Ambulance Safety For Children
A Perspective and a Goal

NASEMSO
Safe Transport of Children Committee
Washington, DC
April 6, 2016

Marilyn J. Bull, MD, FAAP
Morris Green Professor of Pediatrics
Riley Hospital for Children at Indiana University Health
Indiana University School of Medicine
Automotive Safety Program
Section of Developmental Pediatrics
Indianapolis, IN
Child Occupant Protection

Great Measures of Success

The graph shows the number of fatalities for different age groups (13-14 Years Old, 8-12 Years Old, 4-7 Years Old, 1-3 Years Old, and <1 Year Old) from 2005 to 2014. The data indicates a decrease in fatalities across all age groups over the years, suggesting great measures of success in child occupant protection.
Persistent Gaps in Child Occupant Protection

- Child Passengers on Airplanes
- School Bus Transportation
- Safe Transportation for Children with Special Needs
- Occupant Protection for Ambulance Passengers
Occupant Protection for Ambulance Passengers

- Front occupant protection
- Rear compartment attendant protection
- Rear compartment patient protection
- Special considerations for child occupants
6 YO w/Cot Restraints
CRASH PROTECTION FOR CHILDREN IN AMBULANCES

Marilyn J. Bull
Department of Pediatrics, Developmental Pediatrics
Indiana University School of Medicine, Indianapolis, IN

Kathleen Weber
Child Passenger Protection Research Program
University of Michigan Medical School, Ann Arbor, MI

Judith Talty
Department of Pediatrics, Automotive Safety Program
Indiana University School of Medicine, Indianapolis, IN

Miriam Manary
Transportation Research Institute
University of Michigan, Ann Arbor, MI

ABSTRACT

The objectives of the study were to determine the most effective and reliable means of restraining children on an ambulance cot and to develop recommended field procedures for emergency medical service providers. A series of crash tests at 48 km/h were conducted using convertible child restraints, car beds, and harness systems tested with 3-year, infant, and 6-year size dummies. Belt configuration and backrest position were varied. A new cot and fastener system significantly improved restraint performance over older systems previously tested. A two-belt attachment with elevated cot backrest was found to be the method with the least performance variability for securing either a convertible child restraint or a car bed. It was concluded that children who weigh up to 18 kg, fit in a convertible child restraint, and can tolerate a semi-upright seated position can be restrained in a convertible child restraint secured with two belts to an ambulance cot. Infants who must lie flat can be restrained in a car bed modified for two seatbelt paths and secured to a cot. In each case, the cot backrest must be elevated, and the cot and anchor system must be crashworthy. None of the harness configurations tested proved to be satisfactory, but an effective system could be developed by following accepted restraint design principles.
Convertible CSS: Cot Belt Through RF & FF Belt Path
Crash Test Video: Convertible
<table>
<thead>
<tr>
<th>Test</th>
<th>Dummy Mass (kg)</th>
<th>Head Peak $g$</th>
<th>HIC</th>
<th>Chest Peak $g$</th>
<th>Chest $g \geq 3$ ms</th>
<th>Max Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cvt – A</td>
<td>15</td>
<td>41</td>
<td>362</td>
<td>43</td>
<td>42</td>
<td>53°</td>
</tr>
<tr>
<td>Cvt – B₁</td>
<td>15</td>
<td>48</td>
<td>739</td>
<td>48</td>
<td>48</td>
<td>77°</td>
</tr>
<tr>
<td>Cvt – B₂</td>
<td>15</td>
<td>52</td>
<td>460</td>
<td>46</td>
<td>45</td>
<td>54°</td>
</tr>
<tr>
<td>Cvt – B₃</td>
<td>18</td>
<td>52</td>
<td>501</td>
<td>44</td>
<td>43</td>
<td>52°</td>
</tr>
<tr>
<td>FMVSS 213</td>
<td>15</td>
<td>n/a</td>
<td>1000</td>
<td>n/a</td>
<td>60</td>
<td>70°</td>
</tr>
</tbody>
</table>

Acceleration and maximum back-angel results for 3-year dummies in convertible child restraints secured facing rearward with two belts on an ambulance cot, with FMVSS 213 criteria.

AAAM, 2001
Dream Ride Car Bed
Crash Test Video: Car Bed
<table>
<thead>
<tr>
<th>Test</th>
<th>Dummy Mass (kg)</th>
<th>Head Peak $g$</th>
<th>HIC 22 ms</th>
<th>Chest Peak $g$</th>
<th>Chest $g \geq 3$ ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB – $A_1$</td>
<td>8</td>
<td>72</td>
<td>520</td>
<td>68</td>
<td>65</td>
</tr>
<tr>
<td>CB – $A_2$</td>
<td>8</td>
<td>52</td>
<td>405</td>
<td>63</td>
<td>55</td>
</tr>
<tr>
<td>Melvin, 1995</td>
<td>8</td>
<td>50</td>
<td>390</td>
<td>50</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Acceleration results for 6-month dummies in car beds secured laterally with two belts on an ambulance cot, with Melvin [1995] criteria.
- 6 months
- 61 cm.
- 7.3 kg.
- 6 months
- 61 cm.
- 7.3 kg.
- 2 years
- 90 cm.
- 13.8 kg.
- 2 ½ years
- 98 cm.
- 15.5 kg.
- 5 years
- 96.6 cm.
- 16 kg.
- 7 years
- 115.5 cm.
- 23.4 kg.
- 10 years
- 134.6 cm.
- 32 kg.
This seat will be rear facing in the vehicle. In this picture, the seat is not tight enough.
Working Group Best-Practice Recommendations for the Safe Transportation of Children in Emergency Ground Ambulances
Recommendations:

1. For a child who is uninjured/not ill
2. For a child who is ill and/or injured and whose condition does not require continuous and/or intensive medical monitoring and/or interventions
3. For a child whose condition requires continuous and/or intensive medical monitoring and/or interventions
4. For a child whose condition requires spinal immobilization and/or lying flat
5. For a child or children who require transport as part of a multiple patient transport (newborn with mother, multiple children, etc.)
EMS Training

Improving Occupant Protection for Non-Critical Pediatric Patients in Ambulances:

A Training Curriculum for EMS Personnel

NHTSA, NCS, Riley Hospital
EMS
Improving Occupant Protection for Non-critical Patients in Ambulances

• Module to train EMS providers on child restraints for ambulance use

• Instructed by CPST with EMS certification

• Length-4 hours

• Available at www.preventinjury.org or 1 800 KID N Car
Safe Guard Transport by IMMI

- Cot-mounted restraint for patients over 1 year of age from 22 to 100 lbs
- Color-coded installation system for ease of use
- Restraint weighs 22 pounds
- 5-point harness system with one-handed adjustment for harness height and tightness
Safe Guard Transport by IMMI

- Children 22-40 pounds can use with cot back angle at 70 and 45 degrees
- Children 40-100 pounds can use with cot back angle at 70 degrees and completely flat
- **Not** intended for use with potential spinal cord injuries
- Crash test footage available on website [www.IMMI.net.com](http://www.IMMI.net.com) 317-896-9531
Ambulance-specific child restraint accommodating children 10-40 pounds

AAP PEPP, 2016
Pedi-Mate by Ferno

- For infants and toddlers 10-40 pounds
- For use on specific Ferno ambulance cots
- 3 straps attach to cot
- 5-point harness system
- Made of lightweight vinyl, rolls up for storage
- Contact manufacturer for crash test information
  1-877-733-0911

www.ferno.com

- For children 20-40 pounds and less than 40” tall
- Stores in 21” x 14” x 6” padded carrying case
- Weighs 12 pounds
- Must purchase “cot harness system” separately to use on ambulance cot

- Five-point restraint system with pelvic adjustment
- 2-level adjustable shoulder harness
- Inflates/deflates with included 12v DC pump in 60 seconds
- Cot installation system sold separately
- According to manufacturer meets FMVSS213
- Contact manufacturer for crash test information
  1-800-322-5725
  www.epandr.com
Crash Protection for Infants Transported in Incubators

Gary R. Whitman
David L. Gushue, Ph.D.
Larry Sicher
ARCC Inc.

Marilyn J. Bull, M.D., FAAP
Riley Hospital for Children

ABSTRACT

This paper reports the findings from an investigation of an ambulance crash during which an infant, occupying a transport incubator, was seriously injured. In addition, it reports on the results from the development and testing of a methodology for restraining infants being transported by an ambulance while occupying a transport incubator. During the crash, the incubator detached from the ambulance attachment system. The infant was ejected from the incubator and sustained critical head injuries. Sled testing of a similar incubator system, incorporating exemplar hook-and-pile straps (one common trade name is Velcro®) to secure the infant, demonstrated the inadequacy of this restraint for occupant crash protection as used. Additional sled testing with a five-point restraint harness, increased incubator stability, and improved incubator to ambulance attachment demonstrated the feasibility of effectively restraining an infant while being transported in an incubator during a crash. During the simulated frontal crash tests, the alternate restraint prevented ejection of the infant dummy from the incubator and impact of the infant dummy with the incubator or ambulance interior and applied the restraining loads over a wide area of the body to the strong structural skeletal portions.

INTRODUCTION

It is widely recognized that motor vehicles including ambulances are frequently involved in crashes.\textsuperscript{1,2,3,4,5,8} These crashes put the occupants at great risk of injury. Other than suffocation, motor vehicle crashes are the leading cause of death for children.\textsuperscript{7} However, the risk of injury can be significantly reduced by properly restraining the occupant and/or compartmentalizing the occupant within a small padded space.\textsuperscript{6,9,10,11}

In the U.S., young children are required by state law to be restrained by a child restraint when traveling in a passenger vehicle, in compliance with Federal Motor Vehicle Safety Standard (FMVSS) 213. Infants with medical challenges requiring an incubator are not required to be restrained when transported in the incubator. Nor is a transport incubator required to be crashworthy. Therefore, infants are frequently transported in ambulances within an incubator that will not provide adequate crash protection.\textsuperscript{12}

Despite recent research that has investigated ambulance crashworthiness and associated occupant protection,\textsuperscript{13,14,15} few studies have focused on methods for proper restraint and adequate crash protection for neonatal and child transport in an ambulance.\textsuperscript{16} Although the American Academy of Pediatrics' published guidelines include crashworthiness recommendations for the overall structure and associated securing equipment
Simulated Crash Tests of Alternative 5-point Restraint
(Infant’s head toward front)

- FMVSS 213 crash pulse: 48 kph (30 mph) 24 G
- Civil Aerospace Medical Institute (CAMI)
  newborn infant dummy (3.38 kg, 52 cm)
Kangoofix System

“Certified CEN 1789, 2007-a2010 compliant”
KANGOOFIX 1

SPEEDMANUAL / STEP BY STEP

1. [Illustration of step 1]
2. [Illustration of step 2]
3. [Illustration of step 3]
4. [Illustration of step 4]
5. [Illustration of step 5]
6. [Illustration of step 6]

AB GERMA

www.germa.se
Embrace for Neonates

Embrace transportation safety for neonates. Can be used for all the world’s incubators.

The device is a transport safety system for planned transports of premature babies with a body weight up to 3.9 kg. The main purpose of the device is to protect the child in case of hard braking, fast turns or violent crashes. The device can be manually formed to fit the body shape of the patient and be configured in different safety levels. The child is fully visible and can be accessed easily during transport.

The device is intended to handle forces up to 20G.

<table>
<thead>
<tr>
<th>Scope</th>
<th>Method</th>
<th>Test report</th>
<th>Date</th>
<th>Passed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Impact test, 10g</td>
<td>P300330A - Impact test of equipment to an incubator according to EN 1786:2007 (5 appendices)</td>
<td>2010-05-20</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Impact test, 20g</td>
<td>P300330B - Impact test of equipment to an incubator according to customer requirements (4 appendices)</td>
<td>2010-05-20</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Sinusoidal vibration</td>
<td>P318009-01 - Mechanical environmental tests</td>
<td>2011-12-22</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Random vibration</td>
<td>P318009-01 - Mechanical environmental tests</td>
<td>2011-12-22</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Drop</td>
<td>P318009-01 - Mechanical environmental tests</td>
<td>2011-12-22</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Free fall</td>
<td>P318009-01 - Mechanical environmental tests</td>
<td>2011-12-22</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Warm-up test</td>
<td>2011-12-28 - Warm-up test</td>
<td>2011-12-28</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>Cytotoxicity</td>
<td>P325002</td>
<td>2012-09-11</td>
<td>Y</td>
</tr>
<tr>
<td>Belt lock</td>
<td>Dynamic load</td>
<td>Fert BandIB8</td>
<td>2011-09-09</td>
<td>Y</td>
</tr>
<tr>
<td>System</td>
<td>MRI safety</td>
<td>2012-01-20 - MRI test</td>
<td>2012-01-20</td>
<td>N</td>
</tr>
<tr>
<td>System</td>
<td>X ray safety</td>
<td>2012-01-20 - X-ray and MRI test</td>
<td>2012-01-20</td>
<td>N</td>
</tr>
<tr>
<td>System</td>
<td>Impact test 20G</td>
<td>P327357 - 2012-10-10 - Impact test of equipment to an incubator according to EN 13718 (1 appendices)</td>
<td>2012-12-16</td>
<td>Y</td>
</tr>
</tbody>
</table>
Proposed Goals
Safe Transport of Children Committee (NASEMSO)

• To recommend the criteria or specifications for proper restraint of children in ambulances. Such criteria will be evidence-based and will consider safety of both patients and providers.

• To have the recommended criteria adopted by one or more accredited standard setting organizations.

• To develop a strategy and resources for educating EMS providers on safely transporting children in ground ambulances based on the recommended criteria or standards.
Trends in Occupant Fatality Rates Per 100,000 Population

- Age 0-4
- Age 5-9
- Age 10-15

NHTSA
Combined, side impact injuries occurred in 14.6/1000 children and 26.8% of crashes. According to PCPS: Children in belt positioning boosters were at a 58% reduction in risk of injury than those in seat belts in side impact crashes.


Annual Proceedings of the Association for the Advancement of Automotive Medicine, 2005.