Good, Better, Best: What about rear impacts and other seating positions?

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Lifesavers 2018
Session: Good, Better, Best: Laws, Best Practice & Car Seat Instructions
Rear-facing CRS in rear impacts
Rear-facing orientation is safest for children under two years of age.

Studied extensively for frontal and side impact.

What about when crash forces are reversed in a rear impact?
- Child is now facing the direction of impact.
Objective 1:
Literature Review
• Jakobsson et al. 2005: Volvo crash database
  - Includes 454 children in rear-facing CRS
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No rear-facing children suffered injuries more than AIS 1 in side or rear impacts!
Literature: Children

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  – Includes 454 children in rear-facing CRS

No rear-facing children suffered injuries more than AIS 1 in side or rear impacts!

“The rearward-facing child seats are designed primarily for frontal impacts, however the outcome for side and rear-end impacts indicates a good performance also in these situations.”

--Jakobsson et al. 2005
Langwieder et al. 1999: Institute for Vehicle Safety (IFV) study in Germany. Small sample size of 42 rear-facing children.

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“Hence, rearward facing infant carriers have a low risk of injury in rear-end collisions.”

--Langwieder et al. 1999
• Rear impacts appear to be low risk for children, even those in RF CRS.
• However, sample sizes for children are small.
Objective 2: Sled testing
Sled testing

Sedan seat

Four CRS models
Target:
ECE R44 corridor (UNECE, 2014) (European standard)

Actual:
Peak velocity: 18.4 ± 0.1 mph
Peak g’s: 17.5 ± 0.1 g

~80th percentile in terms of rear impact severity
Handle stowed
Handle upright
Sled testing

Handle stowed with anti-rebound bar
Sled testing

Handle stowed
Handle upright
Anti-rebound bar

Lowest neck loads
(tension and compression)

All trials for this CRS:
Low Head Injury Criteria (HIC15) near 32-38 (injury threshold is 389 (Mertz et al. 2016))
Chest acceleration near 31-32 g (injury threshold is 60 g (NHTSA, 2011))
Sled testing

12-month-old (CRABI)
Sled testing

3-year-old (Hybrid III)
12-month-old

Higher neck compression, flexion moment, and extension moment (but still below injury thresholds)

3-year-old

Very similar HIC15 values (16 and 19) with injury thresholds of 389 and 568 (Mertz et al. 2016)
Objective 3: Communication with Caregivers
“If a child is rear-facing and you get hit from behind, isn’t that the same as a forward-facing child in a frontal crash?”
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First off—This is a really great question!
“If a child is rear-facing and you get hit from behind, isn’t that the same as a forward-facing child in a frontal crash?”

First off—This is a really great question!

No, it’s not the same:

RF CRS interact with the vehicle seat to absorb crash forces.

FF CRS rely primarily on the five-point harness to restrain the occupant.
Communication with caregivers

Forward-facing in frontal impact
Communication with caregivers

Forward-facing in frontal impact
Communication with caregivers

Forward-facing in frontal impact

Occupant projects out of CRS

CRS is stationary
Communication with caregivers

Forward-facing in frontal impact

- Occupant projects out of CRS
- CRS is stationary
- Torso engages **quickly**, head continues forward.

Frontal impact
Forward-facing in frontal impact

Occupant projects out of CRS

CRS is stationary

Torso engages **quickly**, head continues forward.

Rear-facing in rear impact

CRS interacts with vehicle seat.
Communication with caregivers

Forward-facing in frontal impact

- Occupant projects out of CRS
- CRS is stationary
- Torso engages quickly, head continues forward.

Rear-facing in rear impact

- CRS interacts with vehicle seat.
- Torso engages slowly, head stays aligned.
• Rear-facing CRS have features to mitigate forces in rear impacts
  – This crash mode is different than a forward-facing CRS in a frontal impact.
• These data are insufficient to conclude whether RF or FF is safer in a rear impact scenario.
• Ultimately, these conclusions align with best practice recommendations to keep children rear-facing.
• More results in publication: SAE International 2018
Center vs. outboard seating positions
• How can a CPST help a caregiver choose the best seating position for their child?
  – What is the “best”?
  – Are there other good/better options?
  – What factors should the caregiver consider?
Near side impact
Far side impact
Center seating position keeps occupant away from both doors
• Kallan et al. 2008
  – Children ages 0 to 3 years, 1998-2006
  – Insurance claim records and telephone survey
  – Reported injury corresponding to AIS ≥ 2
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  - Reported injury corresponding to AIS ≥ 2

- Injury risk (as a percentage of population)
  - Left outboard: 0.27%
  - Center: 0.17%
  - Right outboard: 0.29%

43% lower injury risk than outboard positions
• Kallan et al. 2008
  – Children ages 0 to 3 years, 1998-2006
  – Insurance claim records and telephone survey
  – Reported injury corresponding to AIS ≥ 2

  – Injury risk (as a percentage of population)

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All positions showed <5 injuries per 1,000 children
• Kallan et al. 2008

These data do not indicate the outboard position is a poor choice… but rather, given available space and ability to obtain a tight installation, the center position allows for further reductions in injury risk beyond the already excellent protection afforded by CRSs attached in the outboard positions.

-Kallan et al. 2008

– Injury risk (as a percentage of population)

Left outboard 0.27%
Center 0.17%
Right outboard 0.29%

All positions showed <5 injuries per 1,000 children
• **Supporting literature:**
  – Howard et al. 2004
    • *Near side:* 7 injuries per 1,000 children
    • *Center:* 2 injuries per 1,000 children
    • *Far side:* 1 injury per 1,000 children
• Opposing literature:
  – Lund, 2005
    • Found no significant differences among all rear row positions using police report data
    • 0.12% to 0.14% injury risk across all positions
  – Maltese et al. 2004
    • For older kids (4-15 yo), the center and near side position performed similarly
    • Benefit in far side position only (45% reduction)
Challenges with Center Position

- Center position seat belts can be narrow
- Center position LATCH is often not available
- CRS interference with front row seat
- Difficult for caregivers to reach center, especially in large vehicles
- Two rear seat passengers fit best in outboard positions
Communication with Caregivers

- Slight benefit of center position
- Outboard positions are not inherently bad choices

*The safest position is where ever the caregiver can get a good installation and use the CRS correctly during every single ride.*
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Please use the Lifesavers Conference Mobile App to evaluate this presentation.
Thank you!

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Center for Child Injury Prevention Studies (CChIPS):
www.cchips.research/chop.edu

Buckle Up with Brutus (Caregiver-oriented):
www.buckleup.osu.edu