (37%) of the NICUs that performed ICSCs. The next most commonly used thresholds were <88% (21% of NICUs), <85% (12% of NICUs), and <92% (10% of NICUs). Similar to the bradycardia criteria, the minimum duration for a desaturation to result in failure ranged from no minimum duration to >60 seconds.

Discussion

Our survey assessed adherence to AAP guidelines for ICSC testing and attempted to identify consensus eligibility and failure criteria among level II and III NICUs in New England and New York. Our high survey response rate (87%) ensured excellent representation of the region, and we were able to identify a number of key issues related to ICSC testing. First, a large number of NICUs do not adhere to current AAP guidelines either by not performing ICSC testing, by having more restrictive interpretation of eligibility criteria, or by having an inadequate testing duration. Among the NICUs that do perform ICSC testing, we found no consensus on criteria for failure.

We found that of the 103 NICUs that responded, 89% did perform some form of a predischARGE ICSC and 11% did not. Very little comparison information is available about implementation of the ICSC. A small study from 2003 looked at NICUs randomly selected from across the nation and found an 84% compliance rate for level II and III NICUs with performing any ICSC.¹¹ Since that article was published, the additional guidelines from the AAP were released on duration of testing, which may have affected ICSC testing at different sites. But overall, there does not seem to be a dramatic change in the number of NICUs that perform the test, despite continued AAP recommendations.

The AAP based their initial recommendations regarding which infants qualify for ICSCs on several small studies from the 1980s that indicated that preterm infants were at risk for desaturation events while in a car safety seat.⁶⁻⁸ Since that time, NICU care has changed dramatically, and as a result, the epidemiology and characteristics of resulting lung disease and respiratory fragility have also changed.¹² Despite these changes, the gestational age ICSC screening criterion has not changed since the initial guidelines were published in 1991.³ We found that 83% of institutions in New England/New York that had current ICSC policies complied with these AAP guidelines to test all infants born at less than 37 weeks' gestation. Among the 17% of institutions that lowered the gestational age threshold for testing, it is likely that a lack of resources was the primary factor for limiting the screening guidelines to more premature infants. Studies focused on late preterm infants suggest that this population is still at substantial risk of desaturation when placed upright in the car seat, so reallocation of resources to ensure the testing of appropriate populations may be warranted.^{13,14}

Although it is not in the official AAP recommendations, we were interested in assessing whether NICUs included LBW screening guidelines in their policies. Although the idea to include LBW infants in ICSC screening is more recent, the original articles that formed the basis for the AAP recommendations from the 1980s speculated that the mismatch of preterm infant size with the available car seats intended for full-term infants was a major contributor to respiratory fragility.⁸ The NHTSA developed the National Standardized Child Passenger Safety Training Curriculum in the mid-1990s to help train child passenger safety technicians (CPSTs) to ensure proper fit and positioning of infants in their car seats. The AAP, National Standardized Child Passenger Safety Training Curriculum, and the CPSTs all emphasize the importance of properly sized seat selection and proper fit assessment as a part of any ICSC protocol. Interestingly, a majority (51%) of NICUs did not use birth weight as an inclusion criterion for testing. Future epidemiologic studies will need to identify whether weight needs to be included as a screening criterion, or whether there can be refinement of gestational age or birth weight criteria to allow more selective testing.

Of all testing criteria, test duration is one of the few variables for which the AAP has provided explicitly detailed guidelines. The most recent guidelines from 2009 suggest a specific duration of 90 to 120 minutes or the duration of car ride home, whichever is longer.⁹ Increasing length of time in the car seat position has been associated with decreased saturations.^{13,15} In one study looking at ICSCs lasting 120 minutes, the proportion of infants whose first event occurred after 60 minutes of observation was 40%, and after 90 minutes of observation was 30%.¹⁵ A shorter testing duration may therefore miss episodes of desaturation or bradycardia. Our findings that over 40% of NICUs are not following the guideline of a minimum of 90 minutes suggests that if the ICSC does in fact detect significant desaturations, current testing protocols may be missing at-risk infants. In addition, many infants spend time in the upright position throughout the day when not in an automobile. The AAP recommends that car safety seats should only be used for travel and that infants at risk for apnea, desaturation, and bradycardia in their car seat should avoid other upright devices. Despite this recommendation, many infants are often left to sleep in the semiupright position in car seats, bouncy chairs, and other infant carriers. The risk for cardiorespiratory events may therefore not be specific to automobile travel, but it may be

generalizable to any time spent in the semiupright position, which is an important topic for future research.

There is no consensus regarding the definition of clinically significant bradycardia or saturation thresholds for neonatal inpatients or outpatients, making the determination of what might be considered an abnormal saturation during the ICSC challenging. The Canadian Pediatric Society position statement from 2000, which was reaffirmed in 2012, recommends defining significant cardiorespiratory abnormalities in the ICSC as 2 or more episodes of oxygen desaturation (less than 88%) for 10 seconds or more during a 90-minute monitoring period.¹⁶ Obtaining consensus in the United States has been more difficult. In 2010, Bass noted a wide range of failure saturation cutoffs in the ICSC literature, from values as low as 85% to as high as 95%.¹⁷ It is therefore not surprising that we noted wide variability in heart rate and saturation thresholds for failure of the ICSC in our surveyed NICUs. Still, several consistent trends emerged. Over 70% of the surveyed NICUs use the threshold of 80 bpm to define bradycardia in the ICSC. Consensus on the saturation threshold was more elusive. The most common saturation threshold (<90%) was used by less than half of the NICUs. There was even less consensus surrounding the minimum duration of a bradycardia or desaturation event that each institution defined as clinically significant. Again, the lack of current understanding of what is a minimum “safe” saturation or a “safe” duration of desaturation makes identifying appropriate parameters very difficult.

Strengths and Limitations

Our survey response rate (87%) ensured excellent representation from the majority of level II and III NICUs in New England and New York. This is the only study we know of to date that evaluates ICSC implementation and testing parameters since the most recent AAP guidelines were released in 2009. Because there is very little information available on ICSC practices in the United States in general, we chose to focus on a narrow geographic area to assess regional agreement in testing parameters. There is wide variation between NICUs in this narrow region, though this may not be generalizable across the nation. We recognize that regional differences may also play a role in determining failure criteria, specifically for desaturation criteria. A limitation is that our data are based on protocols and surveys of individual NICUs, not on direct observation. We cannot account for what degree of protocol variation occurs at each institution. We also chose to focus on level II and III NICUs because prior studies have shown that the greatest number of ICSCs are being done in these 2 areas.¹¹ Late preterm infants are being delivered at level I nurseries as well, so this information may not reflect the practices of level I units. Future studies looking at all nursery levels would be useful to further define practices.

ICSC Policy Implications

Although on the basis of our cohort of institutions there does not appear to be universal implementation in level II and III NICUs, the ICSC is still one of the most commonly performed tests on premature neonates in the United States. Consensus on the definition of a failure is lacking, even between NICUs in one defined region of the country (New England/New York). The same neonate may have very different clinical care based solely on which NICU performs the test. Because of the wide variation, the same neonate who may

fail at one institution and either have a prolonged length of stay or be retested in a car bed would pass at a neighboring institution and go home in a car seat. It is difficult to assess the validity of the ICSC when the actual testing parameters vary widely, and the outcomes therefore are not generalizable from institution to institution.

Agreement among experts in the fields of newborn medicine and pulmonology is of the utmost importance when determining what saturation level is safe and acceptable. It is difficult to identify the optimal parameters for ICSC failure when we still have limited data on what a clinically significant desaturation is in a neonate. Several recent studies have attempted to identify appropriate target oxygen saturation ranges. One study looked at former preterm infants with bronchopulmonary dysplasia who had oxygen saturations of 88% to 91% for >1 hour during sleep and showed that they had poorer growth velocity than those whose sleeping saturations remained >92%.¹⁸ More recently, the Surfactant, Positive Pressure, and Oxygenation Randomized Trial (SUPPORT) found that infants randomized to maintain lower saturation ranges (85% to 89%) had increased risk of in-hospital death than those kept in a higher saturation range (91% to 95%).¹⁹

Identifying the ideal parameters for failure is extremely difficult, so we recommend starting with a more practical approach. The most commonly used criterion for brady-cardia was <80 bpm; therefore, this seems to be the most agreed-upon standard in the majority of NICUs. Though current data are limited, they seem to indicate that infants who have saturations maintained at a minimum in the low 90s have better growth velocity and decreased risk of in-hospital death.^{18,19} We found that the most commonly used desaturation level in our cohort of NICUs was <90%, perhaps based on this information. We think that this is an appropriate saturation level to use as a starting point for standardizing the ICSC. Identifying a significant duration is also challenging. However, we think that defining a desaturation or bradycardia as lasting >10 seconds would minimize the likelihood that this is the result of an artifact but would still identify sustained events. The Canadian Pediatric Society uses 10 seconds to define one event, so there is a precedent for this duration.¹⁶ This level is also one of the most commonly used by NICUs in their protocols, so would be a practical approach as well. We recognize that the use of commonly applied criteria as a starting point has its weaknesses. However, the better alternative, which is criteria based on scientific evidence, does not yet exist.

A major barrier to the standardization of testing is a lack of evidence available to inform clinicians on which criteria allow the ICSC function as intended: to predict subsequent respiratory physiology in the upright position. Because of this lack of evidence, guidance from leaders in the fields of newborn medicine and pulmonology is necessary to allow proper evaluation of the ICSC. Our study provides some baseline information to help form potential consensus guidelines. Standardization of testing criteria will allow more collaboration across different NICUs and will allow more generalizability of testing results and assessment of later outcomes of ICSC failure. We propose a standardized ICSC that incorporates (1) testing infants born at <37 weeks' gestation, (2) ICSC duration of at least 90 to 120 minutes or the duration of the car ride home, whichever is longer, (3) bradycardia failure thresholds of 80 bpm for >10 seconds, and (4) saturation failure threshold of <90% for >10 seconds will be the most generalizable, at least in New England and New York.

Further research is necessary to help refine these recommendations in order to identify the safest parameters for our neonates. We hope that by standardizing these guidelines, future studies can be performed to determine the utility of the ICSC in predicting adverse cardiopulmonary outcomes in at-risk neonates in their car safety seats.

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What's New

This is the largest study to date looking at implementation of the Infant Car Seat Challenge and highlighting the wide variation in testing parameters. We recommend universal parameters for testing to help improve generalizability of this test between nurseries.

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Figure 1.
Infant Car Seat Challenge birth gestational age criteria.

Figure 2.
Infant Car Seat Challenge duration.

Figure 3.
Infant Car Seat Challenge bradycardia failure criteria.

Figure 4.
Infant Car Seat Challenge desaturation failure criteria.