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CLINICAL REPORT

Safe Transportation of Preterm and Low Birth Weight Infants at Hospital Discharge

Guidance for the Clinician in Rendering Pediatric Care

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ABSTRACT

Safe transportation of preterm and low birth weight infants requires special considerations. Both physiologic immaturity and low birth weight must be taken into account to properly position such infants. This clinical report provides guidelines for pediatricians and other caregivers who counsel parents of preterm and low birth weight infants about car safety seats. *Pediatrics* 2009;123:1424–1429

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Key Words
safe transportation, preterm, premature, low birth weight, car safety seats, car beds

Abbreviation
FMVSS—Federal Motor Vehicle Safety Standard

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INTRODUCTION

Improved survival rates and earlier discharge of preterm (<37 weeks' gestation at birth) and low birth weight (<2500 g at birth) infants have increased the number of small infants who are being transported in private vehicles. Car safety seats that are used correctly are 71% effective in preventing fatalities attributable to passenger car crashes in infants.[1] To ensure that preterm and low birth weight infants are transported safely, the proper selection and use of car safety seats or car beds are necessary.

Federal Motor Vehicle Safety Standard (FMVSS) 213, which establishes design and dynamic performance requirements for child-restraint systems, applies to children weighing up to 65 lb. However, the standard has no minimum weight limit and does not address the relative hypotonia and risk of airway obstruction in preterm or low birth weight infants. Most rear-facing car safety seats are designated by the manufacturer for use by infants weighing more than 4 or 5 lb, with some designated for use from birth regardless of weight.

Infant dummies as small as 3.3 lb have been shown to be satisfactorily restrained in standard rear-facing car safety seats during crash tests.[2,3] Test dummies, however, cannot replicate the airway and tone variables that occur in preterm infants, and there is no information on restraint of infants who weigh less than 3.3 lb (1.5 kg).

Rear-facing car safety seats provide the best protection in a frontal crash, because the forces are transferred from the back of the restraint to the infant's back, the strongest part of an infant's body. The restraint also supports the infant's head. Severe tensile forces on the neck in flexion are also prevented by use of rear-facing car safety seats.[4]

The long-term experience and documented protective value of car safety seats make them the preferred choice for travel for all infants who can maintain cardiorespiratory stability in the semireclined position.[4] A car bed that meets FMVSS 213 may be indicated for infants who manifest apnea, bradycardia, or low oxygen saturation when positioned semireclined in a car safety seat.[2,5] Of note, some preterm and term infants positioned in car beds and car safety seats seem to have similar rates of apnea, bradycardia, and oxygen desaturation.[6,7]

A car bed is designed to accommodate an infant in a fully reclined position and is oriented in the vehicle seat perpendicular to the direction of travel. An infant is secured in the car bed with an internal harness, and the car bed is secured to the vehicle with the vehicle's seat belt. Car beds, like car safety seats, have specific weight requirements designated by the manufacturer and, like car safety seats, should be used according to manufacturer recommendations.

The size of the infant, especially for those born preterm, is an important consideration when selecting a car safety seat or car bed.[2,8] Weight, length, neurologic maturation, and associated medical conditions (especially bronchopulmonary dysplasia) all influence the potential risk of respiratory compromise for infants in seating devices.[6,9]

Preterm infants are subject to an increased risk of oxygen desaturation, apnea, and/or bradycardia,[10] especially when placed in a semireclined position in car safety seats.[5,11–13] Furthermore, frequent cardiorespiratory events and

intermittent hypoxia may adversely affect later neurodevelopment, psychosocial behavior, and academic achievement.[14,15] In 1 study, mental development in preterm infants with 5 or more cardiorespiratory events during 210 hours or more of cardiorespiratory monitoring was associated with a lower mental development index on the Bayley Scales of Infant Development (95.8 vs 100.4; $P = .04$)[14]; physical developmental indices were not different (94.4 vs 91.7; $P = .37$). It is unclear whether the association of cardiorespiratory events and lower mental development reflects an underlying abnormality or a negative consequence of the events. It is rational, if practical, to attempt to reduce the frequency and severity of cardiorespiratory events experienced by preterm infants seated in car safety seats to minimize potential neurodevelopmental sequelae. Therefore, car safety seat monitoring in the infant's own car safety seat before discharge from the hospital should be considered for all infants less than 37 weeks' gestation at birth to determine if physiologic maturity and stable cardiorespiratory function are present, as recommended in the American Academy of Pediatrics publication *Guidelines for Perinatal Care*.[16] Because information is limited about the severity and frequency of adverse outcomes in preterm infants who experience cardiorespiratory events, including those events that occur while in car safety seats, additional research is needed.[17]

Many infants are discharged from the hospital with cardiac/apnea monitors, supplemental oxygen, and, occasionally, portable ventilators, suction machines, batteries, and other equipment. These objects are heavy and could cause injury if they were to hit the child or another vehicle occupant in the event of a sudden stop or crash. Although there is no commercially available securement system for portable medical equipment, restraint is recommended.[18]

No data are available to establish a specific age or neurodevelopmental status at which an infant with respiratory compromise who was discharged from the hospital in a car bed can safely transition to a semireclined car safety seat. Before discontinuing use of a car bed, the physician can consider arranging for a follow-up study to determine when the infant can travel semireclined without apnea, bradycardia, or oxygen desaturation. The time to perform the test may vary depending on the rate of growth and neurologic maturation of the infant and the infant's respiratory status and should be determined by the treating physician.

Car safety seats are used frequently for positioning infants for purposes other than travel. Potential detrimental effects of excessive use of infant seating devices, including exacerbation of gastroesophageal reflux and potentiation of plagiocephaly, have been documented.[19,20] Use of car safety seats for purposes other than travel also may increase the risk of adverse cardiorespiratory and other adverse medical events.

CLINICAL IMPLICATIONS

Several important considerations for transportation of preterm and low birth weight infants at risk for recurrent oxygen desaturation, apnea, or bradycardia include the following.

1. The increased frequency of oxygen desaturation and episodes of apnea or bradycardia while sitting in car safety seats suggests that preterm infants should have a period of observation in a car safety seat, preferably their own, before hospital discharge. This period of observation should be performed with the infant carefully positioned for optimal restraint and the car safety seat placed at an angle that is approved for use in the vehicle. A period of observation for a minimum of 90 to 120 minutes or the duration of travel, whichever is longer, is suggested.[5,6,11,21]
2. Hospital staff who are trained in positioning infants properly in the car safety seat and in detecting apnea, bradycardia, and oxygen desaturation should conduct the car safety seat observation.
3. Hospitals should develop protocols to include car safety seat observation before discharge for infants born at less than 37 weeks' gestation.[22] Some hospital protocols include car safety seat observations for infants at risk of obstructive apnea, bradycardia, or oxygen desaturation other than those born at less than 37 weeks' gestation. Examples include infants with hypotonia (eg, Down syndrome or congenital neuromuscular disorders), infants with micrognathia (Pierre Robin sequence), and infants who have undergone congenital heart surgery.[9]
4. Families should be taught by trained hospital staff how to position the infant properly in the car safety seat.
5. The duration of time the infant is seated in a car safety seat should be minimized. Parents should be advised that car safety seats should be used only for travel.
6. A conventional car safety seat that allows for proper positioning of the preterm infant should be selected if a semiupright position can be maintained safely by the infant. Better observation of the infant may be possible when the child is in a rear-facing car safety seat adjacent to an adult rather than in a car bed. In addition, the protection provided by a rear-facing car safety seat is better documented than the protection provided by car beds.[4]
7. If events documented on cardiorespiratory monitoring in a car safety seat are deemed significant by the treating physician or the hospital policy, interventions to reduce the frequency of desaturation and episodes of apnea and bradycardia are recommended (eg, use of car bed; supplemental oxygen; continued hospitalization or further medical assessment). If a car bed is considered, a similar period of cardiorespiratory monitoring while the infant is in the car bed should be performed before discharge.
8. Infants with documented oxygen desaturation, apnea, or bradycardia in a semiupright position should travel in a supine or prone position in an FMVSS 213–approved car bed after an observation period

that is free of such events as described in point 1 above. This may need to be revised as new evidence becomes available from future research. Specific information regarding currently available car beds can be obtained from several resources.[23]

9. Before transitioning from a car bed, a period of observation of an infant for apnea, bradycardia, and oxygen desaturation in the infant's own semireclined car safety seat should be considered. The study can be performed as a home oxypneumocardiogram, as an outpatient polysomnogram, or as an observed outpatient clinical evaluation performed similarly to that described in point 1 above.
10. Infants at risk of respiratory compromise in car safety seats may be at similar risk with use of other upright equipment, including infant swings, infant seats, backpacks, slings, and infant carriers. Consideration should also be given to limiting the use of these devices until the child's respiratory status in a semireclined position is stable.[24]
11. Infants for whom home cardiac and apnea monitors are prescribed should use this monitoring equipment during travel and have portable, self-contained power available for at least twice the duration of the expected transport time.
12. Commercially available securement systems for portable medical equipment such as monitors are not available; therefore, this equipment should be wedged on the floor or under the vehicle seat to minimize the risk of it becoming a dangerous projectile in the event of a crash or sudden stop.[2,8]

Proper positioning of preterm and low birth weight infants in car safety seats is important for minimizing the risk of respiratory compromise. Specific national guidance for selecting car safety seats and positioning preterm and low birth weight infants includes the following.

1. Infants should ride facing the rear as long as possible and to the highest weight and length allowed by the manufacturer of the seat for greatest protection.[25-27] By the time infants weigh 20 lb or reach the top length allowed by the manufacturer of the seat, they should ride facing the rear in infant seats or convertible car safety seats approved for rear-facing use at higher weights and lengths. Most convertible car safety seats are approved for rear-facing use up to 30 to 35 lb and 36 in. Parents of infants born preterm may benefit from specific counseling about this concept.
2. Infant-only car safety seats with 3-point or 5-point harness systems or convertible car safety seats with 5-point harness systems provide optimum comfort, fit, and positioning for the preterm or low birth weight infant. A small infant should not be placed in a car safety seat with a shield, abdominal pad, or arm rest because of potential breathing difficulty behind the shield or injury to an infant's face and neck during a sudden stop or crash.[2,21]
3. Car safety seats with the shortest distances from the crotch strap to the seat back should be selected to reduce the potential for the infant to slip forward feet-first under the harness (ie, "submarining"). Some car safety seats have crotch-to-seat back distances as short as 5.5 in, which may accommodate some preterm or low birth weight infants well. A small rolled diaper or blanket between the crotch strap and the infant may be added to reduce the risk of submarining (Fig 1) in smaller infants. A car safety seat with multiple harness-strap slots provides more choice and may be more suitable for small but rapidly growing infants. Ideally, car safety seats with harness straps that can be positioned at or below the shoulders should be selected.[21]

FIGURE 1
Car safety seat with a small cloth between crotch strap and infant, retainer clip positioned at the midpoint of the infant's chest, and blanket rolls on both sides of the infant.

4. The infant should be properly positioned in the car safety seat, with buttocks and back flat against the back of the car safety seat. The harness must be snug, and the car safety seat's retainer clip should be positioned at the midpoint of the infant's chest, not on the abdomen or in front of the neck (Fig 1).
5. Some car safety seats come with head-support systems as standard equipment. Many head-support systems, however, are sold as aftermarket products and may decrease the safety provided by the seat and harness system, because they introduce slack into harness straps. Only products that come with the seat or are sold by the manufacturer for use with their specific seat should be used. Most very small infants require positioning support in addition to the head support that comes with the seat. Blanket rolls may be placed on both sides of the infant to provide lateral support for the head and trunk (Fig 1).
6. The rear-facing car safety seat should be reclined approximately 45° or as directed by the instructions

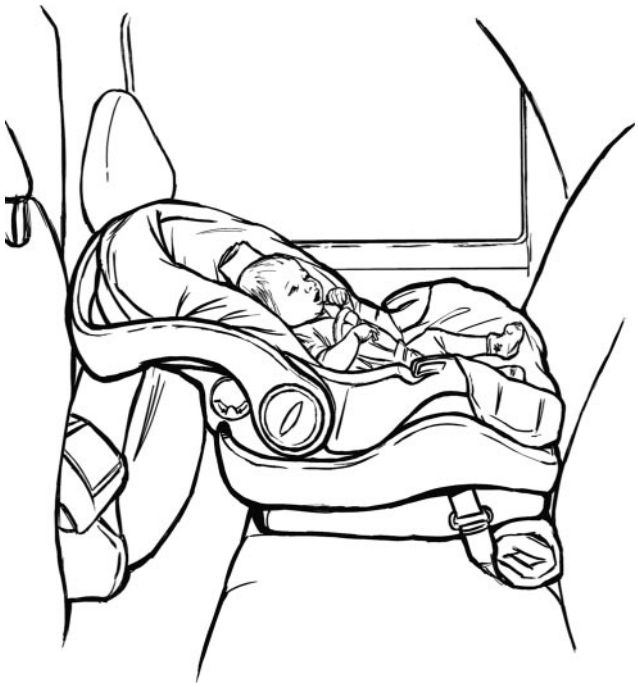

FIGURE 2
Seat with tightly rolled towel to recline seat halfway back at a 45° angle.

provided with the car safety seat. If the vehicle seat slopes and the seat is too upright, the infant's head may fall forward. A lightweight, noncompressible object, such as a tightly rolled blanket or pool "noodle," may be placed under the car safety seat to achieve the appropriate angle. Some car safety seats have built-in angle indicators and angle adjusters to assist with achieving the proper angle (Fig 2).

7. A rear-facing car safety seat should never be placed in the front passenger seat of any vehicle equipped with a passenger-side front air bag because of risk of death or serious injury from the impact of the air bag. In some vehicles without rear seating positions, the air bag can be deactivated when the front seat is used for a child passenger. The back seat is the safest place for all children to travel.[28,29]
8. Infants riding in the rear seat may be more difficult to observe, and whenever possible, parents should arrange for an adult to be seated in the rear seat adjacent to the infant. In the event of a monitor alarm, if a second caregiver is not available, the driver may need to come safely to a stop and assess the infant.
9. An infant should never be left unattended in a car safety seat inside or out of the car.

RESEARCH IMPLICATIONS

1. Studies are needed to gather more information on the severity and frequency of adverse outcomes in preterm infants who experience cardiorespiratory events, including those events that occur while in car safety seats.
2. Studies need to be conducted to determine the risk factors associated with cardiorespiratory events among preterm and low birth weight infants and criteria that indicate neurodevelopmental and physiologic maturity required for an infant to be positioned upright without respiratory compromise.
3. Studies should be designed to assess the correlation of car safety seat monitoring performed in the hospital, while stationary in the car, and while traveling.
4. Methods should be developed to better determine the relative protection provided by rear-facing car safety seats and car beds.
5. Design of car safety seats should be encouraged to specifically meet the positioning and transportation needs of preterm and low birth weight infants.
6. Methods should be developed to better secure heavy medical equipment, such as monitors and oxygen, in vehicles.
7. The efficacy of various protocols for car safety seat monitoring and car safety seats for different patient populations of at-risk infants needs to be determined.

SUMMARY

Proper selection and use of car safety seats or car beds are important for ensuring that preterm and low birth weight infants are transported as safely as possible.

The increased frequency of oxygen desaturation or episodes of apnea or bradycardia experienced by preterm and low birth weight infants positioned semireclined in car safety seats may expose them to increased risk of cardiorespiratory events and adverse neurodevelopmental outcomes.

It is suggested that preterm infants should have a period of observation of 90 to 120 minutes (or longer, if time for travel home will exceed this amount) in a car safety seat before hospital discharge. Educating parents about the proper positioning of preterm and low birth weight infants in car safety seats is important for minimizing the risk of respiratory compromise. Providing observation and avoiding extended periods in car safety seats for vulnerable infants and using car seats only for travel should also minimize risk of adverse events.

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