

## **CRASH PROTECTION FOR CHILDREN IN AMBULANCES Recommendations and Procedures\***

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Safe transportation of children in ambulances presents special challenges for emergency medical service providers and child passenger safety advocates. Effective restraint is dependent not only on the child restraint equipment used but also on the platform to which it is attached. Although research concerning the ambulance crash environment is limited, fundamental principles of occupant restraint can still be used to develop useful and effective procedures in the field.

The federally funded Emergency Medical Services for Children (EMSC) Program acknowledges the special circumstances of ambulance transport and the gap that exists between occupant restraint practices in ambulances vs. other highway vehicles. In the near term, they have concentrated on crash prevention and the general concept of restraint of all occupants and equipment to minimize the risk of injury. They also recommend that children who are not ill or injured be transported in a vehicle other than the ambulance whenever possible.

### **Restraint Considerations in Ambulances**

Providing effective restraint for children in ambulances is a complex problem with many unique and unresolved issues. The occupant requiring transport may be acutely ill or injured, the vehicle has special characteristics for its function, and the crash environment and exposure are different from that of a family car. The ambulance environment is specifically designed for emergency treatment of passengers. Although there are variations in design, the patient compartment is typically equipped with a captain's chair that faces the rear of the ambulance, bench seats along one side of the ambulance, a cot, and storage for equipment and medical supplies. There are no forward-facing vehicle seats in the patient compartment upon which child restraints can be installed according to the manufacturers' instructions.

When determining the best restraint of a child in an ambulance, consideration must be given to the reason the child is being transported (patient vs. accompanying passenger), the medical stability of the patient, and the available locations where the child can be restrained. If not ill or injured, the child should be transported in another vehicle if at all possible, as recommended by EMSC. A police vehicle, however, is not usually a good alternative, because of the presence of prisoner screens, plastic seats, and special equipment that may compromise child restraint performance.

When transporting a child with an acute medical problem that requires constant monitoring, a current practice is to restrain the child directly to the cot with chest and hip

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\* The complete research paper is published in Association for the Advancement of Automotive Medicine, 45<sup>th</sup> Annual Proceedings, pp. 353-367. Barrington, IL, AAAM, 2001.

belts, even though this provides virtually no crash restraint, especially in the forward direction. Whenever possible, a restraint system designed specifically for a child should be used, but the difficult problem is determining the most appropriate restraint location and method of securement in the ambulance.

Rear-facing captain's chairs, or technician seats, can provide a good platform for some types of child restraints, and special instructions can be obtained from some child restraint manufacturers for installation of their convertible models (normal installation being either rear- or forward-facing) on an ambulance captain's chair. It is also becoming increasingly common to equip these technician seats with a built-in child restraint, suitable for use with an accompanying child or a less critical patient, but not a small infant. Use of this seat by a child, however, in either a portable or a built-in child restraint, precludes use of the captain's chair by an EMS technician.

Placement of a child restraint on a side bench seat is not recommended, because this usage applies the severity of a frontal impact to the less protected side-facing child. Such installations are specifically prohibited, with good reason, by all child restraint manufacturers.

Some types of child restraint systems can be attached to the ambulance cot. At present, most cots used in the field are anchored to the ambulance floor with a three-point "antler" positioning system along with a single friction clamp at the foot end that allows quick and easy loading of the patient. These cots do not have positive lock-in mechanisms, and they need only meet static loading requirements.

## **Research Methods and Results**

The objectives of this 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 30 mph was 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, and it was determined that a two-belt attachment with elevated cot backrest was the method with the least performance variability for securing either a convertible child restraint or a car bed. In addition, a new cot and slide-in track fastener system significantly improved restraint performance over the older antler systems previously tested.

The test sequences in Figures 1 and 2 illustrate acceptable crash performance for a convertible child restraint and a car bed. Each restraint is held to the cot by two pairs of belts, and the elevated backrest provides additional support. Installation details are provided under Recommendations.

Unfortunately, none of the harness configurations tested proved to be satisfactory for both ease of use and effective restraint. The test sequence in Figure 3 illustrates the excessive ramping, or the movement of the dummy up the backrest in the direction of the impact, observed in most tests. A confounding factor was the thick, soft, and loose cot cushion that compressed and shifted during impact, making the job of the harness all the more difficult. Guidelines for designing better harness systems are given under Recommendations.

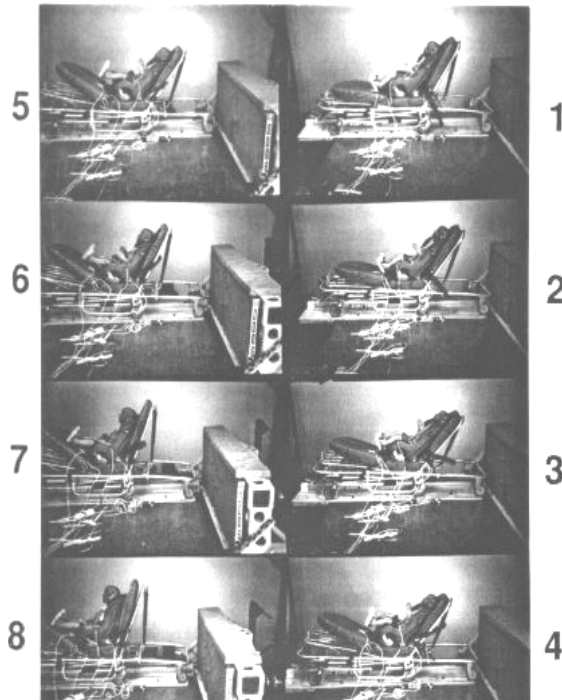


Figure 1. Crash test sequence of an 18-kg child dummy restrained in a convertible child restraint (Cvt-B3) secured using two belts to an ambulance cot with an elevated backrest and a crashworthy tie-down system.

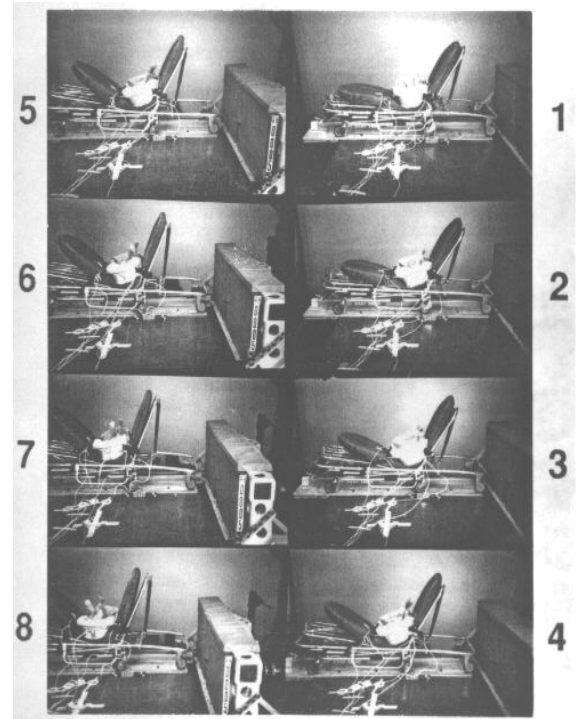


Figure 2. Crash test sequence of an 8-kg infant dummy restrained in a car bed (CB-A2) secured using two belts to an ambulance cot with an elevated backrest and a crashworthy tie-down system.

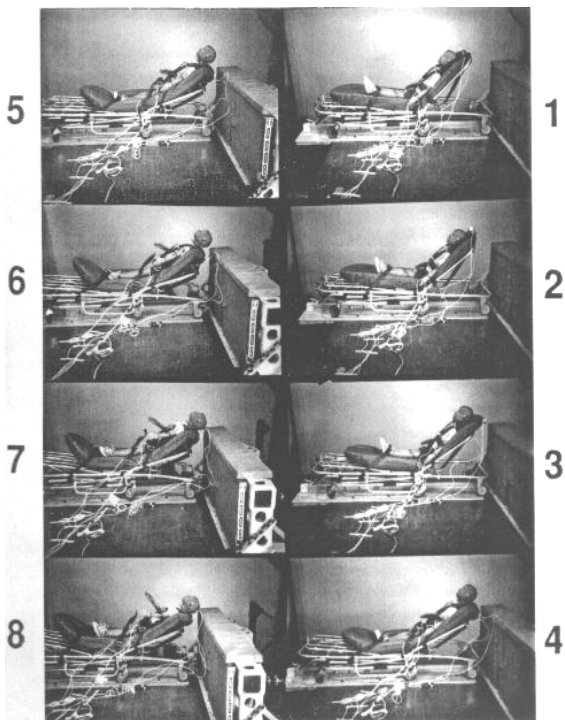


Figure 3. Crash test sequence of a 27-kg child dummy restrained in a standard cot-equipped harness system with an elevated backrest and a crashworthy tie-down system.

## Recommendations

The following recommendations for restraint of children being transported in ambulances are preliminary and are aimed at providing guidance both for field use and for future research and development. They are not specifically endorsed by any child restraint manufacturers, and the usage recommended here may not be consistent with the official instructions for use of a child restraint in a passenger vehicle. Emergency service providers may wish to contact a specific manufacturer for amended instructions.

These recommendations also assume that the ambulance is equipped with a cot and fastener system that has been successfully tested under vehicle crash conditions. Less crashworthy systems may perform adequately in lower speed impacts, but their use could have catastrophic consequences in higher severity collisions.

Even with these recommendations, it is recognized that the very nature of emergency circumstances may require some compromises of best practice. For instance, it is recommended that child restraints not be used again, once they have been in a crash. If a child is found in a convertible child restraint that is still visually intact, however, it may be better to move the child in that restraint to the ambulance for transport than to transfer the child to a different restraint. Likewise, time should not be taken to adjust the height of the shoulder straps of an available restraint if they are not in the best position for rear-facing use.

Use of the EMSC guidelines and the preliminary recommendations provided here will significantly improve the safety of children during ambulance transport. As more information is available about ambulance characteristics and crashes and new products are developed, testing procedures and additional investigations may result in evolving recommendations and establishment of further best-practice procedures. Until additional information is developed, the following recommendations should be incorporated into ambulance transport practice.

### CONVERTIBLE CHILD RESTRAINT SYSTEMS

For restraining children up to about 18 kg who can fit into a convertible child restraint and can tolerate a semi-upright seated position (Figure 4):

- Use only a convertible child restraint, which can be secured with belts against both rearward and forward motion, and select one that has a 5-point harness for routine use. Infant restraints, which have only a single belt path, cannot be installed using this method.
- Position the convertible child restraint on the cot facing the foot-end with the backrest fully elevated. Adjust the restraint recline mechanism so that the back surface fits snugly against the backrest of the cot. The resulting angle should be comfortable for the child but not more than 45° from vertical.
- Anchor the convertible child restraint to the cot using two pairs of belts. One should be attached to the cot backrest in a location that will not slide up or down and routed through the restraint belt path designated for “forward-facing” installation. The other should be attached rearward of the farthest side rail anchor and routed through the restraint belt path designated for “rear-facing” installation.

- Fasten the 5-point harness and snugly adjust it on the child. Ideally, the shoulder straps should be through slots at or just below the child's shoulders, since the convertible child restraint will be oriented rear-facing.
- For small infants, place rolled towels or blankets on either side of the child to maintain a centered position in the restraint.



Figure 4. Recommended method for restraining children up to about 18 kg who can tolerate a semi-upright seated position, showing belt attachment to the cot and routing through the convertible child restraint.

### CAR BED SYSTEMS

For restraining infants who cannot tolerate a semi-upright seated position or who, for other reasons, must lie flat (Figure 5):

- Use only a car bed that can be secured with belts against both rearward and forward motion. Car beds with a single belt installation cannot be installed using this method.
- Position the car bed across the cot, so that the child lies perpendicular to it, and fully raise the backrest.
- Anchor the car bed to the cot with two pairs of belts attached to the cot as described above.
- Fasten the harness or other internal restraint and snugly adjust it on the infant.

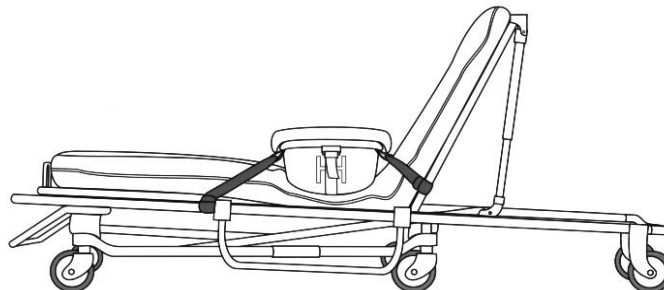


Figure 5. Recommended method for restraining infants who cannot tolerate a semi-upright seated position, showing belt attachment to the cot and routing through the car bed loops.

## HARNESS SYSTEMS

A recommendation cannot be made at this time for restraint of a child who cannot be accommodated in a convertible child restraint or car bed, either due to size or medical condition. Instead, recommendations are made for the design of an effective harness system for use on an ambulance cot. Harness features needed are

1. fixed shoulder belt attachments or slots at or just below the child's shoulders to limit ramping;
2. a belt anchored to the lower side rails of the cot that is restricted from sliding and is routed over the thighs, not around the waist;
3. a belt running parallel to the cot that connects the lap belt to a non-sliding cot member or perpendicular belt in the leg area to keep the lap belt in place and restrict ramping;
4. a soft, sliding, or breakaway connector holding the shoulder straps together on the chest; and
5. lightweight one-handed strap adjusters.

At present the usual alternative for these children is the standard belt system provided on the cot. It is hoped, however, that these recommendations will hasten the development of new harness products.