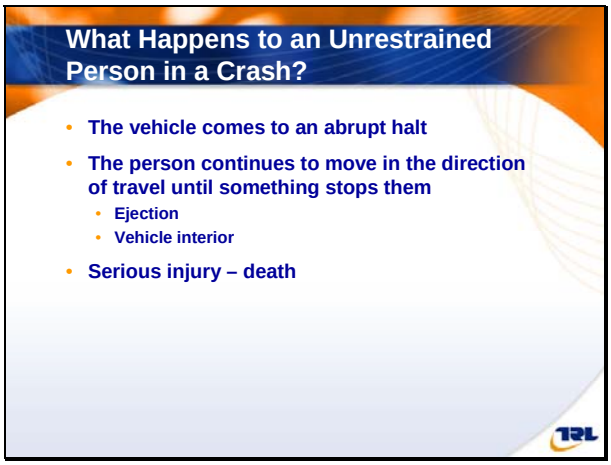
MODERN SAFETY STANDARDS

Marianne Le Claire

Head of Child Safety and Wheelchair Safety in Vehicles

TRL Limited



Why Use a Restraint System?

- Prevents ejection
- Reduces possibility of contact with the vehicle interior
- Reduction of injuries in an accident
  - A restraint system distributes the forces over the strongest parts of the body with minimum damage to the soft tissues

The Three Point Seat Belt

- The main restraint system provided in cars
- Compulsory to wear a seat belt in the front seat since 1983.
- Estimates - wearing of seat belts compared to no seat belt – injuries reduced
  - Minor casualties by 1,590,000
  - Serious casualties by 590,000
  - Deaths by 50,000
- Seat belts provide a high level of protection
- BUT they are optimised for people ? 150 cm tall

What about Children?

- Children cannot achieve the correct placement and fit of the adult belt over their shoulders and pelvis
- For infants, it is necessary to apply the restraint force over different areas of the body to that of an older child
- A dedicated child restraint system must be used to accommodate the needs of children in cars

The Developing Child

- Understanding of the anatomy, growth and development of children is critical
- Children are not simply smaller adults
  - Proportioned differently
  - Key organs are in different places
  - Tissues have different biomechanical properties
- Needs change as they grow

Infants - Head

- At birth, the head is around 25 percent of their total length and about 30 percent of their body weight
- Skull bones of a new born infant are separated by membrane-filled spaces – fontanels
  - Enable skull to change size and shape during birth
  - Permit rapid growth of the brain during infancy

Infants - Head

- Fontanels
  - Replaced by bone
  - Sutures found in adult skulls
  - Process takes many months to complete
- Some sections are joined within 2 or 3 months of birth but the largest of the fontanels is not closed until 18 – 24 months after birth

Infants - Head

- Skull bones are very thin and the fontanels increase the flexibility of the structure
- Relatively low levels of impact loading can result in significant deformation of the skull and brain
- The smaller the child, the lower the energy involved in the injury

Infants - Neck

- Relatively large head mass to support - developing neck structures
  - Neck injury mechanisms
- It is not simply a question of size
- Immature spines are much more flexible than would be expected by relative size alone
- Structural and material properties are important

Infants - Neck

- Each vertebra - bony segments and cartilage
  - Ligaments are loose to accommodate growth
- Spinal column and ligaments of infants are fairly elastic allowing elongation of up to 50 mm
- Spinal cord ruptures when stretched more than 6 mm
- Spinal cord injury can occur without vertebral damage

Infants - Chest

- Rib cage forms from cartilage and has high degree of flexibility in very young children
- Impact to the chest can result in large compression of the chest wall onto the heart and lungs
- When restraining adults some of the forces are applied to the chest
  - The shoulder and ribs can withstand the load
- This approach is not appropriate for infants

Infants - Abdomen

- The infant abdomen differs both proportionately and in relation to the position of the organs
- Any blunt trauma is potentially injurious
  - Muscle wall is undeveloped
  - Limited skeletal protection
- The liver is particularly at risk
  - Occupies 2/5 of abdominal cavity
  - Not protected by rib cage

Infants - Pelvis

- The pelvis at birth
  - 3 bones connected by cartilaginous tissue
  - Allows relative motion
- Ligaments are more elastic
  - Large displacements without fracture
- Infant pelvis
  - Unstable
  - Unable to withstand the forces from a restraint system

Infant - Restraint

- Motion of the head with respect to the torso must be avoided
- Elastic nature and small size of the infant rib cage and pelvis preclude webbed restraints
- Restraint forces must be distributed as widely as possible over the strongest parts of the body
- In the case of infants, the back is the strongest body surface

Infants – Best Practice

- A rear facing child restraint system is therefore the only solution for protecting infants
- Children should remain REAR FACING until they reach 18 – 24 months
- Rear facing CRS solutions up to 13kg
  - 50th% male – 27 months
  - 50th% female – 30 months

Childhood - Head

- Fontanels closed
  - Thickness and composition of skull still different to adult's
- Ossification not complete until age of 6 or 7
  - Throughout childhood stiffness of skull is less than that of an adult
- Restraint system must:
  - Limit forward head excursion in a front impact
  - Provide protection from intrusion in a side impact

Childhood - Spine

- Muscles and ligaments strengthen
- Bones grow and reach a mature shape and size
- Areas of cartilage and soft bone are replaced with normal calcified bone
- Risk of neck injury in car accidents remains
- Risk of spinal cord damage due to inertial loading from the head has reduced
  - If a child is very heavy for their age >13kg they can forward face from the age of 1 year

Childhood - Chest

- Chest increases in width and depth - elongation takes place
- Raises the child's sitting shoulder height and affects the fit of a restraint system
- Adjusting the shoulder straps is necessary to accommodate children of different sizes
- Ribs remain flexible, but calcified bone gradually replaces soft bone and their strength increases

Childhood – Abdomen and Pelvis

- Abdomen - Rib cage develops downwards
  - Some protection of the liver, spleen and kidneys
- Pelvis - grows larger
  - Greater protection of some abdominal organs such as the bladder
- Formation of superior anterior iliac spines is not complete until around the age of 10
  - Pelvis needs to act as anchor point for belt restraint systems
  - Small, undeveloped pelvis
  - Lap part belt can slip off during crash and load abdomen

Childhood - Restraint

- Protection of the head – priority
- Protection from contact with the vehicle interior in both front and side impact
- Belt must remain on areas with a protective bony structure
- Restraint forces need to be distributed over as wide an area as possible
- Proper placement and good fit of the harness or belts

Childhood - Restraint

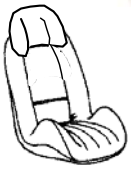
- Best type of child restraint system for early childhood is the child safety seat
- A five point harness secures the child - forces distributed over wide area
- Fifth point keeps the lap straps on the pelvis rather than the soft abdomen
- Booster seats are best used only when a child has outgrown a safety seat
- Boosters raise the seating position of the child so that the adult seat belt fits them properly

Childhood – Best Practice

- Once a child reaches 13kg they will need a forward facing safety seat with a 5-point harness system
- They should stay in this type of seat for as long as possible
  - >3 years
- EITHER their weight exceeds 18kg OR they grow too tall for the height of the harness

Childhood – Best Practice

- Once the safety seat is outgrown
- Booster seat
  - Back and side wings
  - Works with the adult belt
- Head protection adjusts to accommodate children up to 11 yrs old



Restraining Children – Best Practice

Presented by Marianne Le Claire
Head of Child Safety and Wheelchair Safety in Vehicles
Tel: 01344 770980 mleclaire@trl.co.uk