Factors associated with car seat test failure in late preterm infants: A retrospective chart review

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BACKGROUND: Professional organizations recommend car seat testing of preterm infants before discharge from hospital. Late preterm infants (LPIs, 340/7 to 366/7 weeks’ gestational age) are at the greatest risk for failure, despite often being well.

OBJECTIVE: To determine the incidence of car seat testing failure in LPIs and associative factors.

METHODS: A retrospective chart review was performed of inborn LPIs admitted to all levels of newborn care between July 1, 2012 and June 30, 2013. Data collected included maternal demographics, labour and delivery history, and neonatal course. Data were analyzed using backward logistic regression.

RESULTS: A total of 511 charts were reviewed and 367 LPIs were eligible for inclusion. Of the 313 LPIs tested (mean (± SD) gestational age 36 weeks ±6 days and birth weight 2614±405 g), 80 (26%) failed (95% CI 21% to 31%). Most failed due to desaturations (≥ 2) of <88% for ≥ 10 s (n=33 [41%]). Multiple gestation was associated with failure (adjusted OR 2.45 [95% CI 1.44 to 4.18]; P=0.001), and there was a trend toward statistical significance for the variable postnatal age (0.996 [95% CI 0.99 to 1.00]; P=0.05). Infants who passed their car seat test had higher postnatal ages than those who failed (mean difference 39.4 h [95% CI 12.7 h to 66.0 h]; P=0.004).

CONCLUSION: Twenty-six percent of LPIs failed car seat testing. Ideally, infants should be tested after an appropriate transitional period. The authors identified factors that may be important in designing future, prospective studies in this area. Future research should evaluate the clinical significance of car seat testing and resource utilization.

Key Words: Apnea; Car seat test; Desaturations; Infant car seat challenge

Les facteurs associés à l’échec de la vérification des sièges d’auto chez les nourrissons peu prématurés : une analyse rétrospective des dossiers

HISTORIQUE : Les organisations professionnelles recommandent de vérifier les sièges d’auto des nourrissons prématurés avant leur congé de l’hôpital. Les nourrissons peu prématurés (NPP ; de 340/7 à 366/7 semaines d’âge gestationnel) risquent le plus d’échouer cette vérification, même s’ils sont souvent en bonne santé.

OBJECTIF : Déterminer l’incidence d’échec de la vérification des sièges d’auto chez les NPP, ainsi que les facteurs s’y associant.


RÉSULTATS : Les chercheurs ont examiné 511 dossiers, et 367 NPP étaient admissibles à l’inclusion. Des 313 NPP vérifiés (âge gestationnel moyen ± ET) de 36 semaines ±6 jours et poids de naissance de 2 614±405 g), 80 (26 %) ont échoué (95 % IC 21 % à 31 %), la plupart à cause d’une désaturation (≥ 2) de moins de 88 % pendant au moins 10 s (n=33 [41 %]). La gestation multiple s’associait à un échec (RC rajusté 2.45 [95 % IC 1.44 à 4.18]; P=0.001), et on remarquait une tendance vers une significativité statistique de la variable âge postnatal (0.996 [95 % IC 0.99 à 1.00]; P=0.05). Les nourrissons pour qui la vérification du siège d’auto ne posait pas de problème avaient un âge postnatal plus avancé que ceux qui l’échouaient (différence moyenne de 39.4 h [95 % IC 12.7 h à 66.0 h]; P=0.004).

CONCLUSION : Vingt-six pour cent des NPP échouaient la vérification du siège d’auto. Dans l’idéal, il faudrait vérifier les nourrissons après une période transitoire pertinente. Les chercheurs ont déterminé des facteurs susceptibles d’être importants pour concevoir de futures études prospectives dans ce domaine. De futures recherches devraient évaluer la signification clinique de la vérification des sièges d’auto et l’utilisation des ressources.

Both the Canadian Paediatric Society and the American Academy of Pediatrics recommend a “car seat challenge” for preterm infants (<37 weeks’ gestational age [GA]) before discharge from the hospital (1,2). Additional criteria often include full-term infants with significant neurological or cardiorespiratory disorders (3-5). Testing has been recommended in these populations following studies performed in the 1980s, which found that preterm neonates experienced periods of oxygen desaturation when placed in a semi-upright position, which persisted but improved once placed supine (6,7). In 1993, Bass et al (8) collected data over a 15-month period following implementation of a 90 min car seat test for all preterm infants in their level 2 nursery. Sixteen of 87 (18.4%) infants had abnormal results (the majority of which were desaturations <89%). This sample included seven of 33 (21.2%) infants of 36 weeks’ GA (8). A more recent study identified that late preterm infants (LPIs, infants 340/7 to 366/7 weeks’ GA) have higher failure rates than preterm infants with lower GAs (9). The hypothesis for increased failure rates is that LPIs are tested at younger postnatal ages, allowing less time for physiological maturation. Second, infants born more preterm are usually admitted to the neonatal intensive care unit (NICU), undergo prolonged periods of monitoring, and are tested when stable and ready for
discharge home (9). Authors have recommended the infant car seat challenge as a screening test, and possible further testing while supine (10).

The rationale for implementing a predischarge car seat test is to detect infants at risk for hypoxic events. There is emerging evidence that cardiorespiratory events in newborns at home are associated with lower scores on the mental developmental index later in life (as assessed by the Bayley Scales of Infant Development); however, more evidence on long-term outcomes is lacking and this association does not imply causation (11). Importantly, the use of such a test assumes that the events are clinically relevant, and that identification of infants will allow for an intervention that leads to prevention of future cardiorespiratory events while in a car seat (9). The most recent Cochrane review on the topic concludes that it is “unclear whether undertaking a car seat challenge is beneficial or indeed whether it causes harm”. ‘Harm’ in this case is referring to parental anxiety and prolonged length of stay, leading to increased costs and systemic burden. Moreover, there is no evidence of a relationship between positional hypoxic episodes in a car seat and apparent life-threatening events in early infancy (12).

More data are perhaps needed to guide future prospective studies aimed at determining the benefit of testing LPIs and the adverse sequelae of a failed car seat test. Therefore, we sought to determine the incidence of car seat testing failure in LPIs and to identify factors associated with failure in a tertiary level perinatal centre.

**METHODS**

**Study population**

A retrospective chart review of all LPIs admitted to the authors’ mother and baby unit (level 1), and level 2 and 3 NICUs between July 1, 2012 and June 30, 2013 was conducted. Infants with surgical diagnoses were excluded (eg, cyanotic congenital heart disease, gastroschisis and congenital diaphragmatic hernia) because they were transferred to a free-standing paediatric hospital following initial stabilization at the authors’ institution. The study was approved by the Research Ethics Board at Mount Sinai Hospital, Toronto, Ontario.

Data were collected using a predesigned form. Variables included maternal demographics (age, gravidity, parity, history of abortion), antenatal factors (multiple gestation, maternal medications, group B streptococcus status, intrapartum antibiotics, maternal steroids, duration of membrane rupture and mode of delivery), and neonatal factors (GA, birth weight, sex, Apgar scores at 1 min and 5 min, surfactant use, jaundice requiring phototherapy, hypoglycemia, temperature instability, postnatal age and weight at time of testing). Information regarding investigation of a failed car seat test and subsequent treatments were also collected.

**Infant car seat test**

Infants were placed in their caregiver’s personal car seat and positioned according to manufacturer’s instructions. A pulse oximeter (Nellcor Oximax N-595, Covidien, USA) was connected to continuously monitor oxygen saturation and heart rate. A nurse monitored the infant during the 90 min testing period and recorded any period of movement causing artifact. ‘Failure’ criteria were symptomatic bradycardia (<80 beats/min (the duration of which is not specified at the authors’ institution) or oxygen desaturations (≥2 of <88% for ≥10 s or any desaturation ≤80%). Under the protocol in place at the time of the study, well infants who did not pass the 90 min test were retested within 48 h or when the health care team deemed appropriate, and oximeter data trending was reviewed (phase 2). An infant who failed phase 2 testing was monitored for 2 h in the supine position to ensure the infant was not hypoxic at rest. Any unwell infant was admitted to the level 2 or 3 NICU and investigated as required, as well as any infant who failed supine testing.

**Planned analysis**

Data were entered into SPSS version 21.0 (IBM Corporation, USA) and double-checked for any data entry error. Demographic and clinical data are reported as counts and percentages, means and SDs, or medians and ranges, as appropriate. Nominal level data were compared using Fisher’s exact test or χ² test when appropriate. Continuous variables were compared using Student’s t test or Mann Whitney U test when appropriate.

The planned analysis was to determine factors associated with failure using logistic regression. A preliminary analysis was conducted between crude variables to determine insertion into the regression model, where P<0.1 was used for entrance criteria. Multicollinearity between the variables to be included in the model was inspected by examining variance inflation factors for each variable and the distribution of variance associated with each principal component. Variables were also removed to assess the change in model significance. Outcomes are reported as adjusted OR along with 95% CI; P<0.05 for overall model and individual OR was considered to be statistically significant.

**RESULTS**

A total of 511 charts were reviewed and 367 LPIs were eligible (Figure 1). Of the 313 LPIs tested (mean ± SD) GA 36 weeks ±6 days and mean birth weight 2614±405 g), the majority were in the mother and baby unit (level 1, n=265 [85%]). In total, 80 (26%) infants failed their initial car seat test (95% CI 21% to 31%). The majority (n=33 [41%]) of these failed because of desaturations (≥2) of <88% for ≥10 s. Twenty-six had desaturations <80% (33% of failures) and two (3%) infants failed for heart rate <80 beats/min. Nineteen infants did not have a reason documented for failure (23%). Forty infants were admitted to the NICU for further investigation or monitoring after car seat testing failure. Of those who failed, 60 infants underwent a second car seat test, either alone
Following a period of observation she was discharged home. One infant was kept on the level 1 unit despite remaining in level 1 and 40 (55%) were admitted to the level 2 or 3 NICU following resuscitation at birth consisting of a partial sepsis work-up to rule out necrotizing enterocolitis. The remainder of the infants receiving low-flow oxygen had normal chest x-rays. Five infants underwent echocardiography, which revealed a normal study in four cases and a patent foramen ovale in one. One infant had possible dysmorphic features, which the genetics team believed were not representative of an underlying genetic syndrome. One infant, a dichorionic, diamniotic twin, had antenatal amniocentesis secondary to nuchal translucency in her twin and the genotype was found to be 47 XXX. She was eventually re-admitted to the NICU for blood in her stool, which was found to be from an anal fissure. Finally, one infant underwent electrocardiogram and thyroid studies (thyroid stimulation hormone and free thyroxine), which were normal.

Predictors of car seat test failure
Following comparison of crude data (Table 1), the following variables were entered into the logistic regression model: parity, multiple gestation, Apgar score at 5 min and postnatal age at time of testing. The overall model was statistically significant (P<0.001). Multiple gestation was associated with failure (adjusted OR 2.45 [95% CI 1.44 to 4.18]; P=0.001), and there was a trend toward statistical significance for the variable postnatal age, which was included in the final model (adjusted OR 0.996 [95% CI 0.99 to 1.00]; P=0.05). Infants who passed their car seat test had higher postnatal ages than those who failed, (mean difference 39.4 h [95% CI 12.7 h to 66.0 h]; P=0.024). Among the infants who failed, the mean weight at the time of testing was lower in multiple gestation infants compared with single gestation infants (mean difference 246.8 g [95% CI 39.0 g to 454.6 g]; P=0.021), although this variable was not statistically significant in the predictive model.

**DISCUSSION**

Twenty-six percent of LPIs failed their car seat test before discharge from hospital. The majority of these infants were tested on the level 1 unit following uneventful delivery. Approximately one-half of the infants who failed car seat tests were subsequently admitted to the level 2 or 3 NICU, where a range of investigations were conducted with almost always normal results or results not explaining car seat test failure. Nevertheless, approximately 30% of infants who failed required a period of low-flow supplemental oxygen. This finding was not explained by underlying respiratory disease, with only one infant having abnormal findings on chest x-ray. Infants of multiple gestation were more likely to fail, and there was a trend among the cohort toward failure in infants with younger gestational age.

Review of the literature identified one previous retrospective study, conducted over a two-year period, investigating all preterm infants who underwent pre discharge car seat testing (9). Of the 1036 preterm infants, 4.3% failed their infant car seat test; 78% of (n=9) or after a 2 h supine test (n=51). Eighteen infants were discharged after either a passed 2 h supine test (n=11) or a failed 2 h supine test (n=7); and parents of two infants declined further testing and were sent home. Of the 60 infants who underwent a second test, 21 (35%) failed.

**Level of NICU where failure occurred**

Before car seat testing failure, seven infants were admitted to the level 2 or 3 NICU. Reasons for admission included: to rule out intracranial hemorrhage in the context of a cephalohematoma and possible subgaleal hemorrhage; hyperbilirubinemia requiring phototherapy; respiratory distress and need for low-flow oxygen and a partial sepsis work-up to rule out sepsis (n=3, negative cultures in all cases); management of hypoglycemia; and initially admitted to the level 3 NICU following resuscitation at birth consisting of a brief period of intubation and chest compressions. The infant involved in the latter case eventually had a negative blood culture and was well after. Of the seven infants admitted to the level 2 or 3 NICU before care seat failure, two passed both the supine and second car seat test, one infant was transferred out before repeat testing and the remainder passed a supine test or a second car seat test.

Of the 73 infants who failed on the level 1 unit, 33 (45%) remained in level 1 and 40 (55%) were admitted to the level 2 or 3 NICU. Two families declined further testing on level 1 and were discharged home. One infant was kept on the level 1 unit despite failure of the 2 h supine test and failure of a second car seat test; following a period of observation she was discharged home. One infant underwent a chest x-ray, which was reported to be normal. The remaining 29 infants underwent no further investigations as a result of the failed test and were sent home without a follow-up test.

**Summary of investigations**

Of the 40 infants admitted to the level 2 or 3 NICU for further investigation and management of a failed car seat test, 12 (31%) were monitored with no further investigation or intervention. Twelve (31%) underwent a limited investigation including chest x-ray (all normal) and/or a partial sepsis work-up (negative in all cases). Eleven (28%) infants received low-flow supplemental oxygen ranging in duration from 24 h to 13 days. Of these, one infant was not investigated further; one was diagnosed with transient tachypnea of the newborn versus respiratory distress syndrome and was eventually re-admitted to the NICU to rule out necrotizing enterocolitis. The remainder of the infants receiving low-flow oxygen had normal chest x-rays. Five infants underwent echocardiography, which revealed a normal study in four cases and a patent foramen ovale in one. One infant had possible dysmorphic features, which the genetics team believed were not representative of an underlying genetic syndrome. One infant, a dichorionic, diamniotic twin, had antenatal amniocentesis secondary to nuchal translucency in her twin and the genotype was found to be 47 XXX. She was eventually re-admitted to the NICU for blood in her stool, which was found to be from an anal fissure. Finally, one infant underwent electrocardiogram and thyroid studies (thyroid stimulation hormone and free thyroxine), which were normal.

**TABLE 1**

Comparison of unadjusted factors of late preterm infants who passed their car seat challenge and those who failed

<table>
<thead>
<tr>
<th>Variable</th>
<th>Passed (n=233)</th>
<th>Failed (n=80)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maternal factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, years</td>
<td>33.8±5.3</td>
<td>34.4±6.7</td>
<td>0.38</td>
</tr>
<tr>
<td>Gravida, median (range)</td>
<td>2 (1–11)</td>
<td>2 (1–9)</td>
<td>0.16</td>
</tr>
<tr>
<td>Parity, median (range)</td>
<td>1 (0–7)</td>
<td>0 (0–4)</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Antenatal factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple gestation</td>
<td>65 (28)</td>
<td>39 (49)</td>
<td>0.001</td>
</tr>
<tr>
<td>Maternal medications</td>
<td>71 (31)</td>
<td>21 (28)</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Group B streptococcus status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>41 (18)</td>
<td>16 (20)</td>
<td>0.80</td>
</tr>
<tr>
<td>Negative</td>
<td>99 (43)</td>
<td>30 (38)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>92 (40)</td>
<td>34 (43)</td>
<td></td>
</tr>
<tr>
<td>Intrapartum antibiotics</td>
<td>67 (29)</td>
<td>29 (36)</td>
<td>0.26</td>
</tr>
<tr>
<td>Antenatal steroids</td>
<td>45 (19)</td>
<td>11 (14)</td>
<td>0.31</td>
</tr>
<tr>
<td>Rupture of membranes, h</td>
<td>14.6±123.4</td>
<td>12.7±61.7</td>
<td>0.90</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>115 (50)</td>
<td>45 (56)</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>Neonatal factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestational age, weeks</td>
<td>36.0±0.9</td>
<td>36.1±0.6</td>
<td>0.39</td>
</tr>
<tr>
<td>Birth weight, g</td>
<td>2605±390</td>
<td>2643±449</td>
<td>0.47</td>
</tr>
<tr>
<td>Male sex</td>
<td>124 (54)</td>
<td>38 (48)</td>
<td>0.44</td>
</tr>
<tr>
<td>Apgar score at 1 min, median (range)</td>
<td>9 (1–9)</td>
<td>9 (1–9)</td>
<td>0.21</td>
</tr>
<tr>
<td>Apgar score at 5 min, median (range)</td>
<td>9 (4–9)</td>
<td>9 (5–9)</td>
<td>0.03</td>
</tr>
<tr>
<td>Surfactant administration</td>
<td>5 (2)</td>
<td>0 (0)</td>
<td>0.33</td>
</tr>
<tr>
<td>Jaundice requiring phototherapy</td>
<td>41 (18)</td>
<td>9 (11)</td>
<td>0.22</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>58 (25)</td>
<td>28 (35)</td>
<td>0.11</td>
</tr>
<tr>
<td>Temperature instability</td>
<td>18 (8)</td>
<td>7 (9)</td>
<td>0.81</td>
</tr>
<tr>
<td>Postnatal age at testing, h</td>
<td>101.5±143.9</td>
<td>62.1±85.1</td>
<td>0.004</td>
</tr>
<tr>
<td>Weight at testing, g</td>
<td>2502±363</td>
<td>2483±418</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Data presented as mean ± SD or n (%) unless otherwise indicated

(n=93) or after a 2 h supine test (n=51). Eighteen infants were discharged after either a passed 2 h supine test (n=11) or a failed 2 h supine test (n=7); and parents of two infants declined further testing and were sent home. Of the 60 infants who underwent a second test, 21 (35%) failed.
those who failed were LPIs. Our findings were similar in that infants with older postnatal age at time of testing were more likely to pass, suggesting there is a component of transition or maturation, rather than purely mechanical airway obstruction related to size. Our failure rate was perhaps higher because we focused on LPIs only. Another difference was the use of newer pulse oximeter monitors in the present study, which have adaptable algorithms, and variable but shorter averaging times (5 s to 7 s, but up to 40 s depending on artifact) compared with older studies (20 s for the majority of monitors in the study by Davis et al (9).

Previous studies have identified central, rather than obstructive, causes as the initiating event. A nonrandomized controlled trial involving 20 preterm infants (median GA 33 weeks) used polysomnography, as well as cardiorespiratory monitoring, to study infants both in car seats and in infant cots (13). The investigators reported that airway obstruction was not more common in the car seat, although there were fewer central apneas in the cot compared with the car seat overall. In extremely low birth weight infants, intermittent hypoxemia (defined as an acute decrease of 10% of saturated oxygen from baseline stable values for ≥5 s) tends to increase over the first four weeks of life, followed by plateau and eventual decline (14,15), lending further evidence to the theory of maturation originating centrally. Our finding that greater postnatal age was predictive of passing the car seat test supports this mechanism.

Importantly, oxygen desaturations in newborns are not uncommon. In the most recent systematic review investigating oxygen saturation monitoring in infants, the upper limit noted in otherwise healthy newborns for desaturations <86% for any length of time was found to be 14.7 episodes per hour at one day of age (16). In 2011, Hunt et al (17) described episodes of hypoxemia, unrelated to apnea and bradycardia events, in 74% of preterm and 62% of term infants. These events were very similar to those we observed in our study, given that very few failures were associated with bradycardia. Finally, there is a lack of consistency in setting failure criteria. The Canadian Paediatric Society statement from 2000, which was reaffirmed in 2012, discusses the criteria of ≥2 desaturations of <88% for ≥10 s. However, a 2013 survey noted this criteria varies according to institution, with most NICUs using <90% saturated oxygen as a cut-off for failure (3). Therefore, our results are perhaps more generalizable to lower desaturations. The American Academy of Pediatrics guidelines from 2009 do not recommend any specific cut-off values for failure, rather they state if events "on cardiorespiratory monitoring in a car safety seat are deemed significant by the treating physician", then interventions to reduce their frequency are recommended (1).

Previous authors have postulated possible reasons for desaturations in preterm infants (18). One mechanism is apnea or hypventilation causing decreased oxygen saturation and eventual bradycardia. This could be related to tone and positioning. In one study, periods of oxygen desaturation in preterm infants undergoing car seat testing improved with adjustment of the car seat angle to 30° from the recommended 45° (in 18 of 29 infants who failed). However, this is not consistent with manufacturer's instructions, and was not curative in all cases (10). A second mechanism is transient right to left cardiac shunting as a primary event; however, of the infants who underwent echocardiography in our study, the finding of a patent foramen ovale was reported in 62% of term infants. These events were very similar to those we observed in our study, given that very few failures were associated with bradycardia and hypoxia and cyanosis. The infant subsequently experienced respiratory arrest in a car seat at three months of age and "abnormal test results" until 8 months of age. A study in 1996 (10) followed 123 preterm infants (GA range 26 to 36 weeks) who underwent car seat testing. One infant was discharged home on supplemental oxygen following a failed car seat test and was readmitted at six months corrected age for an apparent life-threatening event and was eventually discharged with home monitoring. Despite reports in the literature, it remains unclear whether the use of a car seat test can identify those who experience adverse events later, and whether there is a suitable intervention to prevent adverse events from occurring.

To our knowledge, no deaths have been reported that were associated with a failed car seat test. However, deaths in sitting devices have been reported in the literature. A retrospective, population-based cohort study reviewed all cases of unexpected death in infants between birth and one year of age in Quebec (19). In a 10-year period, 3% of all unexpected deaths occurred in the sitting position and, of these, 40% were explained. Of those unexplained, it was not known whether a car seat test was conducted before discharge from hospital. Interestingly, 80% of the unexplained deaths were full-term GA infants and would not have been candidates for car seat testing based on current recommendations.

Importantly, there is emerging evidence that cardiorespiratory events have an association with developmental outcome. Hunt et al (11), enrolled 256 newborns (118 preterm and 138 full-term infants) in an observational study of home cardiorespiratory monitoring and measured developmental scores at 92 weeks postconceptional age. Preterm infants were <1750 g and ≤34 weeks postconceptional age at birth. Infants were evaluated using the Bayley Scales of Infant Development, 2nd edition. Overall, lower scores on the mental developmental index (MDI) were found in both preterm and full-term infants who experienced >5 cardiorespiratory events, compared with those who experienced none. These data are worrisome, but do not clearly reflect the population of LPIs who routinely fail car seat testing. Moreover, another interpretation of these data is that desaturations may identify infants with low MDI scores due to intrinsic brain injury, rather than desaturations as the primary cause of the low MDI score. More long-term studies are needed to determine the benefit of a car seat test to identify these infants.

Our study had several limitations. First, many infants were excluded due to early transfer to an outside facility for level 2 care. These infants may have been at higher risk for failing. Second, although infants were followed during the antenatal and early postnatal period until discharge, there was no long-term follow-up of infants who failed, and long-term implications of a failed test, if any, were not identified. Furthermore, the results were limited by the retrospective nature of the study design. Differences in testing protocols, management of a car seat failure, including possible NICU admission and investigation, were not standardized.
A significant limitation was that 23% of infants did not have a documented reason for failing, which added to the risk for bias in our sample. Additionally, infants were not continuously monitored in the level 1 nursery, and desaturations and apneic events before testing could have been missed. Finally, we identified a lack of protocol adherence at our institution, which could be further audited at other institutions.

The number of level 2 NICU units in Canada implementing routine car seat testing before discharge of LPIs is unknown. In 1996, Young et al (10) surveyed 22 level 3 NICUs in Canada and identified three units performing routine testing. A 2003 survey from the United States suggests that 91% and 81% of level 2 and 3 units, respectively, perform a predischarge car seat test, and as few as 22% of level 1 units (20). This represents a large number of potential car seat test failures. Interestingly, European guidelines regarding routine car seat testing in infants are lacking, and many centres test only those with underlying cardiorespiratory pathology, suggesting this practice is not widely adopted (personal communication with author VS).

COnCLuSIOn

Twenty-six percent of LPIs failed car seat testing. We identified younger postnatal age and multiple gestation as factors that may be important in designing future, prospective studies in this area. The predischarge car seat test did identify otherwise well LPIs who were admitted to the NICU for cardiorespiratory monitoring. However, it is not an ideal screening tool due to lack of evidence predicting morbidity or mortality. Furthermore, it is unclear what interventions, if any, are useful in preventing adverse sequelae in car seat testing failures. If a car seat test is performed, ideally, infants should be tested after an appropriate transitional period. Future research is needed, and should evaluate clinical significance of car seat testing and failure, resource utilization and economic burden in this population.

DISCLOSURES: The authors have no financial relationships or conflicts of interest to declare.

REFERENCES