Assessment of cardiorespiratory stability using the infant car seat challenge before discharge in preterm infants (<37 weeks' gestational age)

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Preterm infants younger than 37 weeks corrected gestational age are at increased risk for abnormal control of respiration. The infant car seat challenge has been used as a screening tool to ensure cardiorespiratory stability before discharging preterm infants from many hospitals in Canada. While it is clear that infants placed in a car seat are more likely to experience oxygen desaturation and/or bradycardia than when they are supine, neither positioning predicts an adverse neurodevelopmental outcome or mortality post-discharge. A review of the literature yielded insufficient evidence to recommend routine use of the infant car seat challenge as part of discharge planning for preterm infants. This finding has prompted a change in recommendation from a previous Canadian Paediatric Society position statement published in 2000.

Key Words: Apnea; Bradycardia; Desaturation; ICSC; Neonate; PSG

Infants must always be placed in an approved infant car seat when travelling in a motor vehicle. The American Academy of Pediatrics has recommended screening all preterm infants using the infant car seat challenge test (ICSC), preferably in their own car seat, for 90 minutes to 120 minutes, to assess the risk for desaturation, apnea or bradycardia while positioned in situ.⁽¹⁾ The Canadian Paediatric Society (CPS) stopped short of recommending routine use of the ICSC in a position statement released in 2000,⁽²⁾ but acknowledged that the practice of screening before discharge was becoming more common for babies born at <37 weeks' gestational age (GA). Fifteen years later, a wide variation in practices related to infant car seat testing persists in Canada. (Personal communications) The purpose of the present statement, which updates the previous CPS document, is to review the literature and provide guidance for performing the ICSC screen. Regardless of unit practice with regard to the ICSC, parents should be counselled appropriately on safe car seat use at time of discharge, irrespective of their infant's GA.

METHOD OF SEARCHING THE LITERATURE

For this review, articles from Medline, Embase, CINAHL and the Cochrane Library were screened using the key words "car seat", "infant seat", "car bed", or "car safety seat" and "infant or child", "paediatr or pediater", "baby or babies" or "neonate". All articles were limited to the English language, with no date limit being set.

The hierarchy of evidence from the Centre for Evidence-Based Medicine was applied to the publications identified (Table 1).⁽³⁾ Recommendations are based on the format by Shekelle et al (Table 2).⁽⁴⁾

L'évaluation de la stabilité cardiorespiratoire au moyen du test du siège d'auto avant le congé des nourrissons prématurés (de moins de 37 semaines d'âge gestationnel)

Les nourrissons prématurés de moins de 37 semaines d'âge postconceptionnel sont plus à risque de présenter un contrôle anormal de leur respiration. Dans de nombreux hôpitaux du Canada, le test du siège d'auto est utilisé comme outil de dépistage pour garantir la stabilité cardiorespiratoire des nourrissons prématurés avant leur congé. Il est évident que les nourrissons installés dans un siège d'auto sont plus susceptibles de souffrir de désaturation en oxygène ou de bradycardie qu'en décubitus dorsal, mais aucune de ces deux positions ne permet de prédire une évolution neurodéveloppementale défavorable ou un décès après le congé. Une analyse bibliographique n'a pas permis de colliger assez de données probantes pour recommander l'utilisation systématique du test du siège d'auto chez les nourrissons prématurés dans le cadre de leur plan de congé. En raison de cette observation, les recommandations qu'a publiées la Société canadienne de pédiatrie dans un document de principes en 2000 sont modifiées.

WHAT IS THE HISTORICAL BASIS FOR PERFORMING AN ICSC?

The AAP first recommended that all infants be transported in rear-facing car seats in 1974, then formalized this recommendation as policy in 1990.⁽⁵⁾ The CPS issued a similar recommendation in 2008.⁽⁶⁾ It has been 30 years since one study determined that such seats could be appropriately used for preterm infants weighing between 1.8 kg and 2.3 kg (or 4 lbs to 5 lbs), with some designs being better than others for smaller infants.⁽⁷⁾ A 1986 study questioned whether preterm infants could safely tolerate such positioning.⁽⁸⁾ They compared 12 preterm infants with a history of apnea treated with methylxanthines (group one) with eight preterm infants with no history of apnea (group two) and 10 term infants (group three) during a 30-minute ICSC. The percentage of time with desaturation of <85% was higher in group one (18.1%) than in either group two (10.7%) or group three (1.7%). Also, five of the 20 preterm infants studied experienced bradycardia (a heart rate of <80 beats per minute [bpm] for ≥4 seconds) compared with none in the term cohort. This study was repeated in 1989 using a larger sample of 62 patients and confirmed the tendency for preterm infants to experience oxygen desaturation in a car seat. Interestingly, the percentage of infants with an abnormal ICSC result was half that of the previous study (60% versus 30%). This finding may have reflected milder forms of chronic lung disease (CLD) in the second group studied because some of the infants in the second study had also participated in surfactant trials.⁽⁹⁾ These studies prompted the AAP to recommend that the ICSC should be performed in all infants <37 weeks' GA before discharge

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from the hospital.(5) While not specifically recommending ICSC testing, the CPS acknowledged the growing trend.(2)

An ICSC is performed by placing an infant in a car seat for a period of 90 minutes to 120 minutes and monitoring for oxygen desaturation and/or bradycardic events. The criteria for “failure” during such testing have varied but usually include one or more instance of oxygen desaturation to <85% to 90%, bradycardia <80 bpm or apnea (cessation of respiration) for >20 seconds. Preterm infants, especially those born at 24 weeks’ to 28 weeks’ GA, have been shown to experience persistent periodic breathing and apnea until several weeks after term corrected GA and for longer when CLD is present.(10,11) These findings suggested that the tendency toward irregular respiration in infants this young could be exacerbated when they were placed in a semi-upright position.

Later studies examining both preterm and term infants clearly demonstrated that the former population are at much higher risk for oxygen desaturation and/or bradycardic events when they are placed in a semi-upright position.(12,13) This finding cannot be explained by deterioration in pulmonary function. Willett et al studied 50 infants, comparing pulmonary function in car seats with a baseline established in the supine position. On average, lung compliance improved by 19%, resistance decreased by 33% and the work of breathing was reduced by 31% when an infant was placed in a car seat versus a supine position. Also, airway obstruction was not found to contribute to breathing difficulty.(9) These findings were contrary to what had been expected, which leaves the etiology of cardiorespiratory instability in the semi-upright position unknown.

WHAT IS THE EVIDENCE LINKING ADVERSE OUTCOMES WITH PLACEMENT IN CAR SEATS?

Infants, whether term or preterm, should not be left in car seats used as sitting devices when not being transported. Such practice was revealed to be associated with infant deaths from asphyxiation in a review of 30 autopsy findings from Australia. Two deaths from slippage and resultant strangulation in car seats equipped with three-point restraint systems were also found.(14) Another study described four infant deaths in car seats between 1996 and 2011. These deaths occurred in a moving vehicle and a cardiac or pulmonary malformation was found to exist in each case. In most of the other 10 cases under study, car seats were being used inappropriately outside of a moving vehicle; in one case the infant died while left unattended.(15) One Canadian study identified 17 deaths over a 10-year period that occurred while infants were in a car seat. Of these, seven were explained by comorbid conditions. Of the other 10 unexplained cases, only three occurred in a moving vehicle and only one death was in a preterm infant.(16) Taken altogether, reports of infant deaths in car seats during travel are exceedingly low, with only one known case occurring in a (former) preterm infant. When cases with a cardiopulmonary malformation are excluded, it is clear that in almost all cases of reported deaths in a car seat, the child was left in their seat for purposes other than travel. This practice should be strongly discouraged.

A paucity of data links adverse neurodevelopmental outcome in preterm infants with hypoxemia experienced in car seats. One 2004 study reviewed the evidence from 55 eligible articles linking adverse neurodevelopmental outcome with chronic or intermittent hypoxia.(17) The vast majority of articles (76.4%) pertained to children who had either congenital heart disease or sleep-disordered breathing. Of note, preterm infants who experienced chronic or intermittent hypoxia were one group that did not have an increased risk for adverse neurodevelopment.

While not specific to car seat testing, a follow-up study of 118 preterm infants from the Collaborative Home Infant Monitoring

Evaluation (CHIME) study post-discharge, demonstrated a mean reduction in the mental developmental index (MDI) of 4.6 in infants with ≥ 5 recorded desaturation or bradycardic events over the duration of monitoring, compared with infants who experienced no such events.(18) However, when comparing infants with ≥ 5 events with the rest of the cohort – who experienced ≤ 4 events – there was no difference in MDI scores. It is tempting to consider the group with ≥ 5 events as a ‘proxy’ for infants with a failed ICSC, because these same infants were apparently discharged as ‘event-free’. However, the study was hampered by poor follow-up rates, with only 27% of the original cohort being accessible post-discharge and having sufficient hours of monitoring available for analysis. Also, the reduction in MDI is statistically but not clinically significant. Furthermore, there is no indication that the ICSC test would have effectively screened these infants for detectable events, which could occur quite remotely from discharge due to the mean duration of monitoring being nearly two months. Finally, because follow-up was only reported at one year, it is possible that longer term follow-up would have demonstrated a degree of ‘catch-up’, as has been found in other studies when school age performance is assessed. Although it is clear that preterm infants are at higher risk for oxygen desaturation when seated in car seats, there are insufficient data to support an association with future adverse neurodevelopment.

WHO IS AT RISK OF “FAILING” THE ICSC, AND HOW RELIABLE IS THE TEST?

The effect of GA on the probability of experiencing a cardiorespiratory event during an ICSC test is unclear. While one study suggested that infants at the lowest GA are at higher risk of apnea and oxygen desaturation when placed in a car seat, another larger study indicated that late preterm infants (34^{0/7} weeks’ GA to 36^{6/7} weeks’ GA) are at highest risk. Davis et al retrospectively reviewed ICSC results from 1173 preterm infants and identified a failure rate of 4.3%.(19) In contrast to previous reports, the failures clustered in the group of late preterm infants, representing 78% of all failures. Conversely, those infants who ‘passed’ were more likely to have been born at a younger GA, to have been treated previously with caffeine, and to have received respiratory support.

DeGrazia studied 49 preterm infants (<34 weeks’ GA) who had been tested twice, 12 h and 36 hours apart, for up to 90 minutes per test.(20) In 86% of the ICSCs performed, the results were congruent, with infants either passing or failing the test on both occasions. In 8% of cases, an infant passed the first test and failed the second, within a mean time of 17 h between tests. In a second study in 2014, 60 preterm infants born between 30^{0/7} weeks’ GA to 36^{6/7} weeks’ GA were studied at a minimum corrected GA of 35^{0/7} weeks using three consecutive ICSCs, conducted every 24 h to 48 h.(21) In this study, 11% of infants that passed a first test failed one of the two subsequent tests. These studies cast significant doubt as to the reliability and reproducibility of the ICSC. One of every 10 patients who are sent home after passing an ICSC would have failed if the test were repeated.

Additional variability in observed events across studies may be explained by different averaging times (specifically the mean oxygen saturation displayed on a monitor over 2 seconds to 20 seconds) and the different systems used for monitoring events while in car seats. Shorter averaging times of two seconds are quite sensitive for identifying episodes of oxygen desaturation and bradycardia, but are more prone to false positive results. Conversely, longer averaging times reduce the number of false positives but may fail to detect short but possibly significant cardiorespiratory episodes. Closely observing infants in their car seats may help to determine which events are ‘real’ and which may be ‘artifacts’.

TABLE 1
Levels of evidence for therapies

Level	Nature of evidence
1a	Systematic review (SR) (with homogeneity) of RCTs
1b	Individual RCT (with narrow CI)
2a	SR (with homogeneity) of cohort studies
2b	Individual cohort study (or low-quality RCT, e.g. <80% follow-up)
3a	SR (with homogeneity) of case-control studies
3b	Individual case-control study
4	Case-series (and poor quality cohort and case-control studies)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or first principles

Polysomnography (PSG) has been demonstrated to be superior to clinical observation, even with cardiac and saturation monitoring, for detecting cardiorespiratory events.⁽²²⁾ Schutzman et al described a cohort of 785 infants studied with the ICSC and PSG. Out of 313 infants who had both tests, 157 who passed the ICSC failed the PSG, for a discordance rate of 56.6%.⁽²²⁾ Given that more formal testing appears to identify a much higher rate of failure, it is questionable how reassured clinicians should be by an infant's 'passing' an ICSC. Because a PSG is now considered to be the 'gold standard' for assessing respiratory stability in infants at risk for adverse events, the sensitivity of the ICSC as a screening test must be called into question.

One final concern pertains to conditions under which the test is performed. The test is typically done on a sturdy surface: either a floor or table free from vibration and movement. The area around the patient is maintained in a quiet state so as not to disturb the infant who is undergoing the assessment. How can we apply the findings of such testing to "real life" conditions, including vehicular vibration, the jostle from uneven roads and the sound of voices while travelling in an automobile? The transferability of information gleaned from a controlled testing environment is questionable.

While the present position statement pertains to preterm infants, clinicians also use the ICSC test to screen other populations before discharge (eg, infants with a neurological impairment, congenital heart defect and more recently, low birth weight).^(23,24) Testing children with hypotonia appears to be based solely on clinical acumen; this population's cardiorespiratory stability in car seats has not been specifically studied. Low birth weight infants may be at higher risk for failing an ICSC test in the context of

TABLE 2
Grades of recommendation

A	Consistent level 1 studies
B	Consistent level 2 or 3 studies
C	Level 4 studies
D	Level 5 evidence or troublingly inconsistent or inconclusive studies or any level

exposure to maternal opiates. The present statement does not make specific recommendations regarding either group of infants. Rather, the individual clinician must consider whether testing for such infants is needed.

Due to inconsistency among ICSC test results and the lack of evidence that failing an ICSC is associated with either mortality risk or an adverse neurodevelopmental outcome, the Canadian Paediatric Society cannot recommend administering this test routinely as part of the discharge protocol for preterm infants. The test itself has poor reproducibility, with a discordance rate of approximately 10% for subsequent tests performed shortly after the initial pass. Finally, the ICSC is not as accurate as polysomnography for identifying episodes of oxygen desaturation, apnea or bradycardia. Clinicians cannot feel confident that an infant's 'passing' an ICSC test indicates safety for discharge.

RECOMMENDATIONS

- The Canadian Paediatric Society does not recommend routine ICSC testing before discharge for preterm infants (level 3 evidence, grade C).
- Parents and other care providers should be counselled regarding safe car seat use and be able to demonstrate appropriate technique and practice – preferably using their own car seat – before their infant is discharged from hospital (level 3 evidence, grade C).
- Infants should only be placed in a car seat for travel in a moving vehicle and removed promptly once the destination is reached (level 3 evidence, grade C).

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