



CIREN



A Real Time Forensic Center

Martin Eichelberger, M D



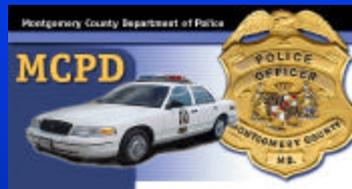
CIREN Case Reviews



- **Create a forum**
- **Promote discussion**
- **Link injury and engineering**
- **Educate all constituencies**
- **Permit consensus**
- **Develop public policy**



CIREN Case Review Coalition Partners



**Montgomery County
Fire & Rescue Service**
Montgomery County, Maryland





- **Child Restraint Selection**
- **Seatbelt Analysis**
- **Child Safety Seat Analysis**
- **Frontal vs. Lateral Crash Analysis**



Child Restraint Selection

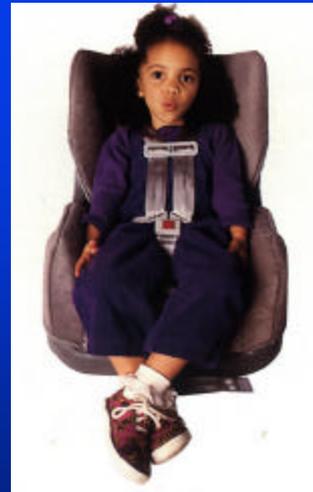
Types of Child Safety Seats



1. Infant Only



2. Convertible



3. Booster





INFANT SEATS



- < 1 year
- < 20lbs.
- Rear-Facing Only



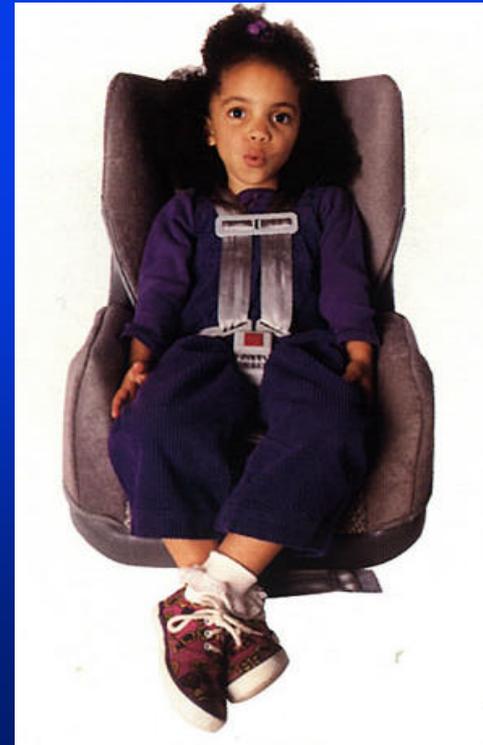


CONVERTIBLE SEATS

- < 20 lbs
- Rear-facing



- 20-40 lbs
- Forward-facing





BOOSTER SEATS



Belt-positioning Booster

- 40 - 80 pounds.

Shield Booster

- No longer recommended

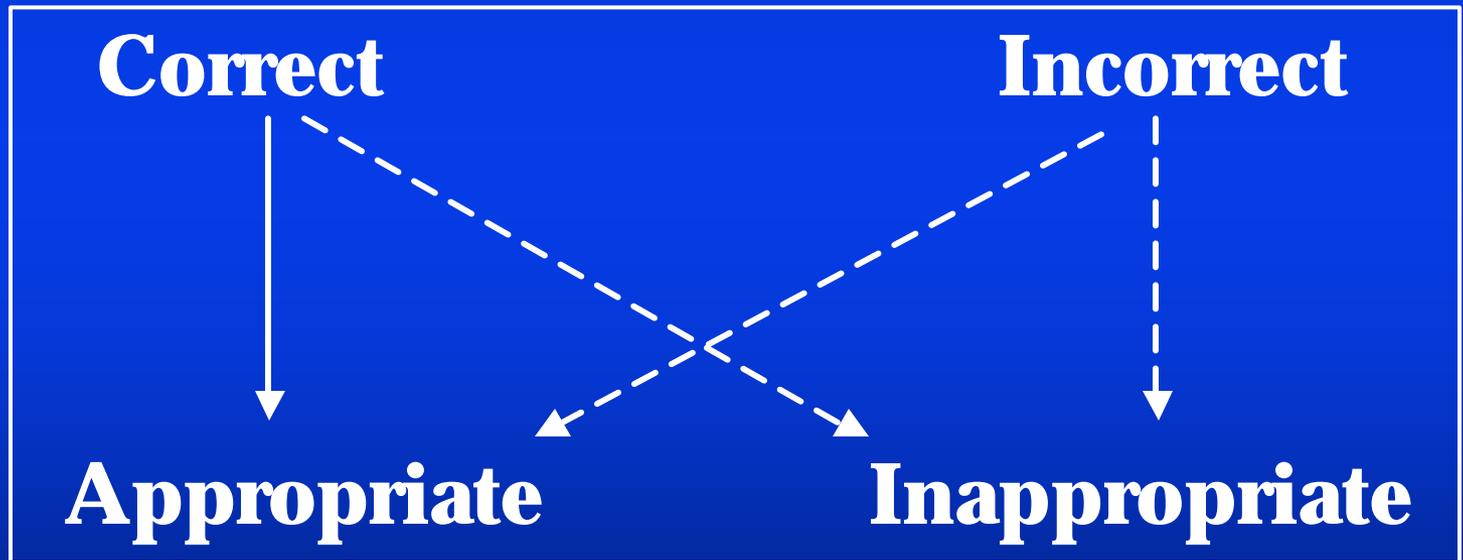




Child Restraint Use/Misuse



HOW:



WHO:



Identify Misuse

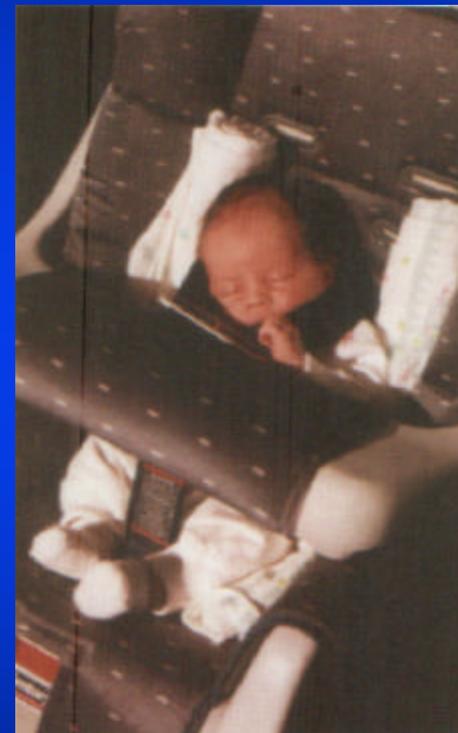


Issues:

- Variety of Devices
- Appropriate Size / Weight
- Correct Installation
- Variety of Seats / Seatbelts



Appropriate



Inappropriate



SAFEKIDS Restraint Use Study: Rear-facing Seat Misuses



• 30% Rear-Facing Seat Not At 45° Angle

• 35% Harness Straps Not Snug

• 61% Seat Belt Not Anchored Tightly

SAFEKIDS Restraint Use Study: Forward-facing Seat Misuses





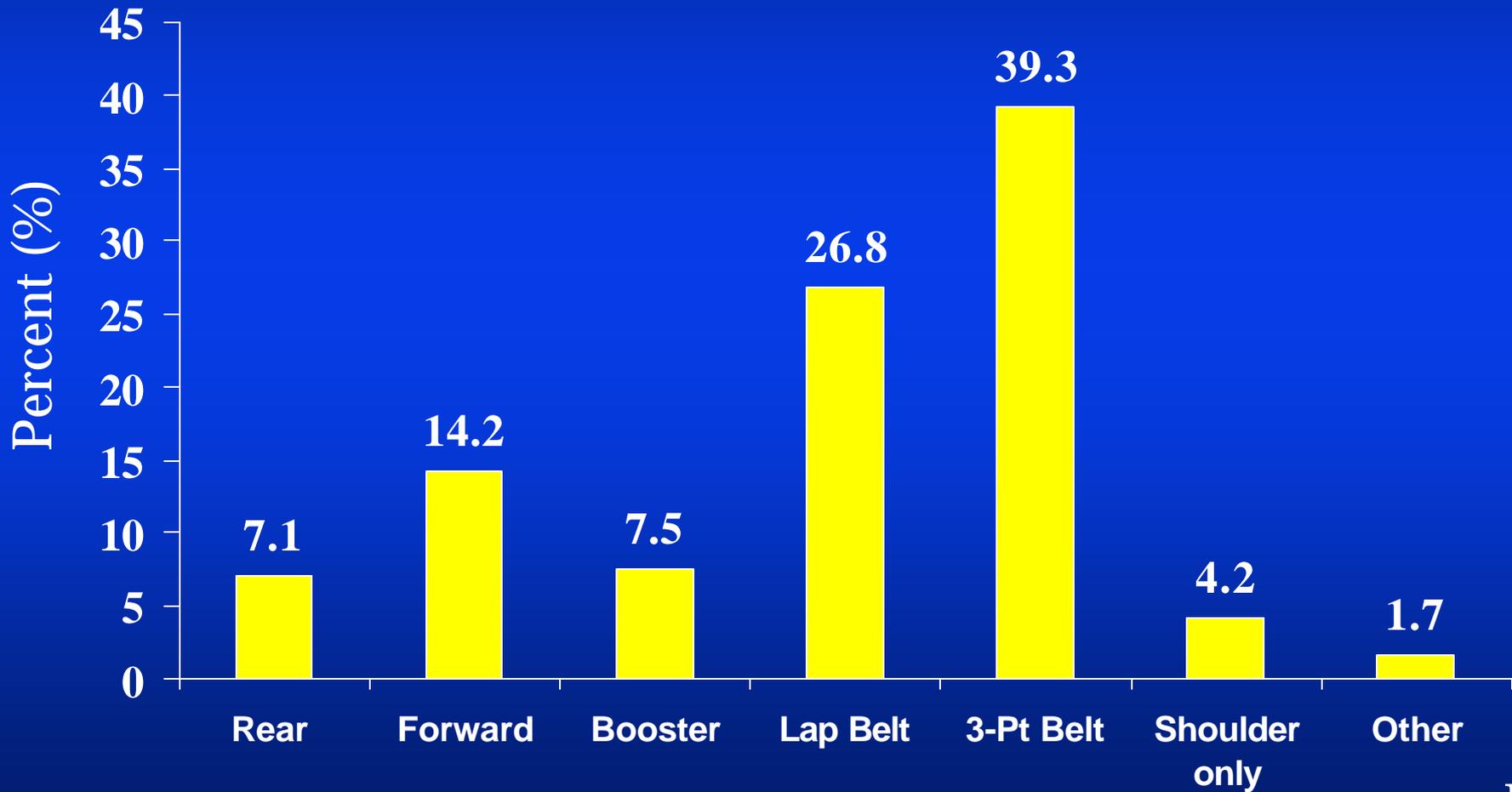
Data Summary

242 Children

Mean:	Age	6.1 years
	Length of Stay	6.26 days
	ISS	11.59
	Cost	\$24,500
	Delta V	22.6 mph
Mortality:		4.1% (n=10)



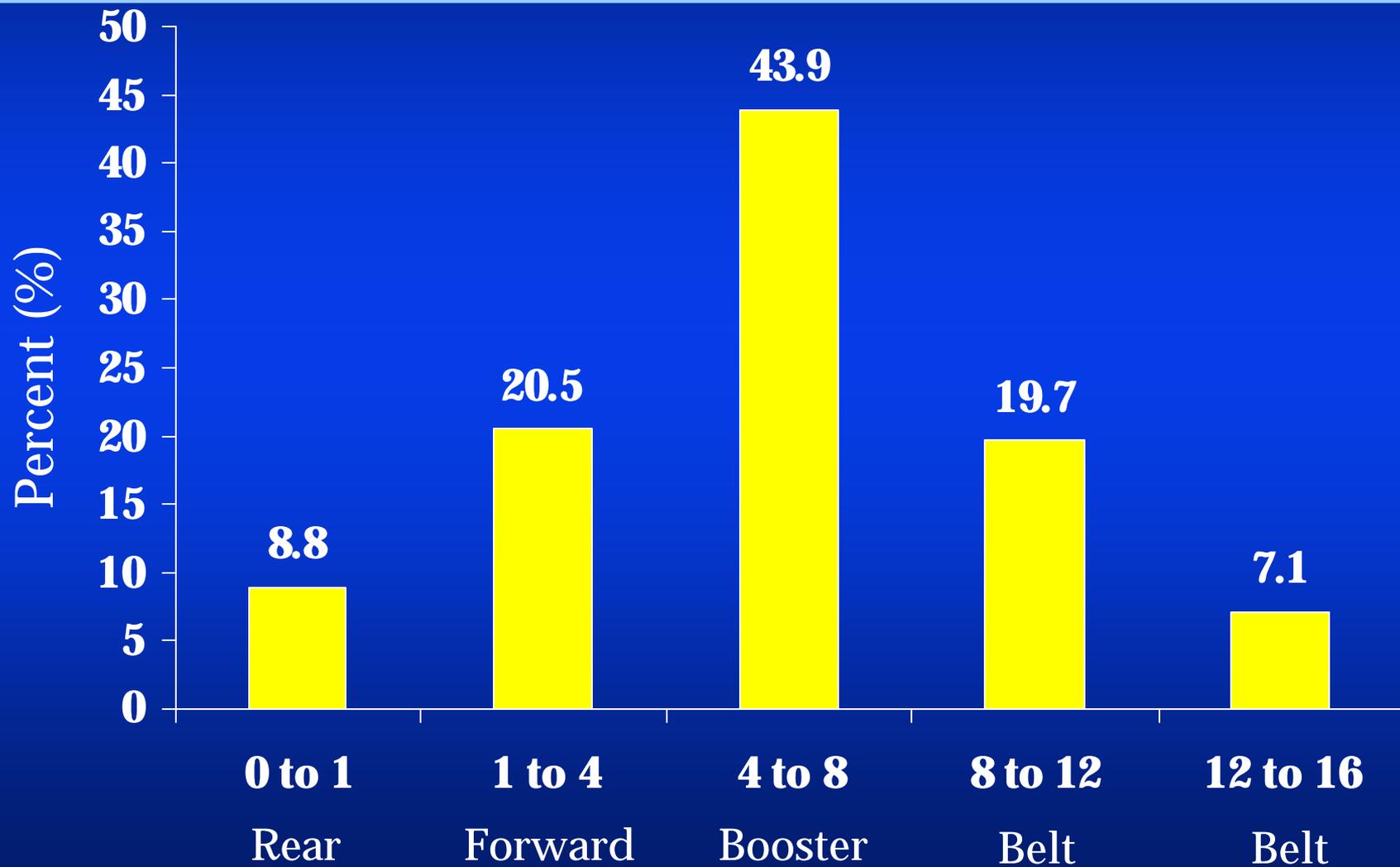
Restraint Distribution



N=249



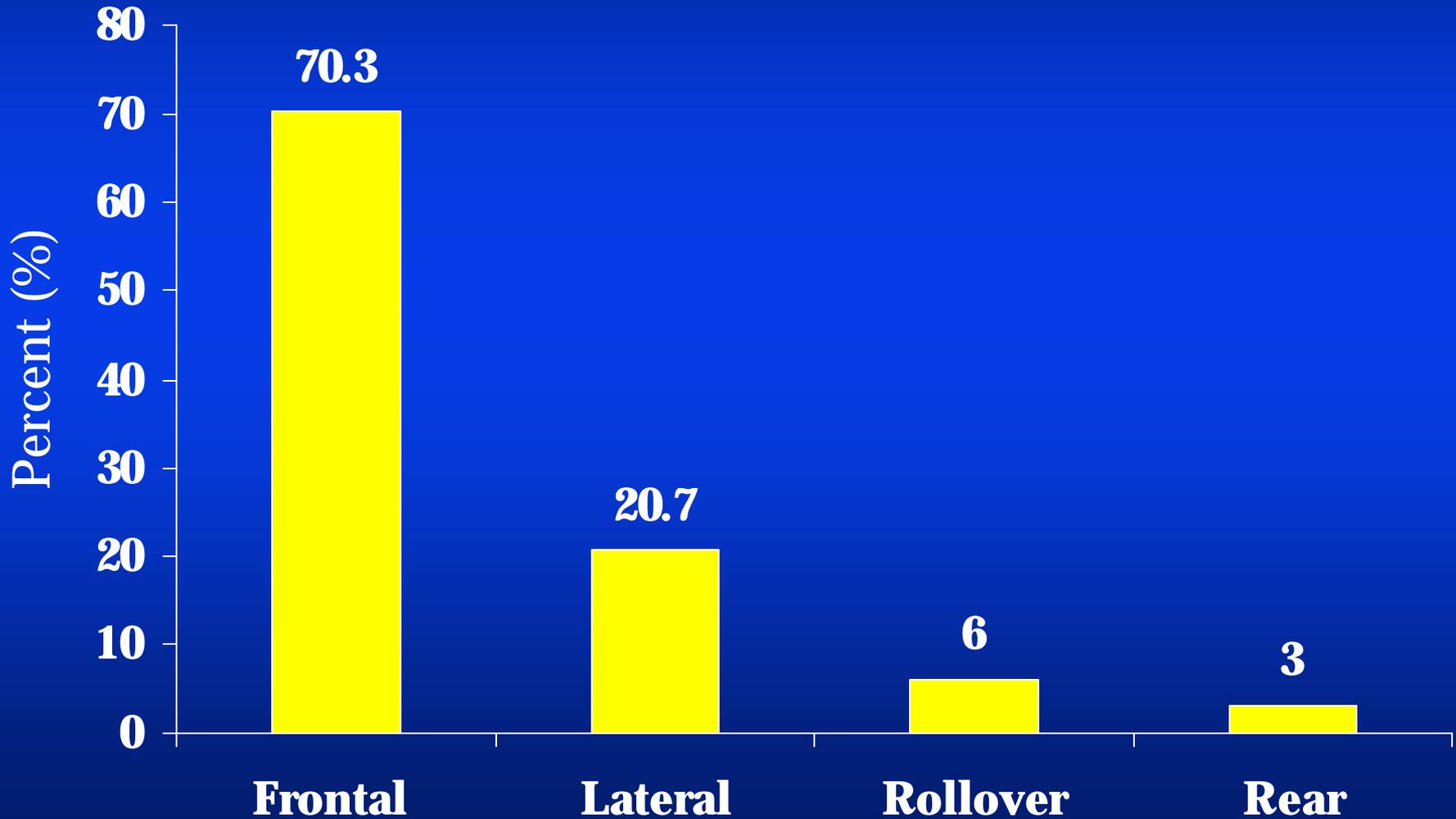
Age Distribution



N=9



Crash Type



N=2



Seatbelt

Injury Analysis



Seatbelt Readiness



- **3-pt. Lap/shoulder belt:**



Appropriate

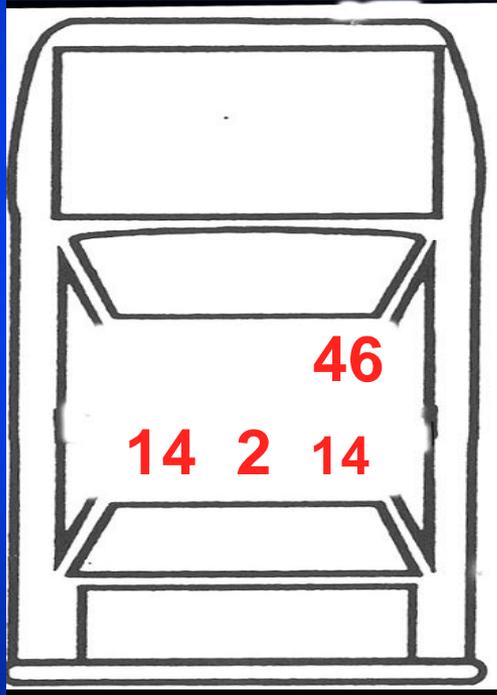
**Wt. > 80 lbs
Ht. > 58 in.**



Inappropriate

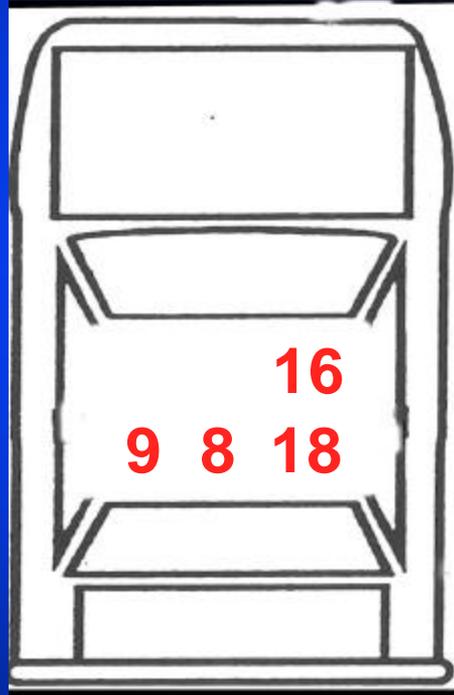


Seatbelt Injuries: Seating Position



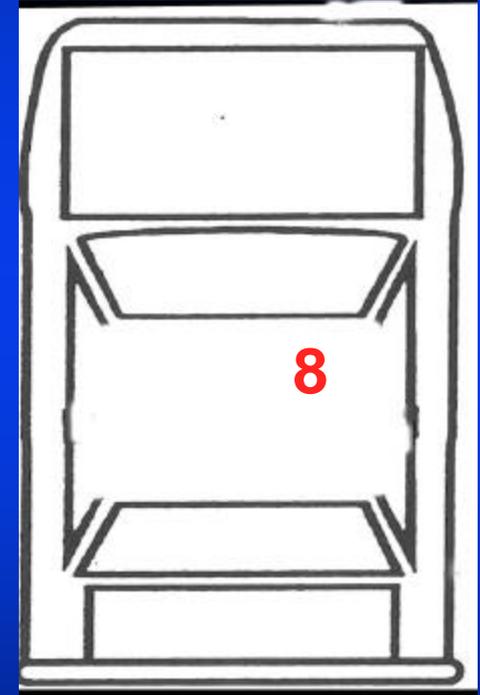
LAP/SHOULDER

n=76



LAP ONLY

n=51

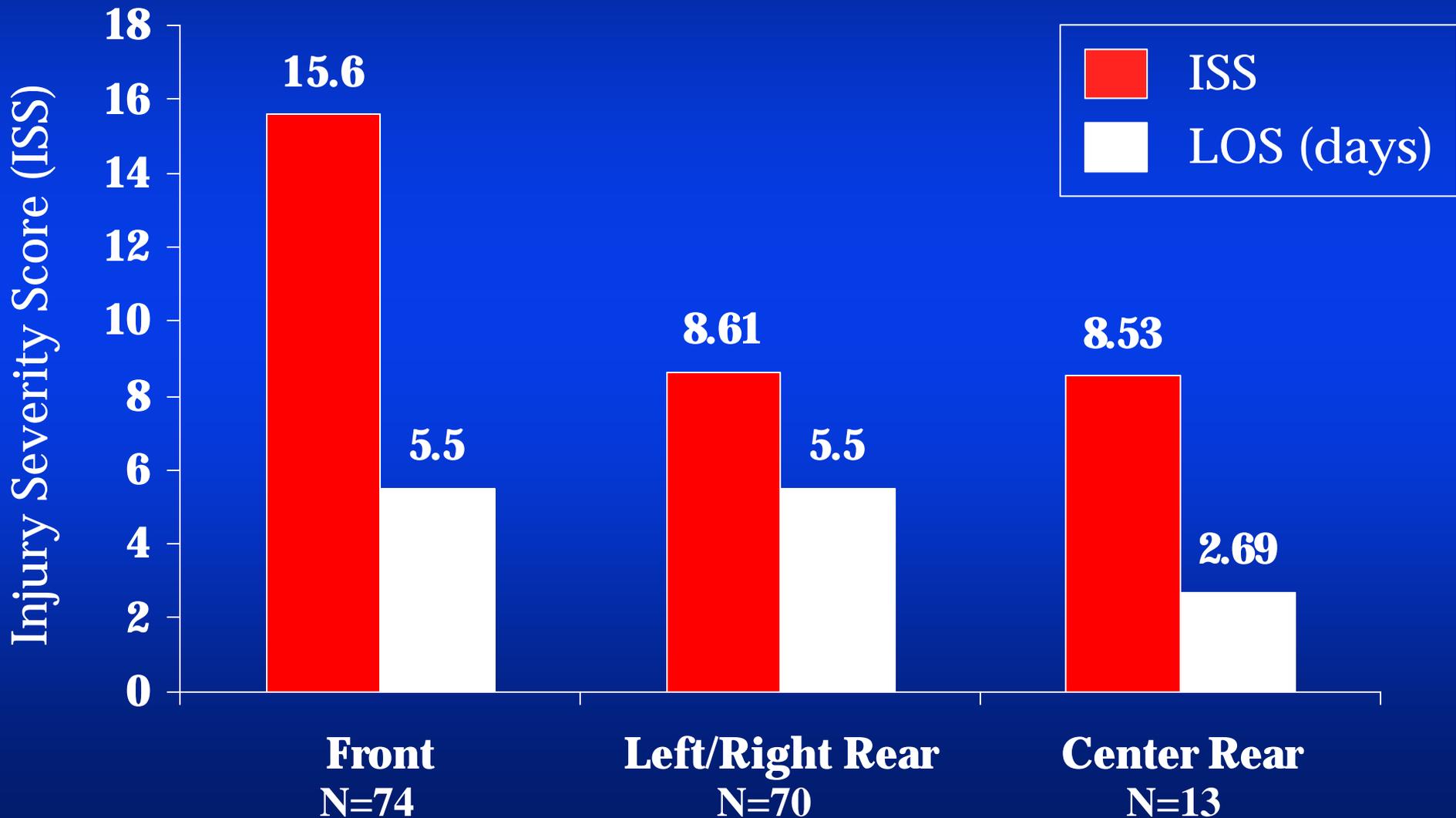


SHOULDER ONLY

n=8



Seating Position



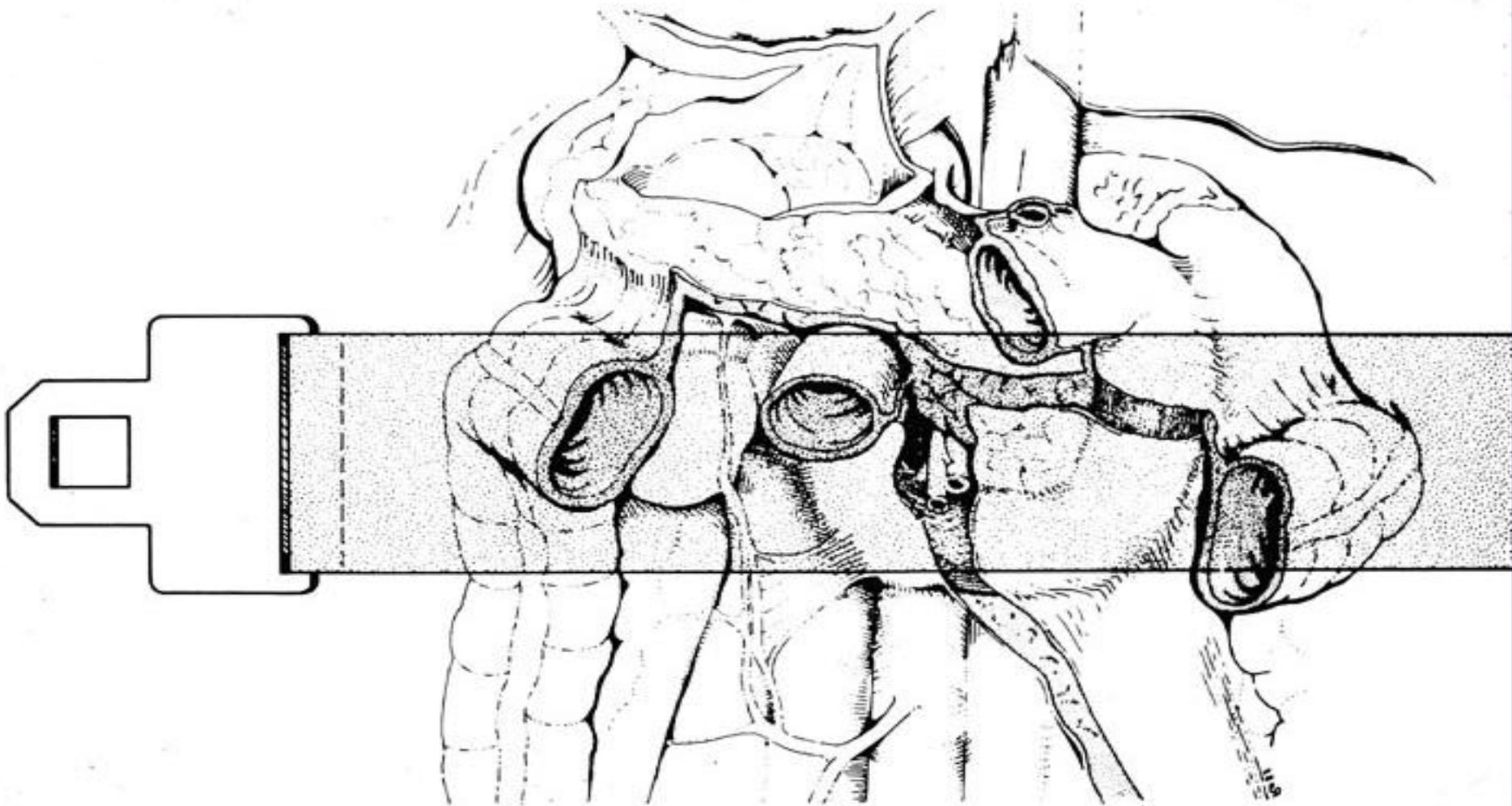


Lap Belt





Anatomy





Lap Belt Complex



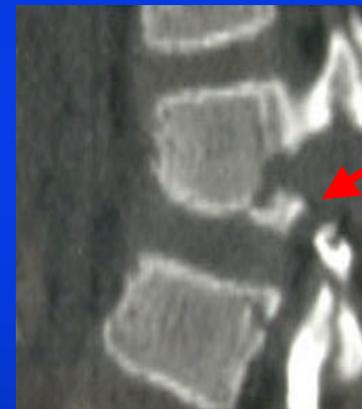
Hyperflexion



Lap belt Ecchymosis



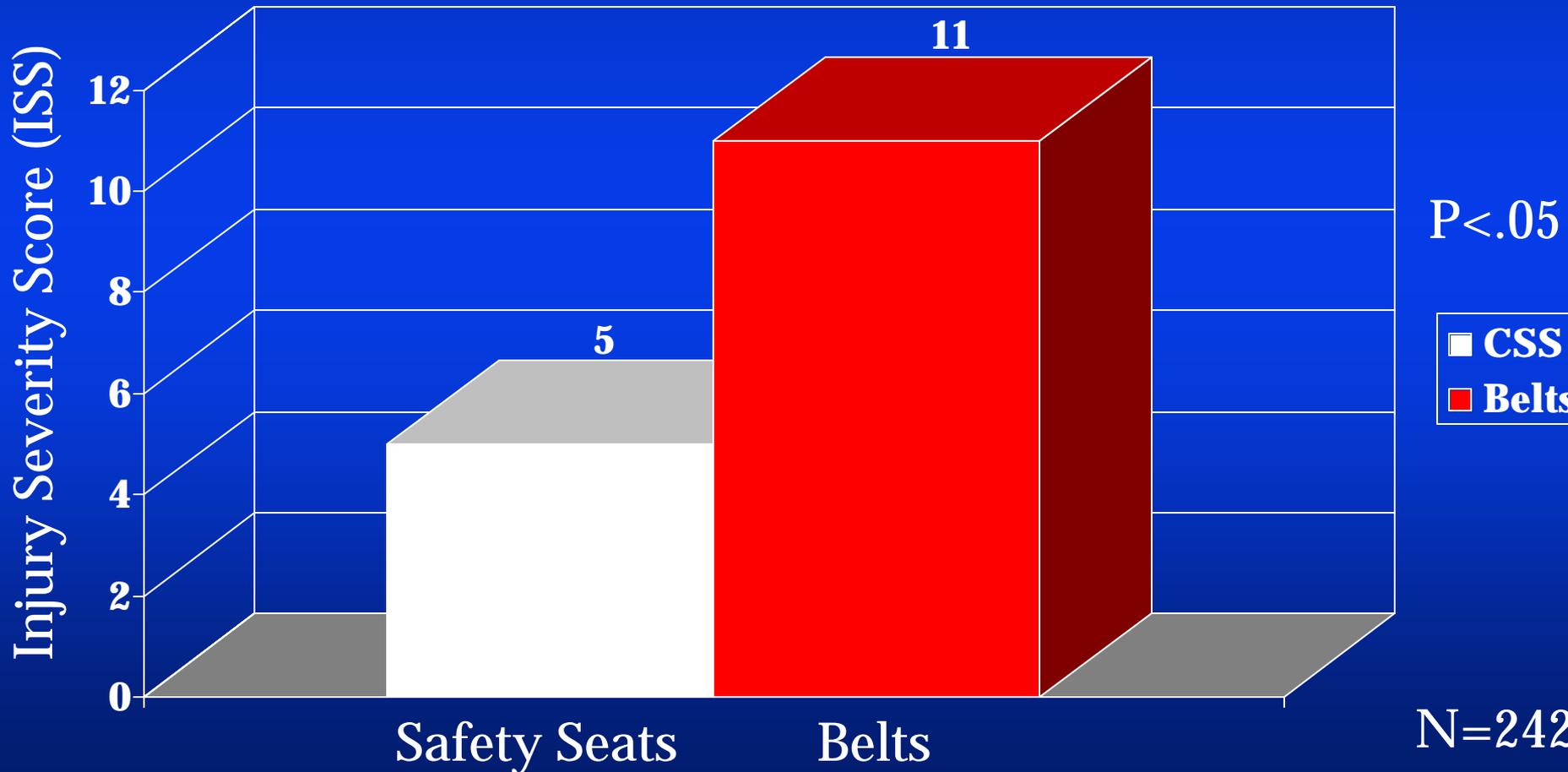
Ruptured Intestine



Chance Fracture



Safety Seats Vs. Belts





Seatbelt Injury: Head



Injury	%	ISS (mean)	COST (mean)
Any Head Injury	79	5	\$6,293
Hemorrhage	51	3	\$5,431
Concussion/Cereb. Cont.	16	11	\$9,731
Skull Fracture	13	10	\$11,323
Mult. Skull Fractures	6	10	\$10,677
No Head Injury	21	8	\$11,301



Seatbelt Injury: Other



Injury	%
Trunk Contusions	59
Extremity Injuries	59
Contusion/Superficial	41
Fractures	18
Internal Abd./Pelvis	20
Spinal Fracture	14
Internal Chest	11



N=13



Seatbelt Injury: Contact Points



Contact Source	Injuries (%)
Lap/Shoulder Belt	25
Instrument Panel	11
Seat Back	8
Floor Panel	8
Non-Contact	3



N=138

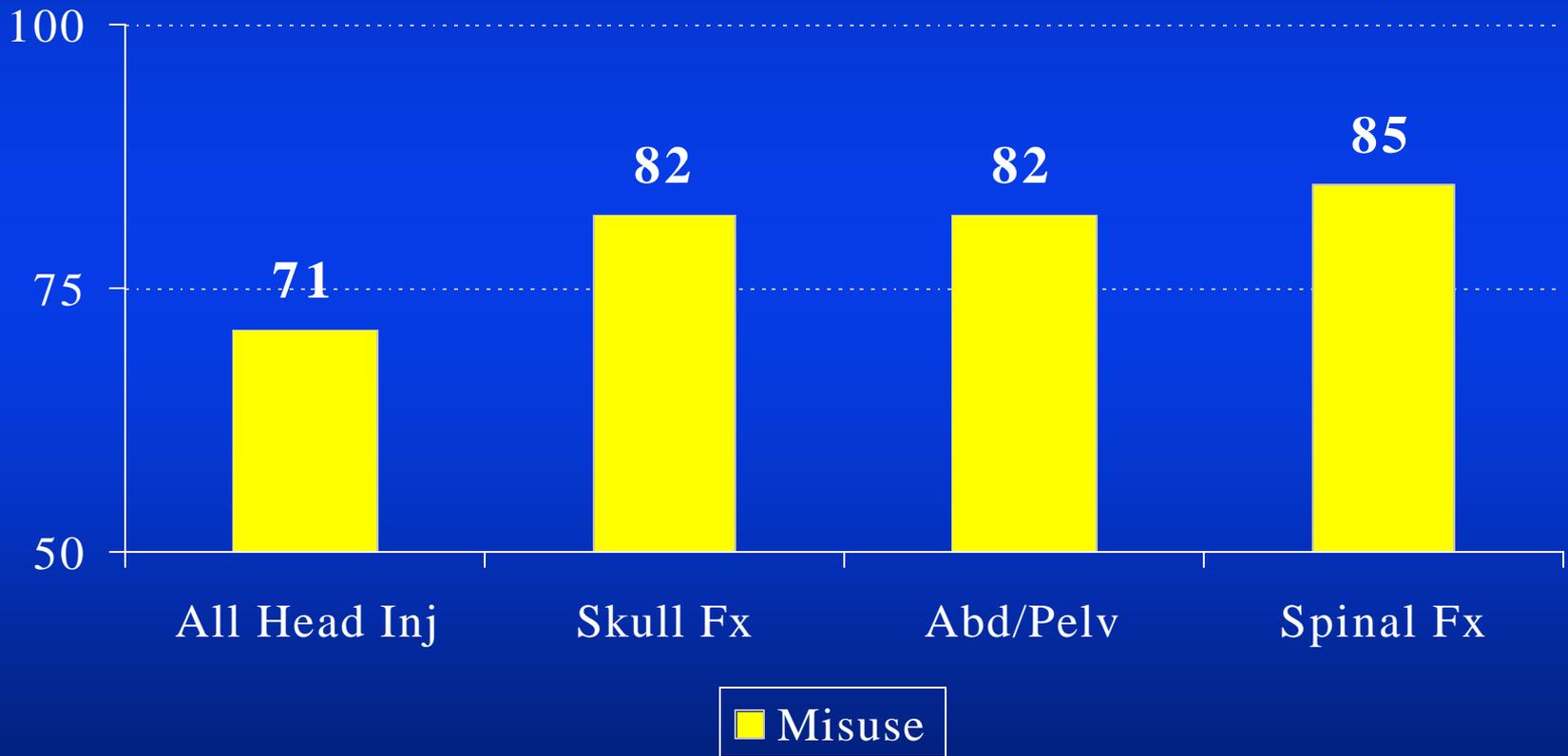
Seatbelt Injury: Belt Misuse



Misuse	(%)
Behind Back	21
Under Arm	7
Right Front Seat	7
Shoulder Only	6
Loose Belt	6



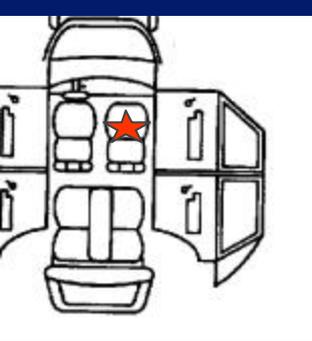
Percent of Seatbelt Injuries Associated with Misuse





Case Example: Seatbelt Syndrome

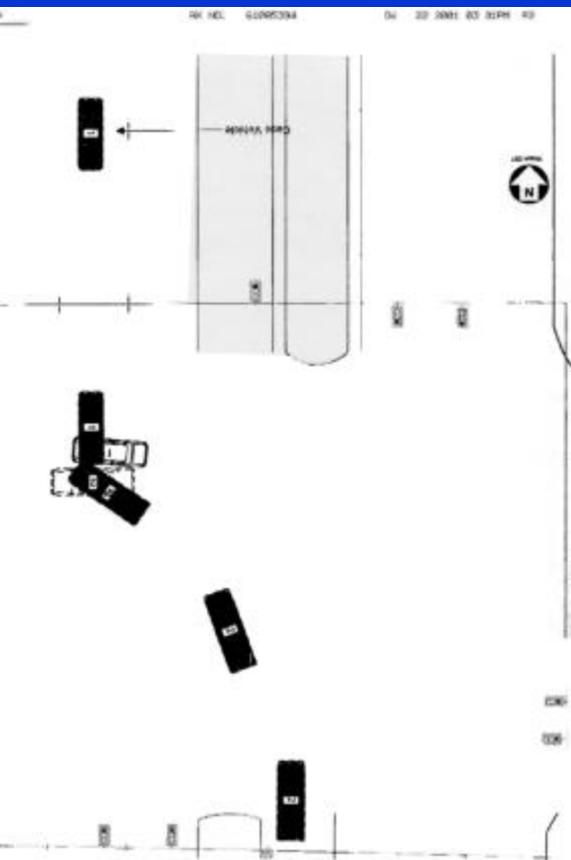
- **Frontal Impact**
- **5-yo female**
- **55 lbs., 45 in.**
- **Front**
- **3-pt.; Air bag deployed**
- **Inappropriate**



Seating Position

Scene and Auto

Crash Investigation



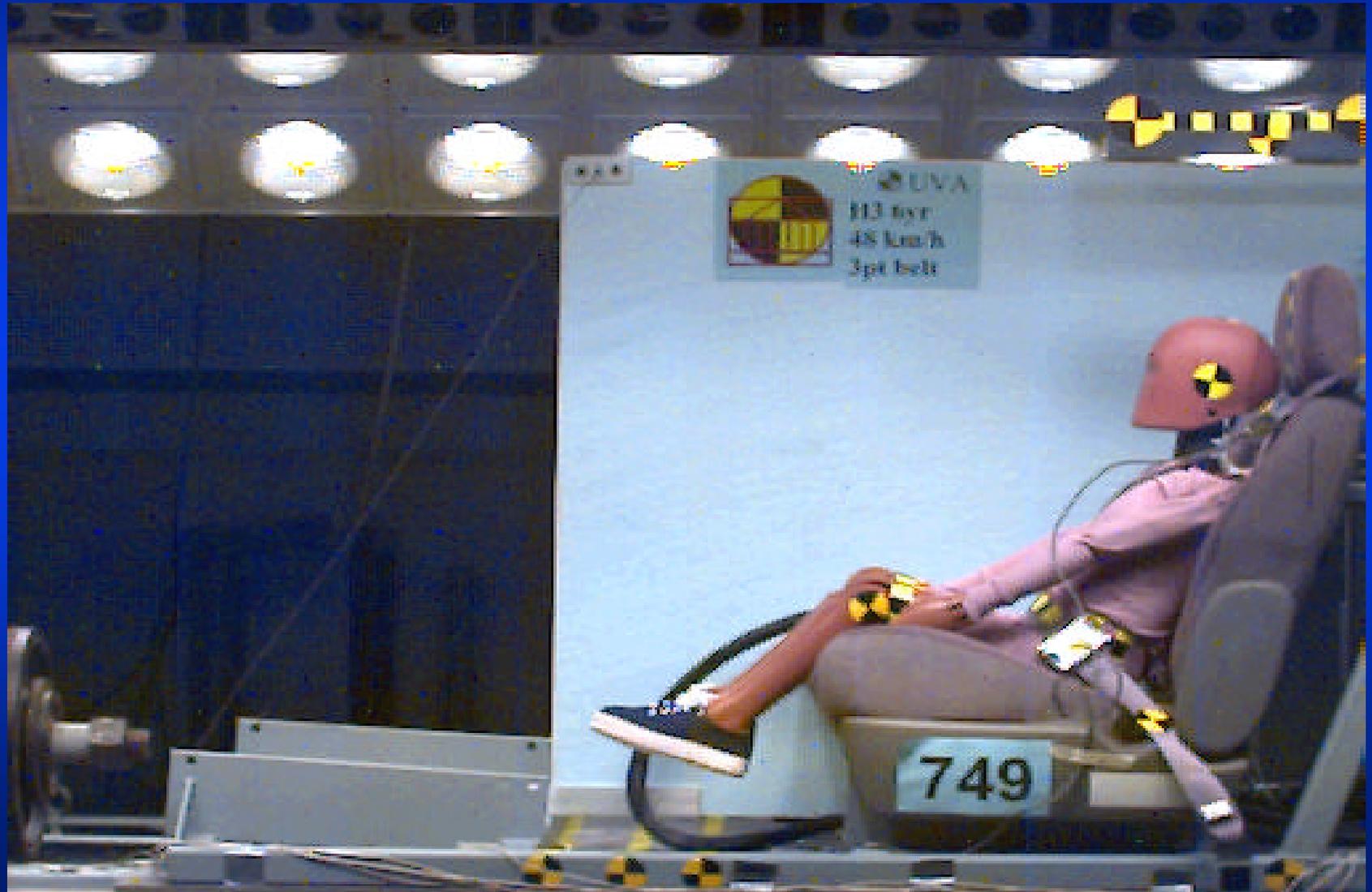
- **1999 Hyundai Accent**
- **Frontal Impact**

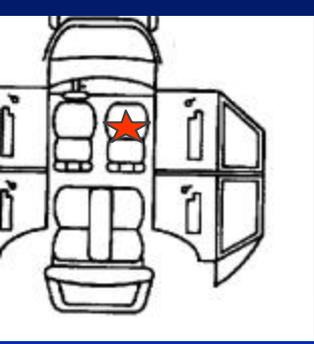
- **Max Crush: 15 in**
- **Delta V: 18.6 m/s**
- **PDOF: +32°**





6-year old - 3-pt. belt - 30 mph



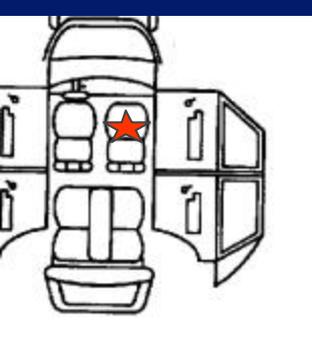


Seatbelt Syndrome



- Contusions
- Abrasions

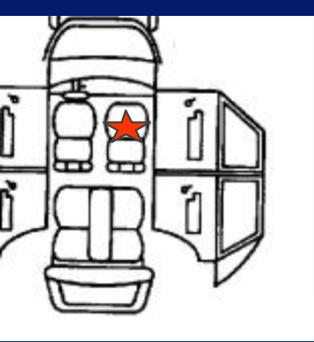
- Surgical incision
- Dx: Bladder Rupture



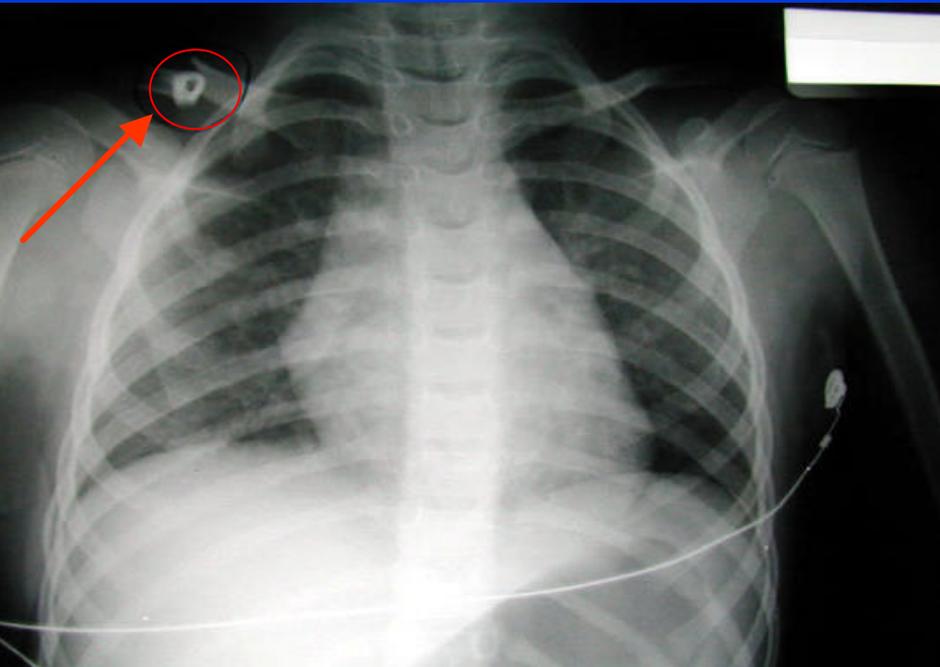
External Injuries

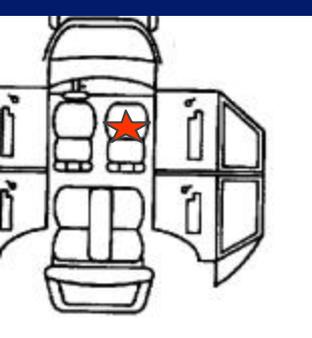


- Right Shoulder Contusion

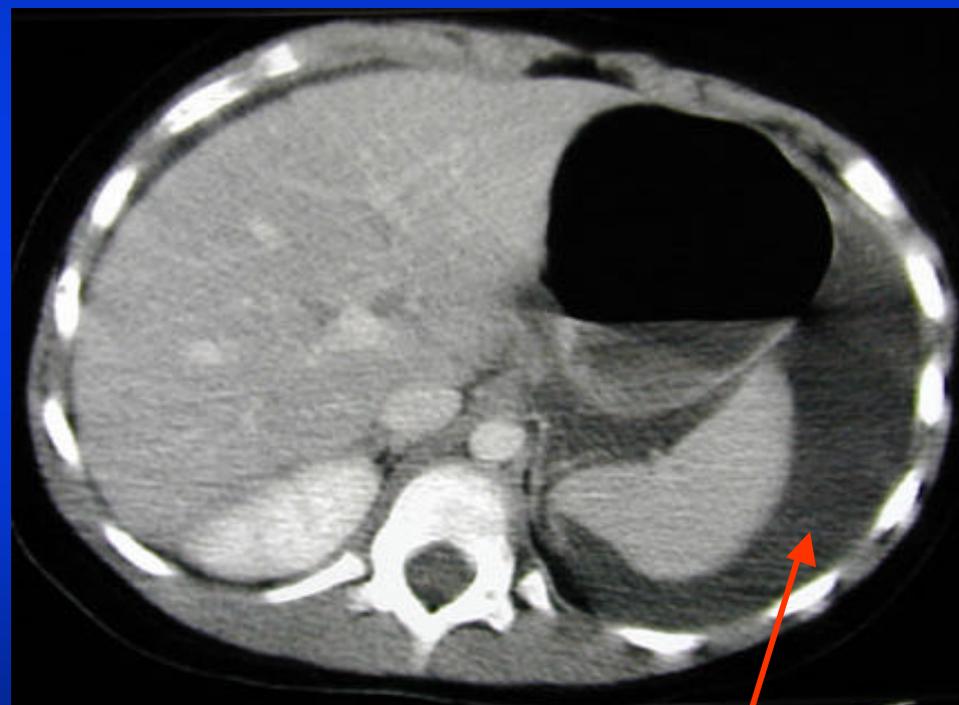
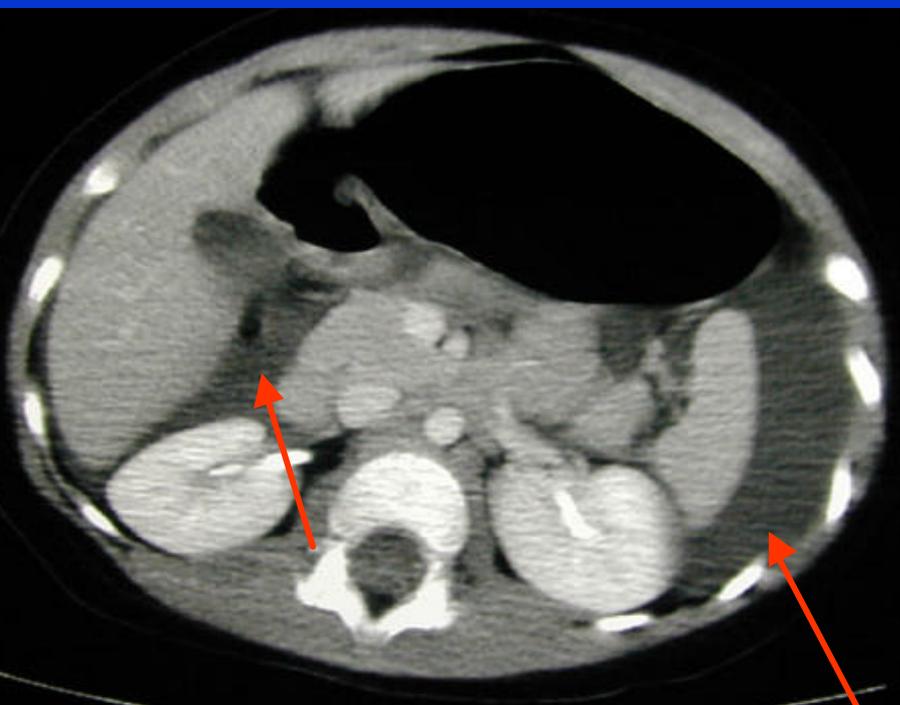


Right Clavicle Fracture

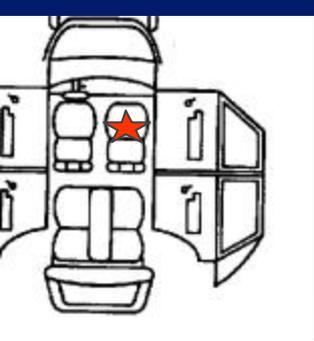




Ruptured Bladder



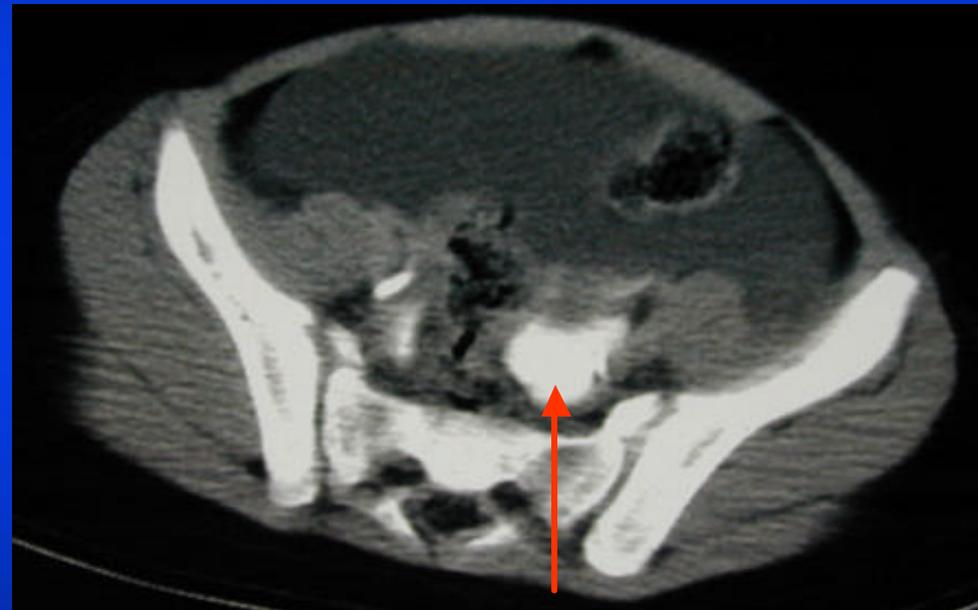
- Urine in abdomen



Ruptured Bladder



- Blood clot at dome of bladder



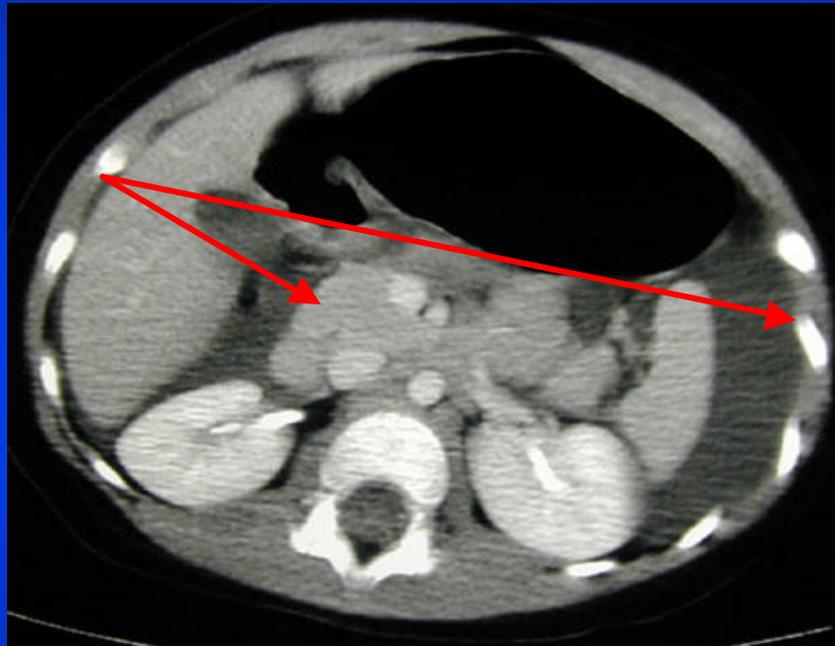
- Evidence of urine extravasation



Putting It All Together:



Urine in Abdomen



Lap Belt

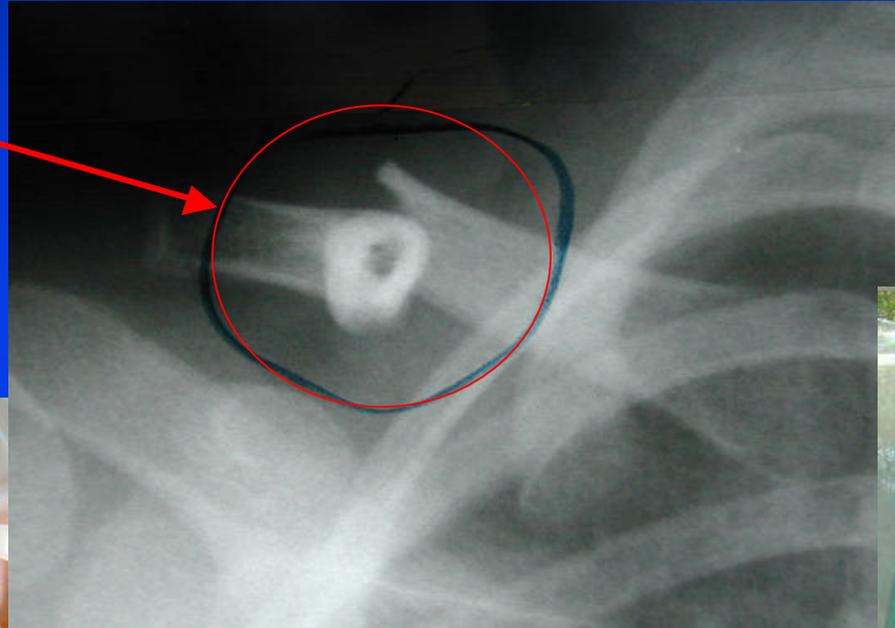




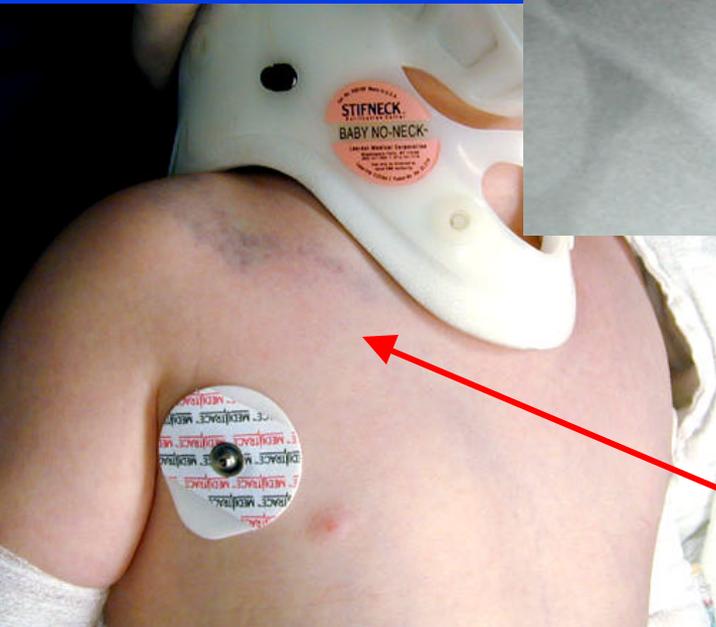
Putting It All Together:



Right Fractured Clavicle



Shoulder Belt



Right Shoulder Contusion

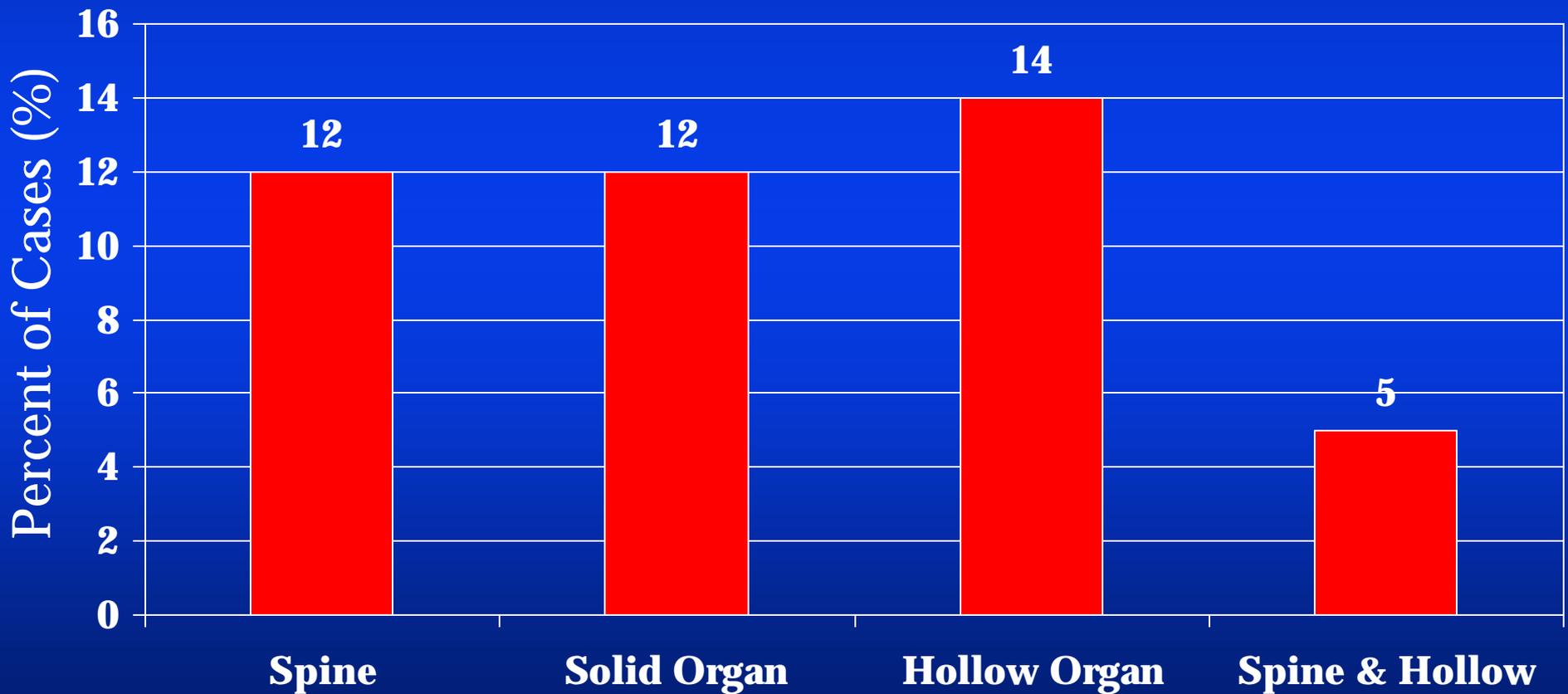


Seatbelt

Spinal Injury



Belt Injury



N=16



Odds of Belt-Related Injury

3-pt. vs. 2-pt.

Body Region	Relative Odds
Chest	1.00
Abdomen	.91



L-Spine	.11
---------	-----

(AIS \geq 2)



Abdominal Injury by Weight

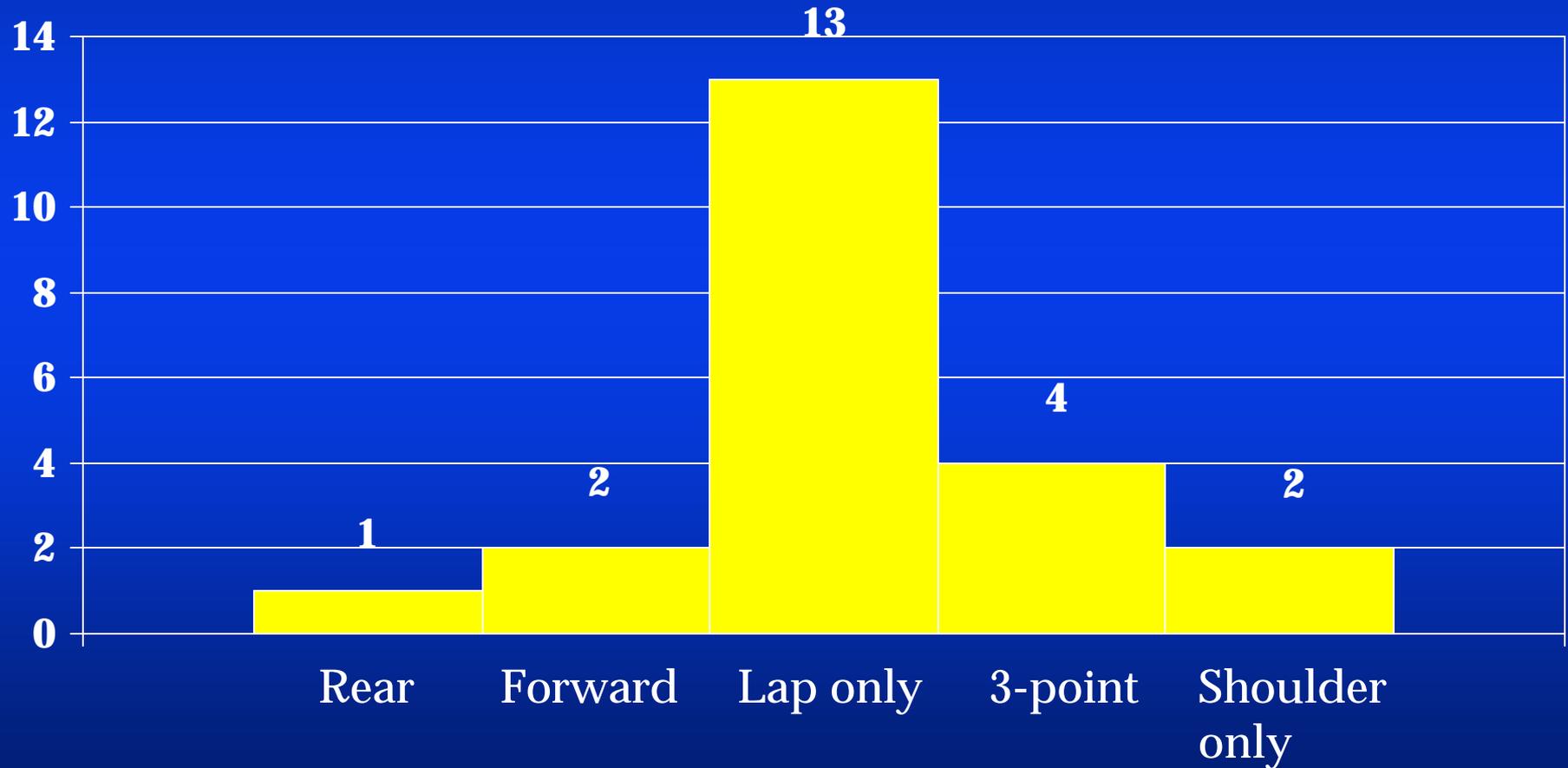


Belt

Weight (lbs)	N	Injured (%)
< 44	22	36.4
44-53	25	28.0
54-63	19	26.3
64-75	13	15.4



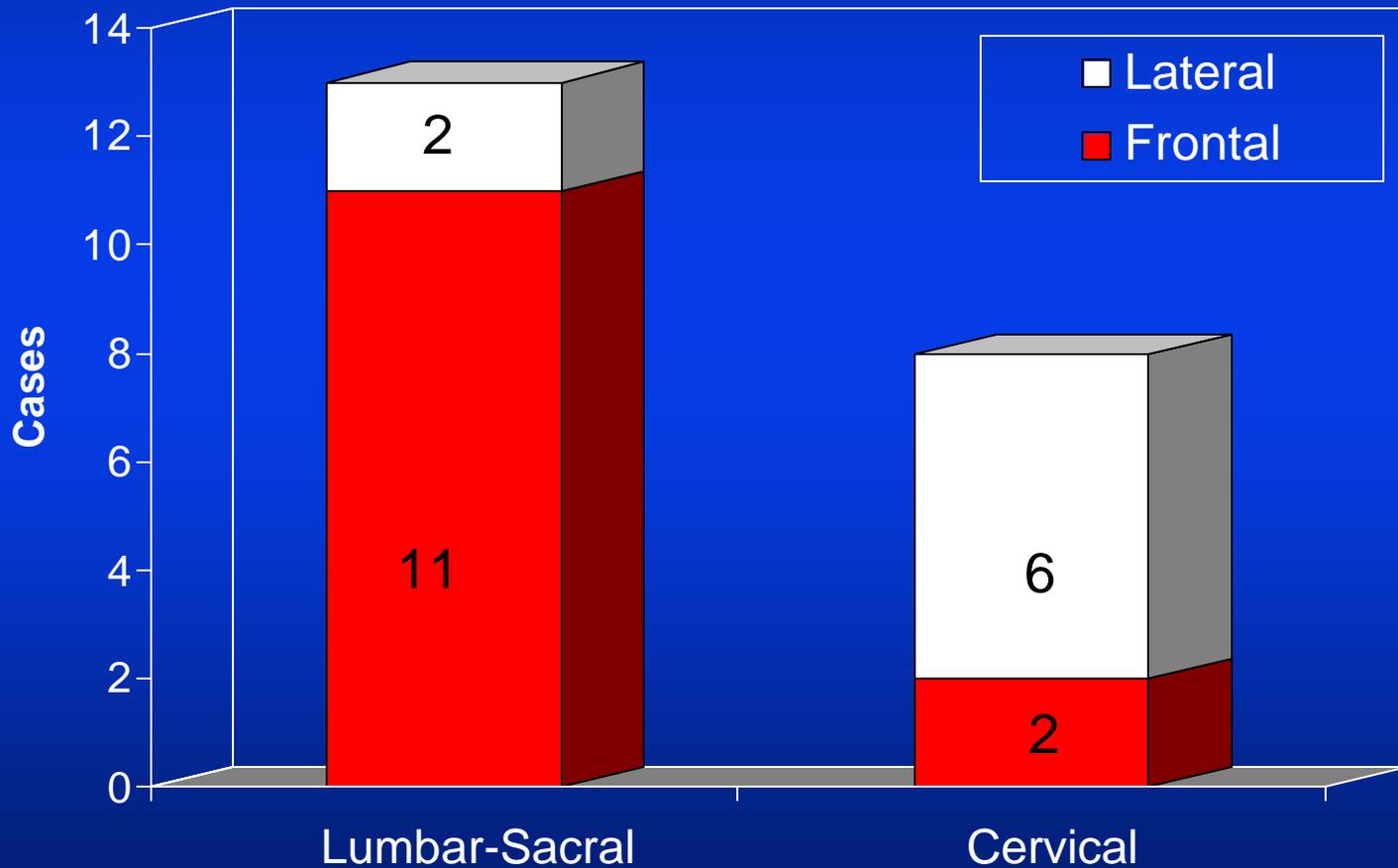
Spinal Injury by Restraint Type



N=20



Spinal Cord Injury Level of Lesion by Crash Type





Spinal Injury: Conclusion



C-spine:

• **L-spine:**

—

3-pt restraint

Lap belt

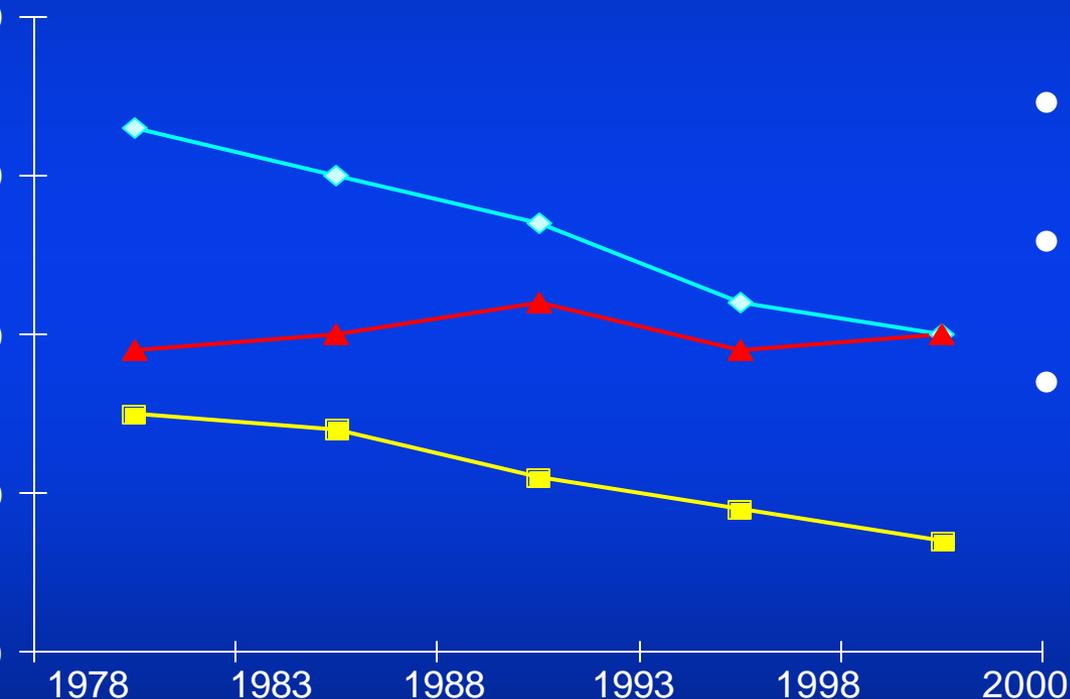
Forward-facing



Trends in MVC Mortality & Morbidity 1978-1998



e/100,000



• 0-4 yrs

↓ 35%

• 5-9 yrs

Unchanged

• 10-14 yrs

↓ 15%

◆ Age 0-4 ▲ Age 5-9 ■ Age 10-14

Source: Traffic Safety Facts 1998, US DOT/NHTSA



Child Safety Seat

Injury Analysis



Child Safety Seat - Misuse



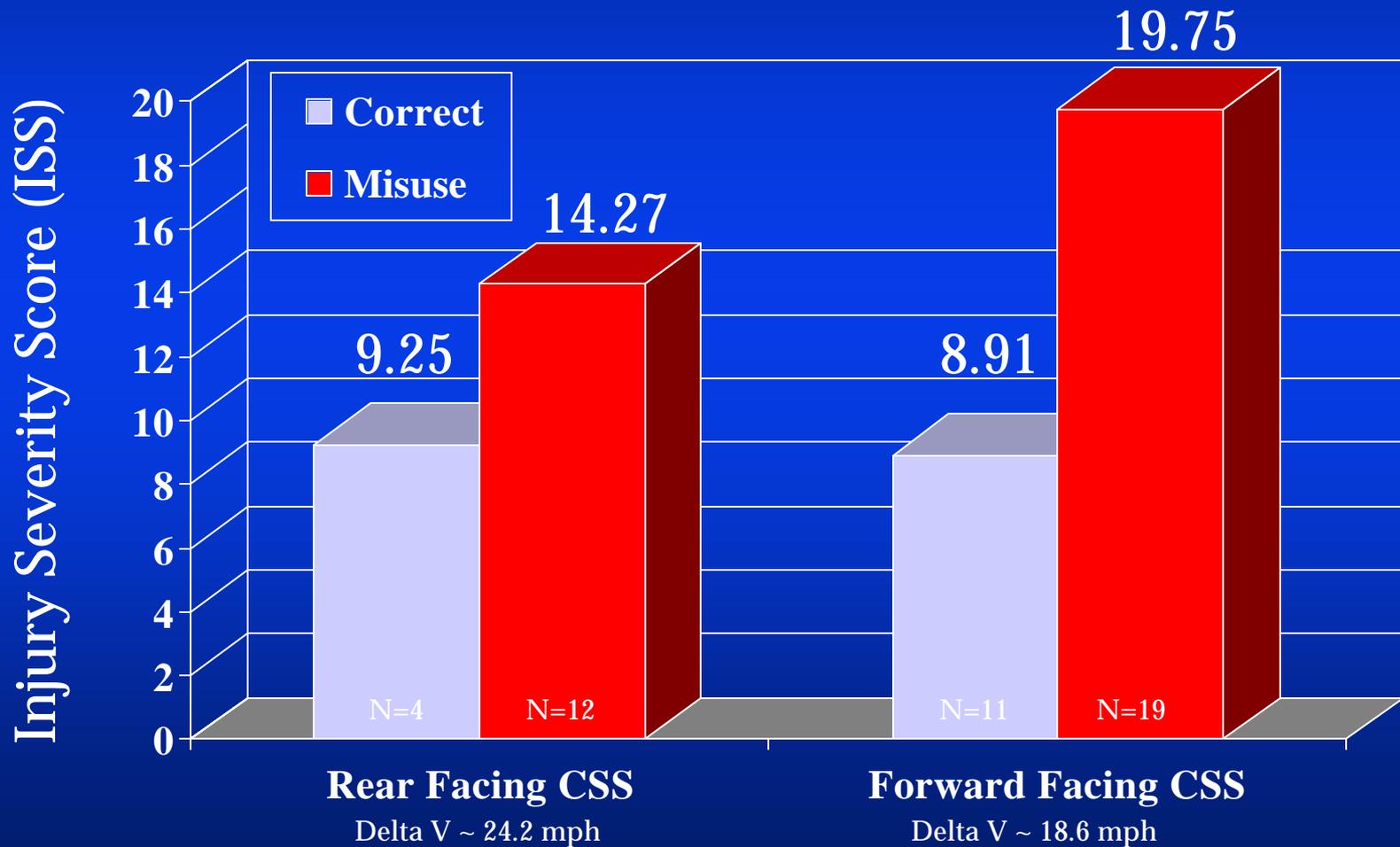
Crash demonstration of
car seat with multiple
misuses (foreground)
including:

- Loose safety belt
- Loose & incorrectly
routed harness straps
- Low harness clip

compared to car seat
used correctly (background).



Correct vs. Misuse Safety Seats





Injuries associated with Misuse Examples



Infant Seats:

• CHI/Brain shearing
(“shaken baby syndrome”)

Convertible Seats:

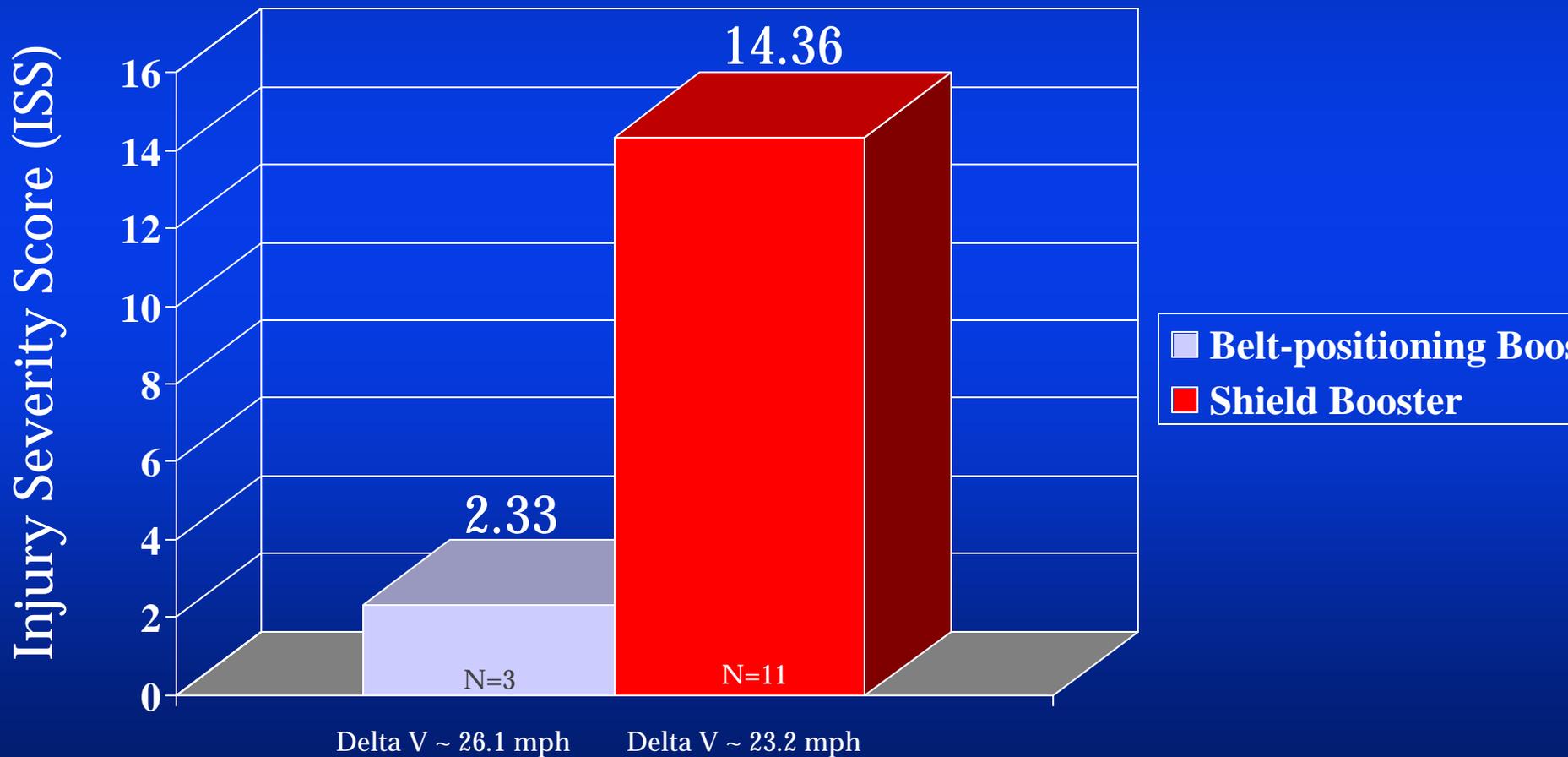
- Cervical-spine injuries
- Facial/Skull fractures
- CHI/Brain shearing
- Lung contusions

Shield Booster Seats:

- Bilateral lung contusions
- Facial/Skull fractures
- Pelvic Fractures
- Femur Fractures



High Back vs. Shield





Safety Seat: Head Injury



Injury	%	ISS (mean)	COSTS (mean)
Any Head Injury	93	6	\$5,827
Hemorrhage	41	2	\$3,678
Skull Fracture	36	12	\$10,290
Multiple	14	17	\$25,461
Concussion/Cereb. Cont.	16	6	\$6,800

N=56



Safety Seat: Other Injury



Injury	%
Trunk Contusions	30
Extremity Injuries	39
Contusion/Superficial	32
Fractures	7
Internal Chest	9
Internal Abd./Pelvis	7
Spinal Fracture	5

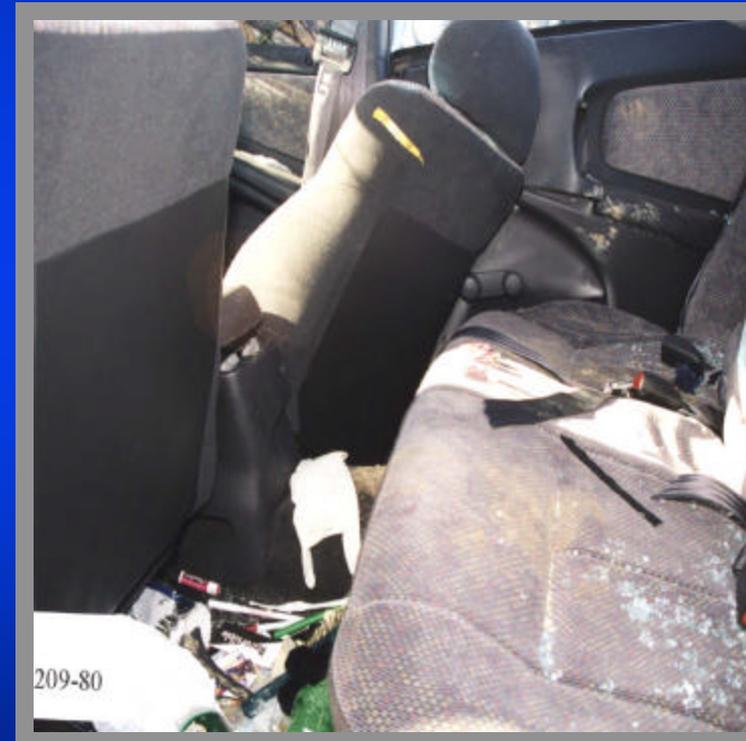
N=56



Safety Seat: Source of Contact



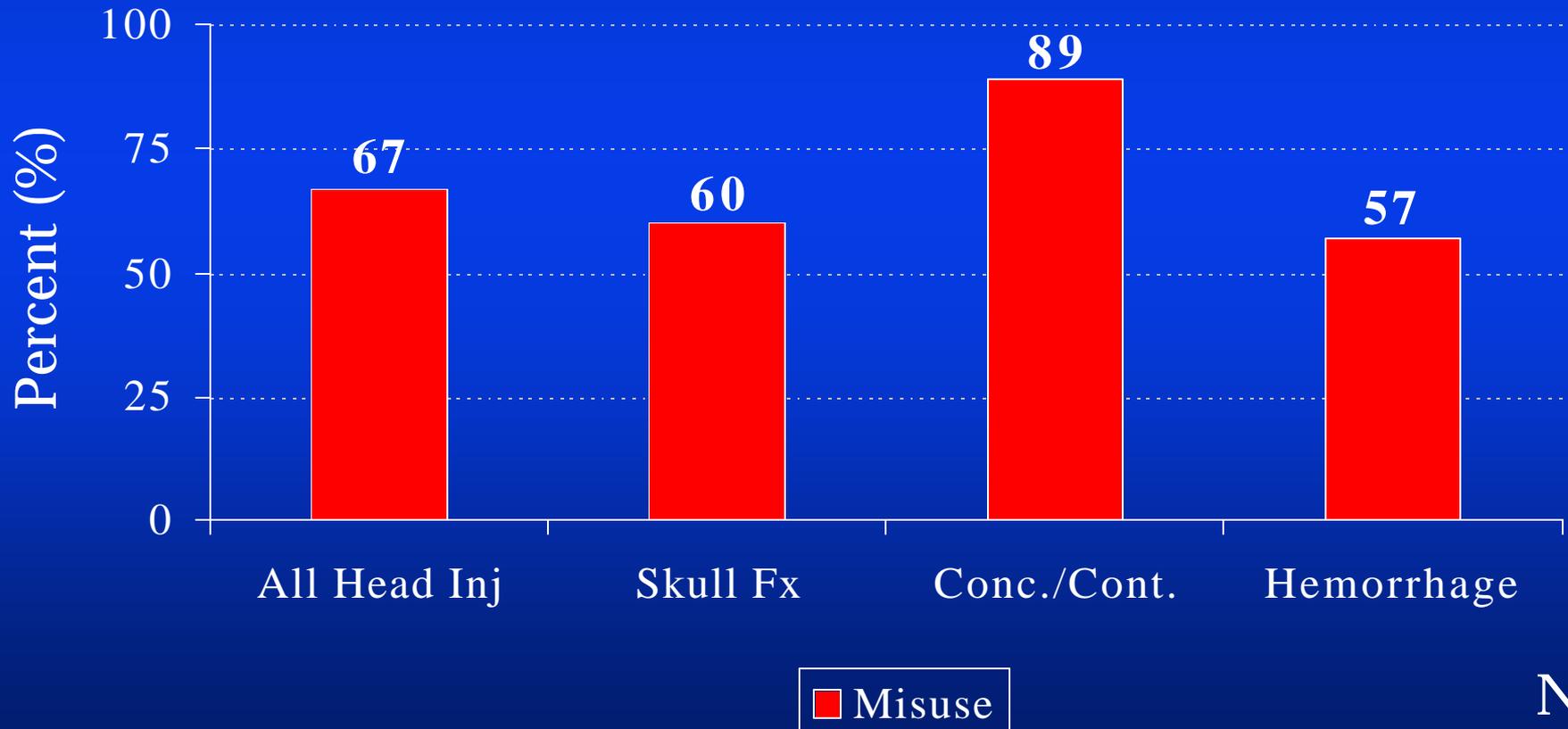
Contact Source	Injuries (%)
CSS	29
Seat Back	14
Door Hardware	10
Non-Contact	8



N=56



Safety Seat Injuries By Restraint Misuse

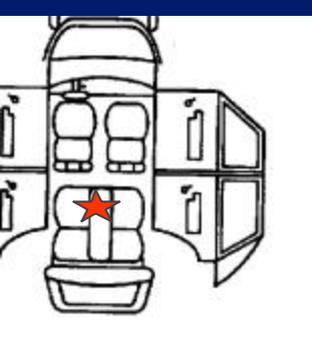


N=56



Forward Facing CSS: Misuse

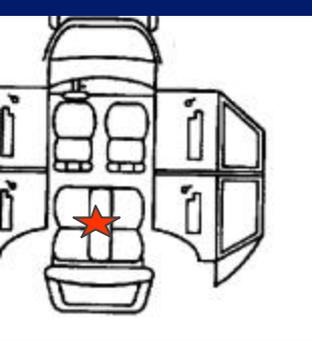
- **14 mo female**
- **33 lbs, 27 in.**
- **Middle Rear**
- **Forward facing CSS**
- **Appropriate**
- ***Incorrect use* of CSS - Loose straps**
- **Lateral**



Case Safety Seat

Actual Seat



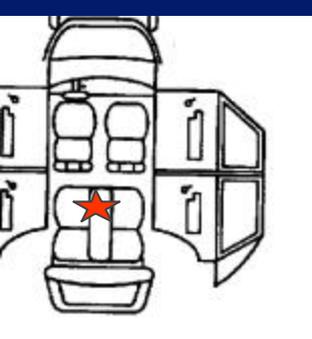


Seating Position

Scene and Auto



- 1998 Dodge Neon
- Lateral Impact
- Max Crush: 14.6
- Delta V: 18 m
- PDOF: +03



Bilateral Upper Arm Contusions

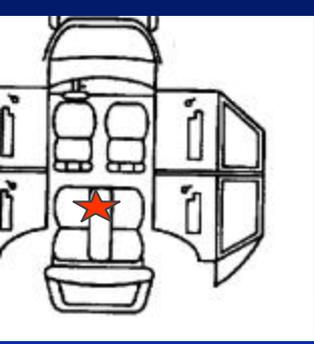
Evidence of Misuse!



Right Shoulder



Left Shoulder



Bilateral Thigh Contusions

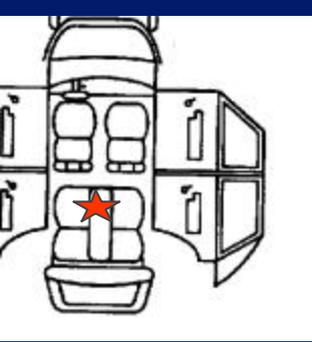
More Evidence...



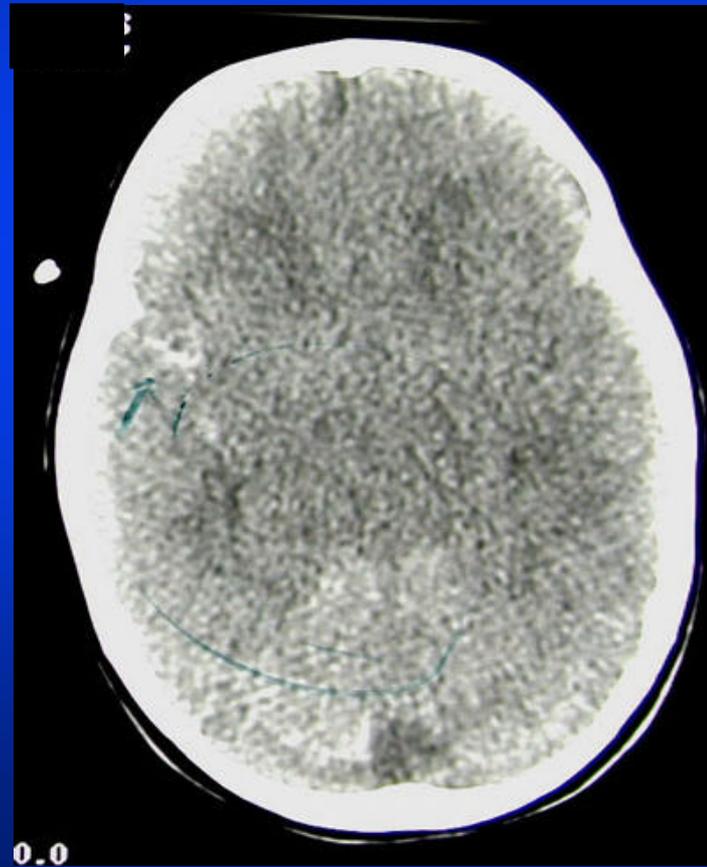
Right Thigh

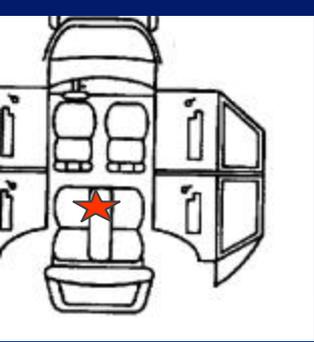


Left Thigh

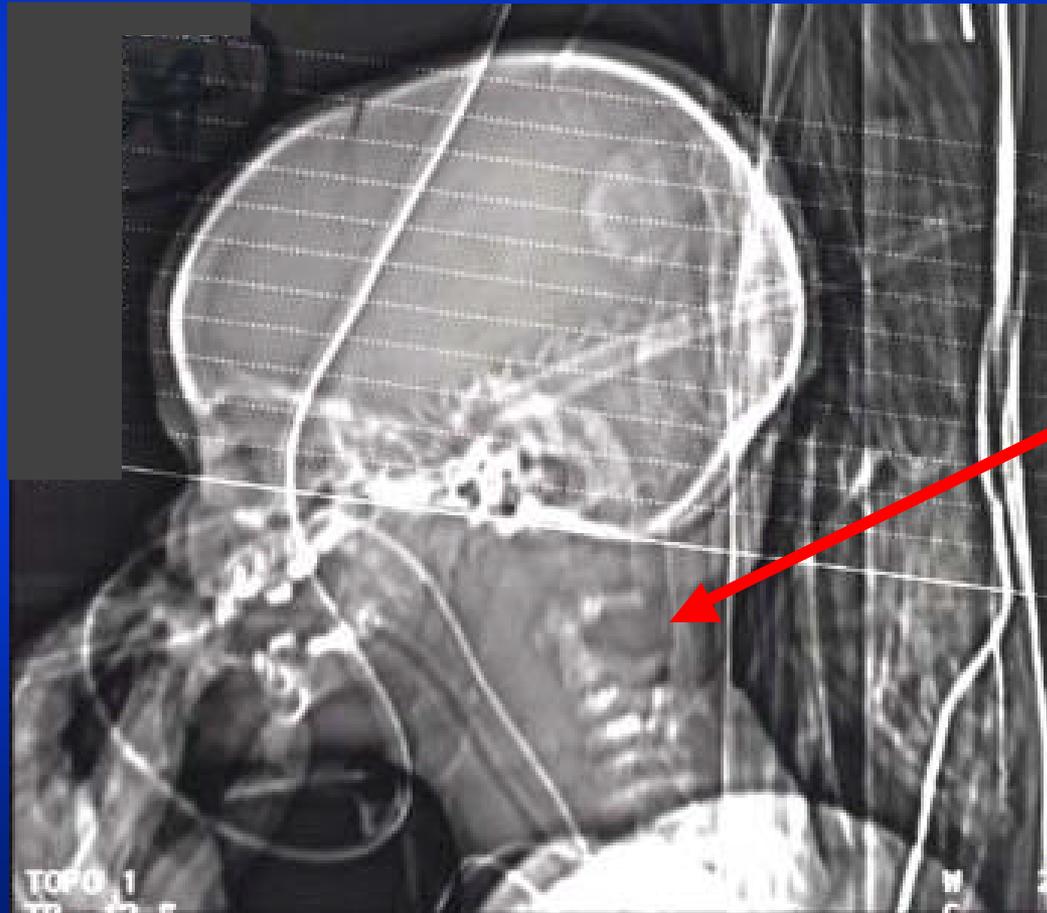


Cerebral Edema





Cervical Spinal Cord Laceration



C1- C2



Outcome

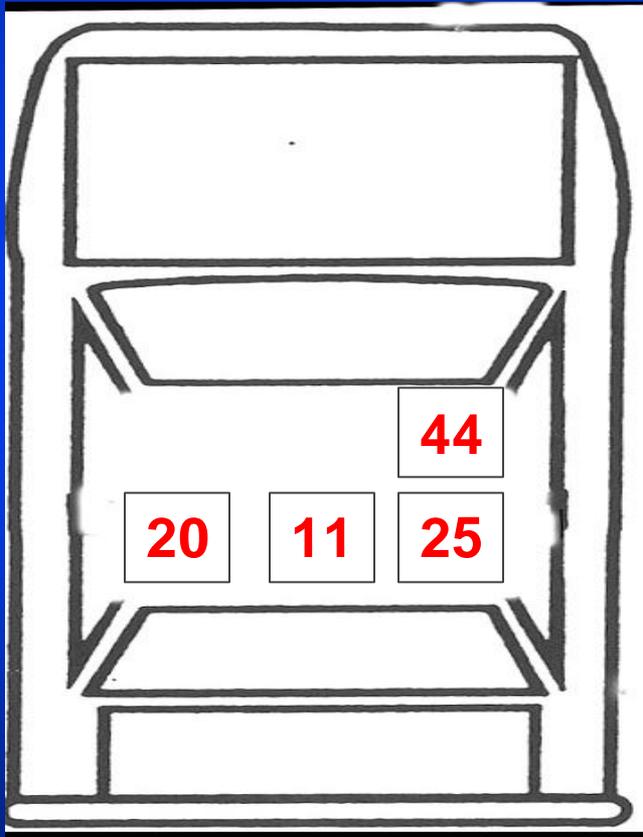
- **Deceased**
- **Injury Etiology: Movement in CSS**
- **CSS Movement: Loose Belt**



Frontal vs. Lateral

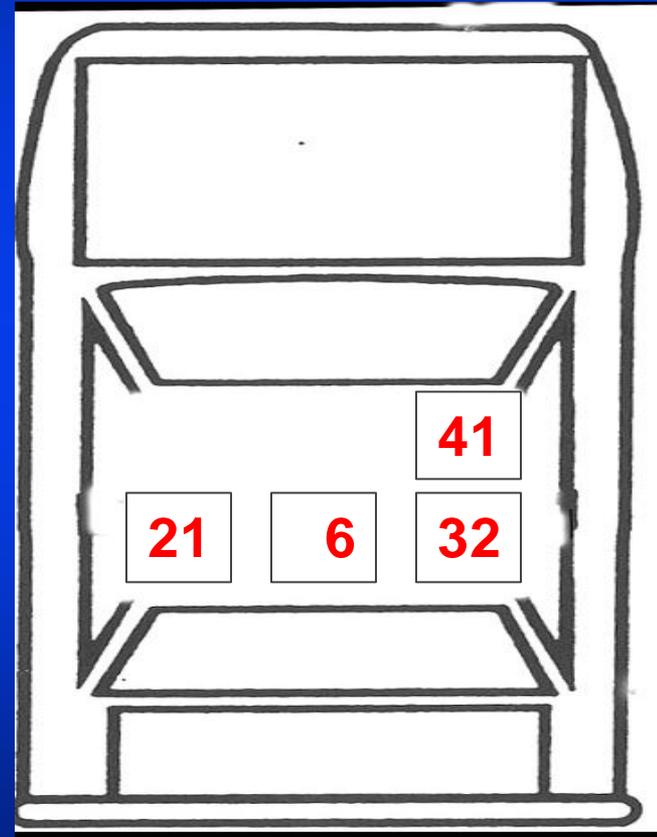


Seating Position by Crash Type



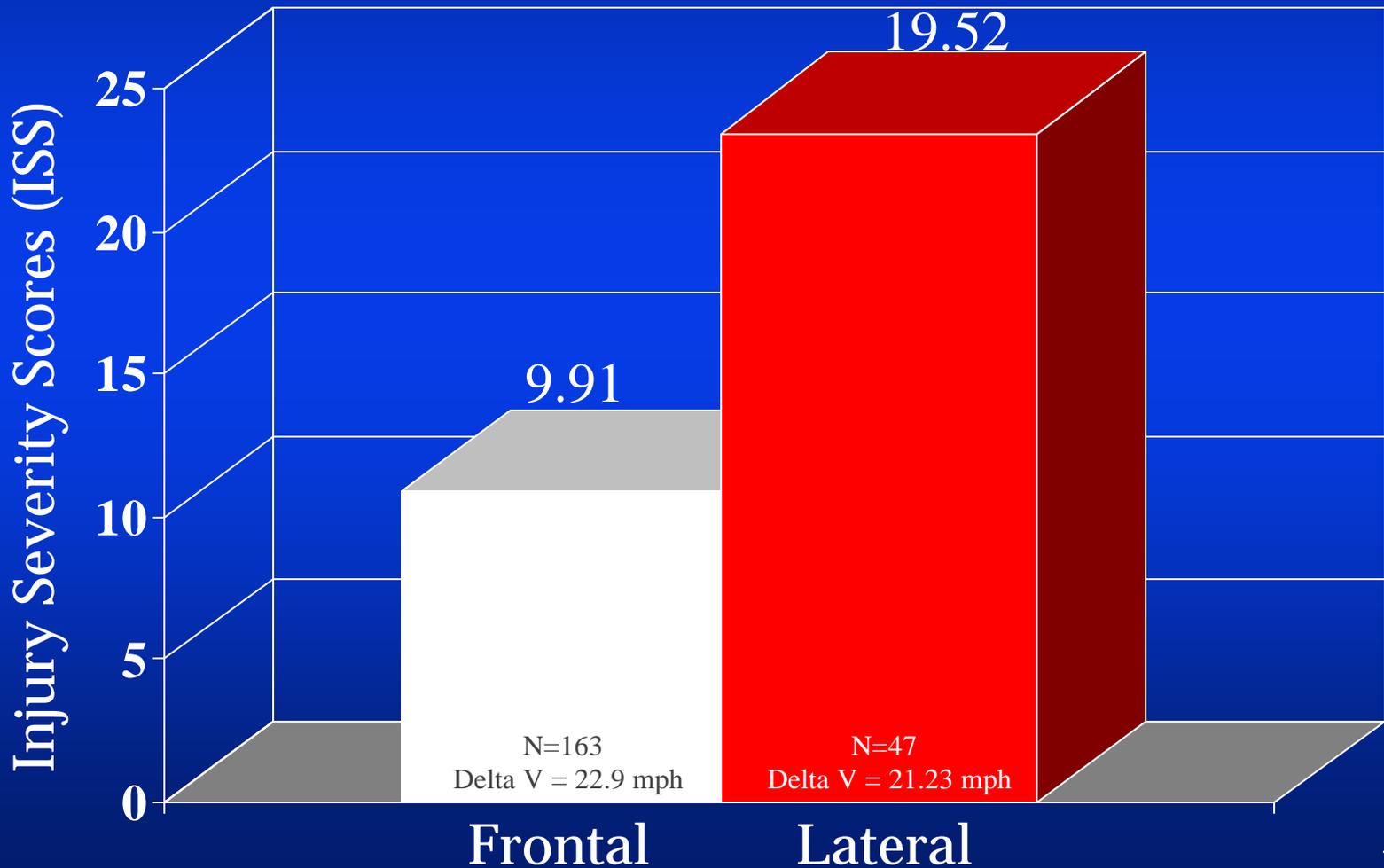
Frontal
(n=145)

%



Lateral
(n=34)

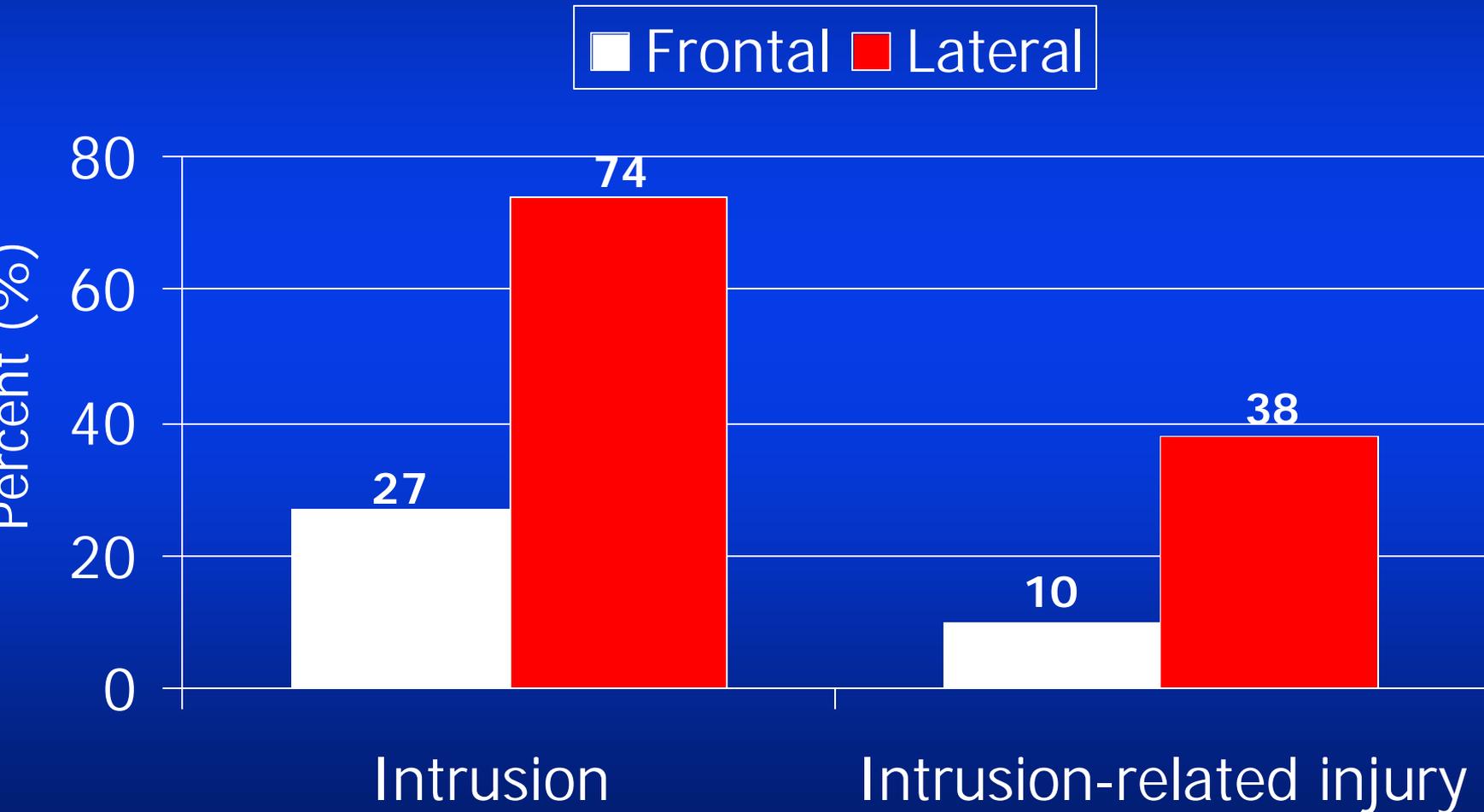
Frontal vs. Lateral ISS:



p < 0.0



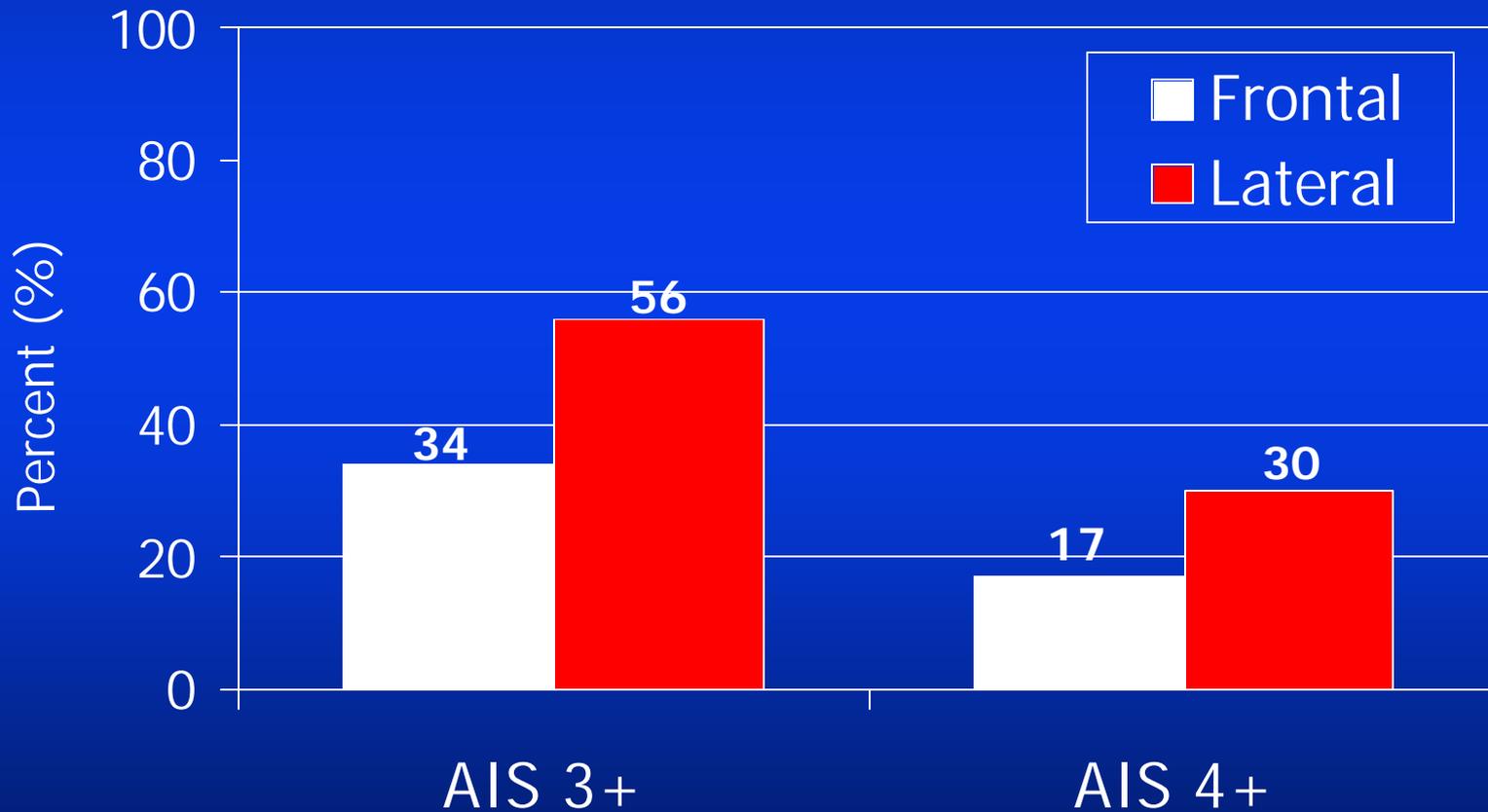
Frontal vs Lateral



p=0.0



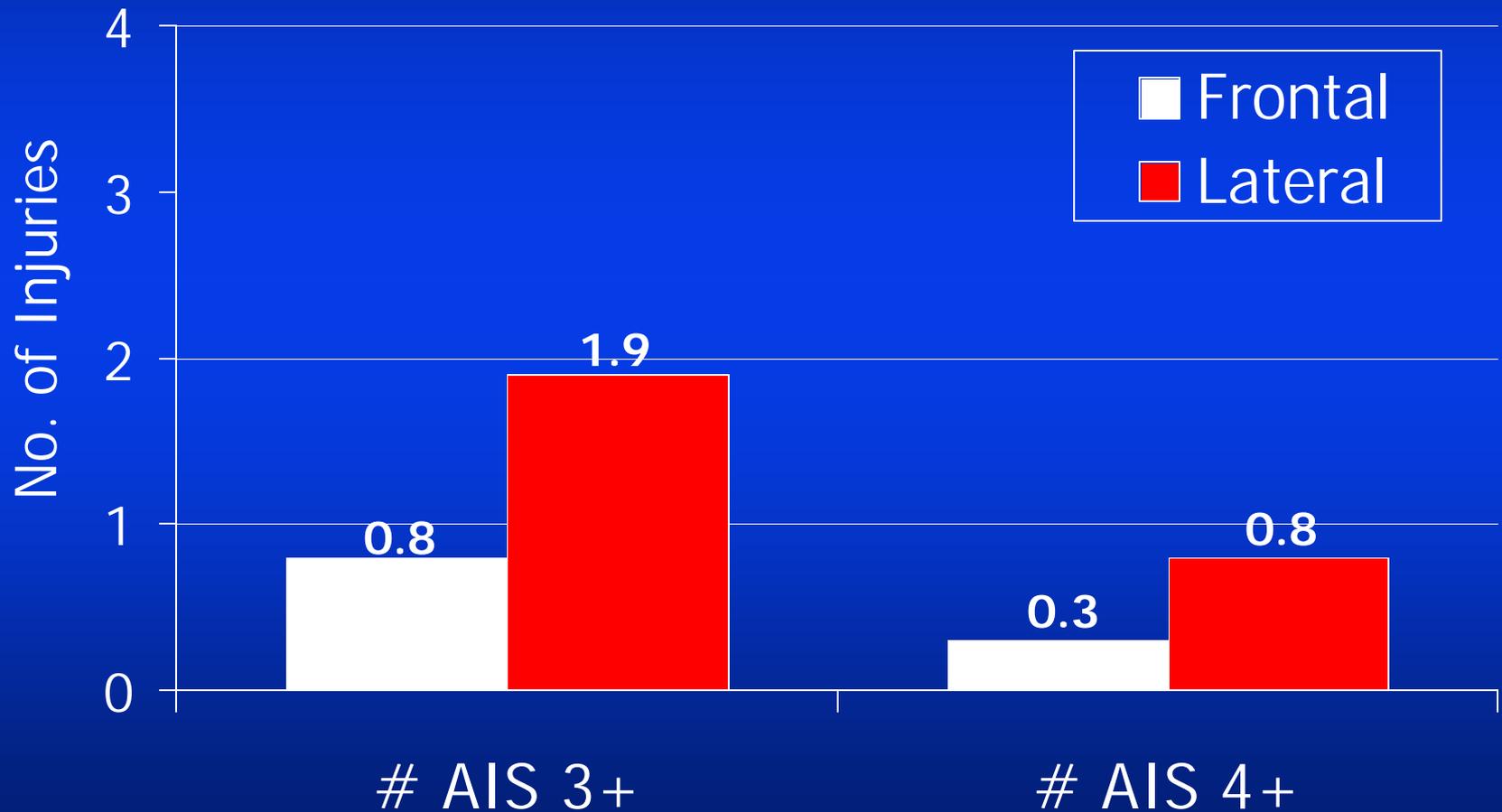
Frontal vs Lateral AIS Scores



$p < 0.0$

Frontal vs Lateral

AIS Scores

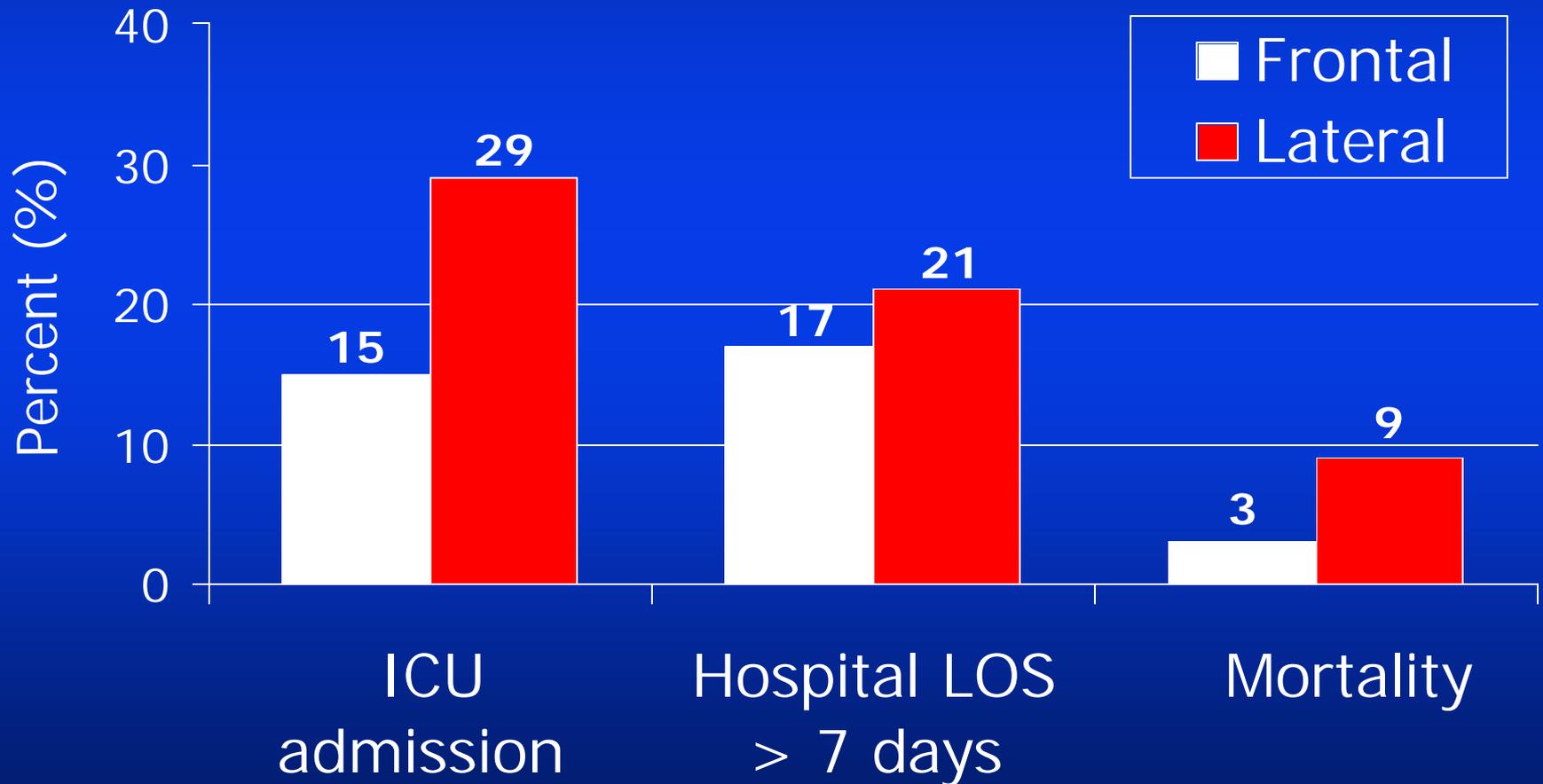


$p < 0.0$



Frontal vs Lateral

Other Indices



$p < 0.0$



Frontal vs Lateral



AIS 4+ Leading Injury Diagnoses

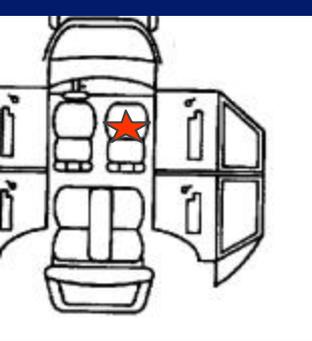
<u>AIS 4+ Diagnoses</u>	<u>Frontal</u> (%)	<u>Lateral</u> (%)	p
Intracranial Injury	71	90	n
Internal Abdomen, Pelvis	58	70	n
Lower Extremity Injury	42	70	n
Internal Chest Injury	29	80*	<0.



Case Example: Lateral Impact

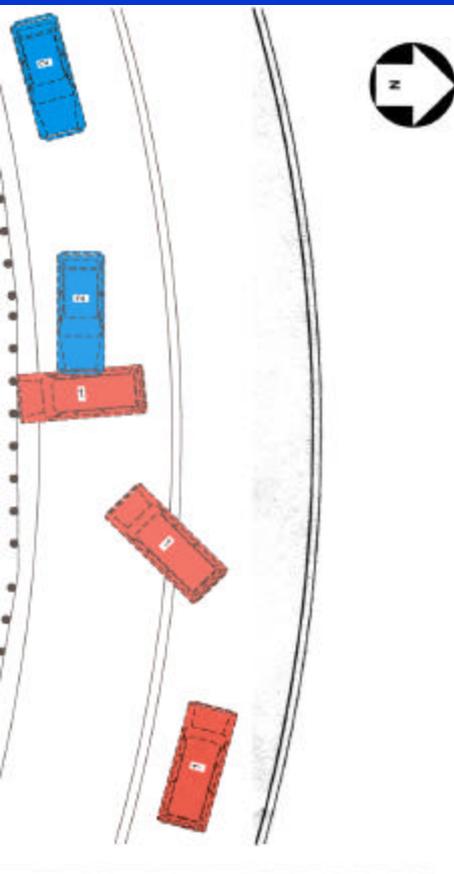


- 8 yo male
- 60 lbs, 51 in
- Front
- 3-Point
- Inappropriate
- Lateral (right)

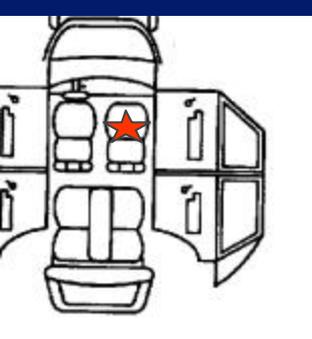


Seating Position

Scene and Auto

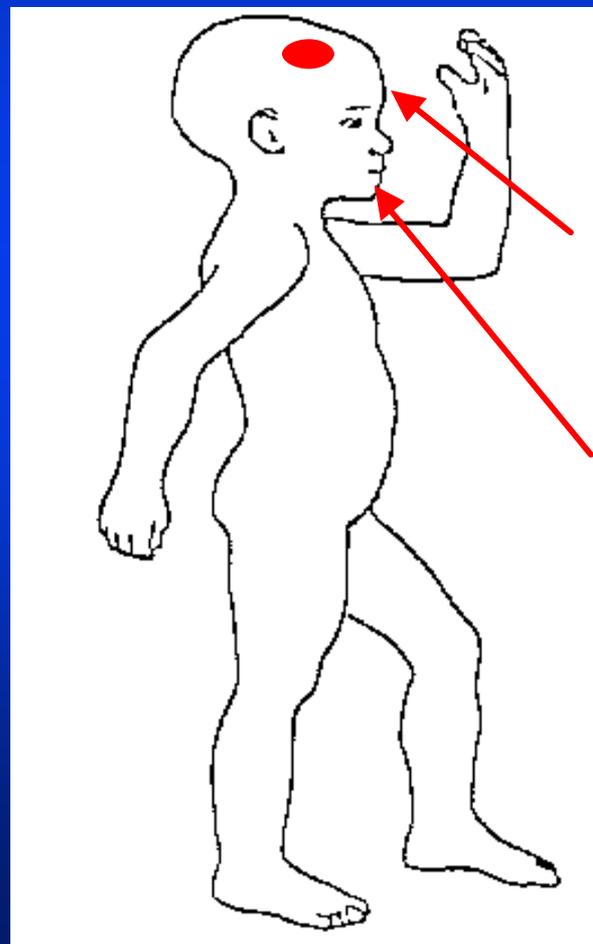
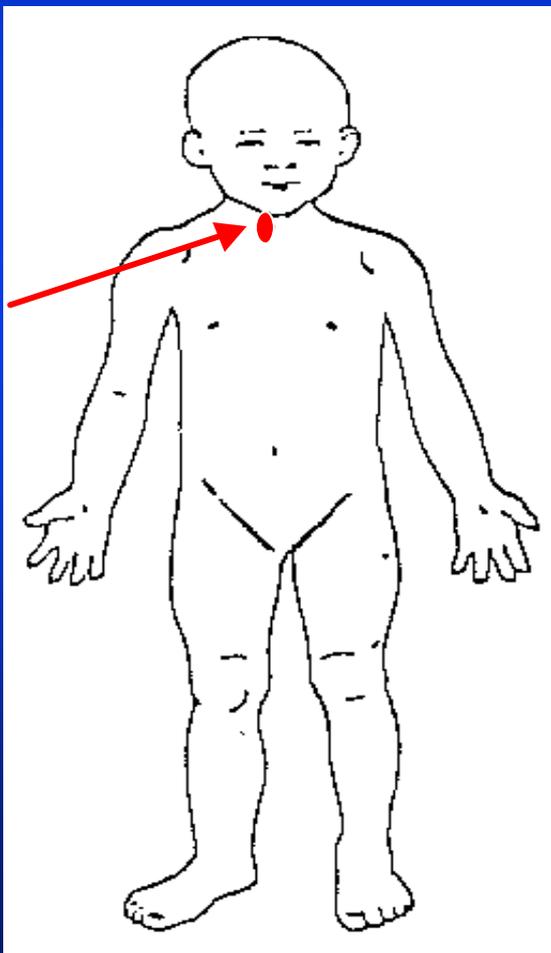


- **1996 Aerostar**
- **Lateral Impact**
- **Max Crush: 24.8**
- **Delta V: 15.5 m**
- **PDOF: +100**



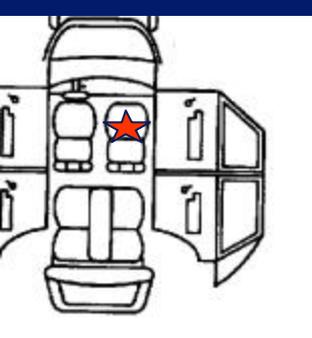
External Injuries

Neck Contusion



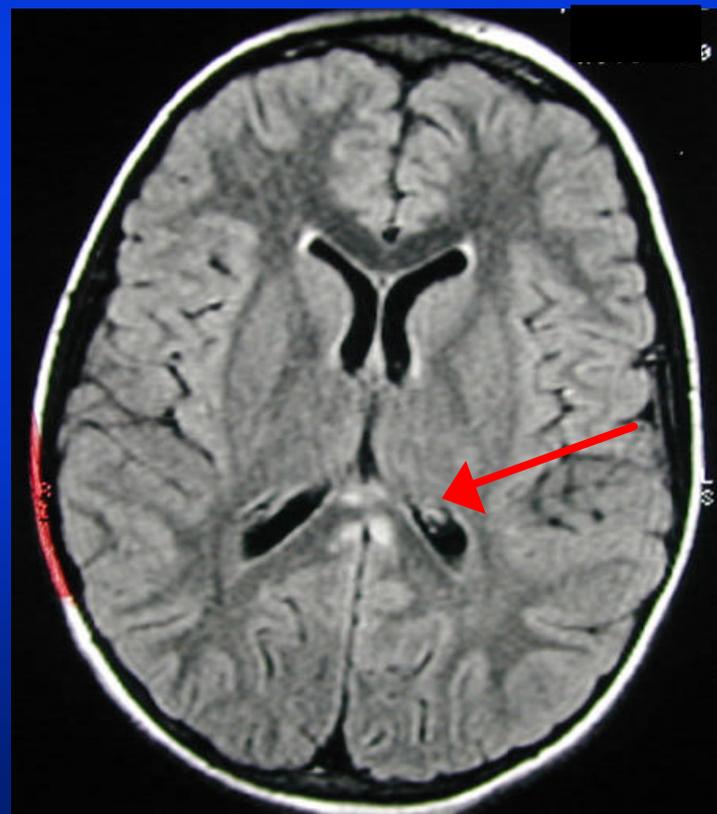
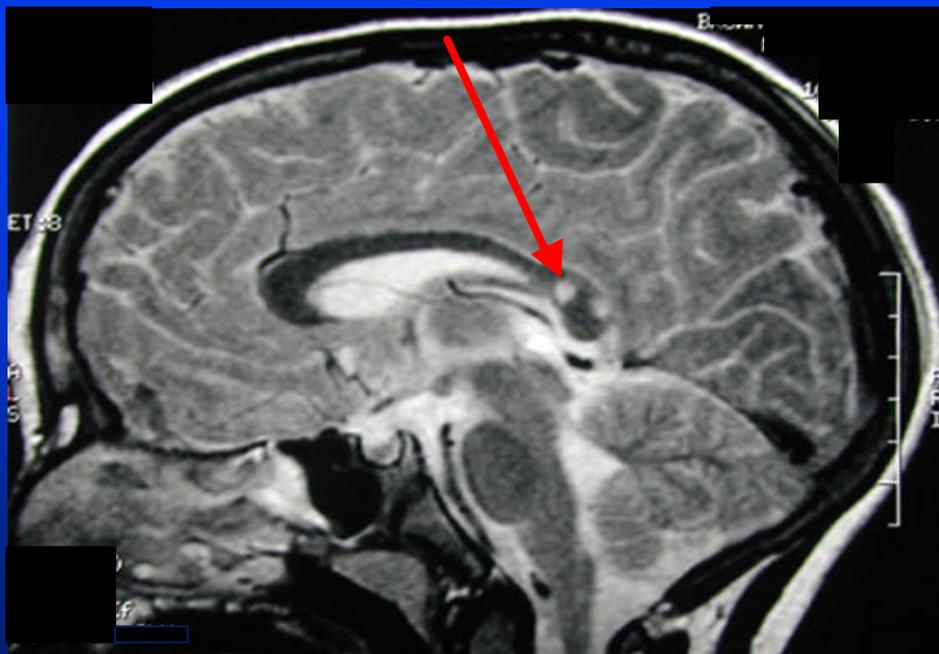
Scalp Laceration
& Contusion

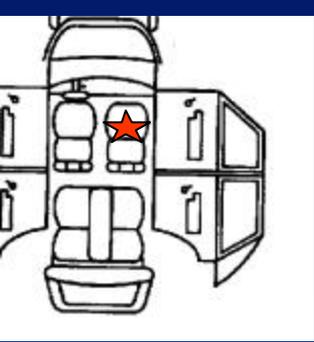
Chin Laceration



CHI - Shearing Injury

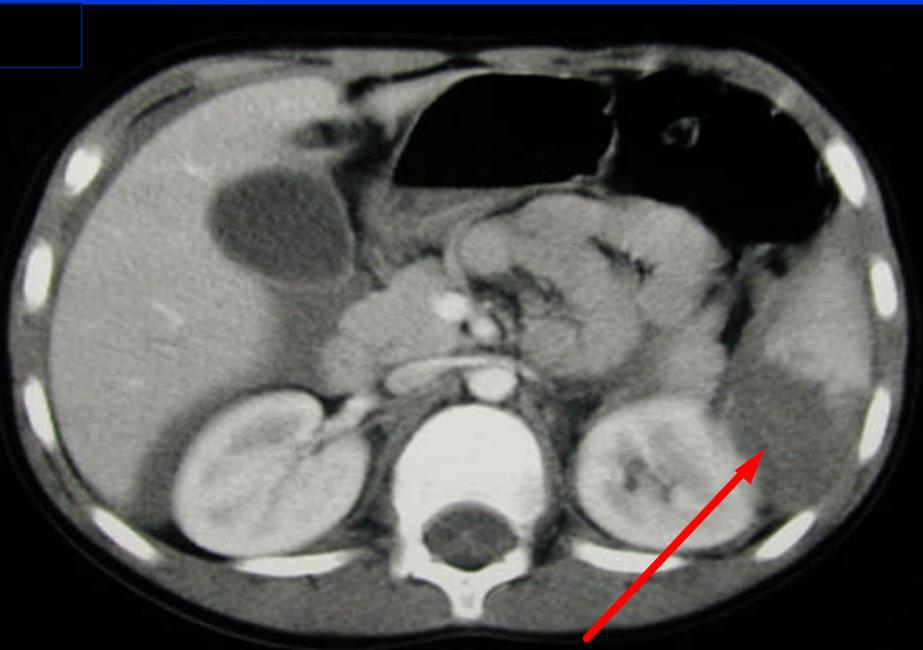
Shearing to the Corpus Callosum



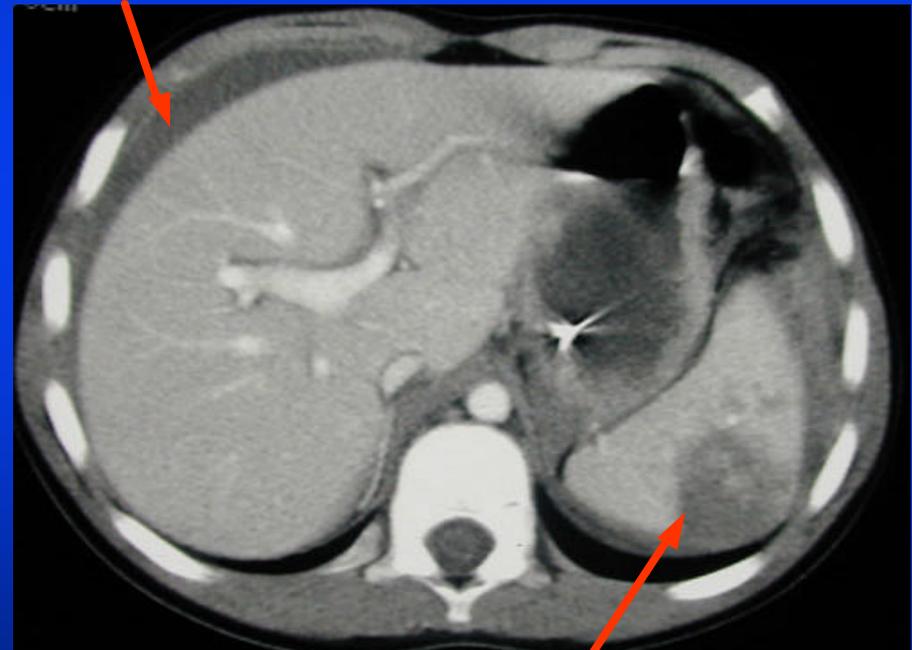


Splenic Laceration (Grade IV)

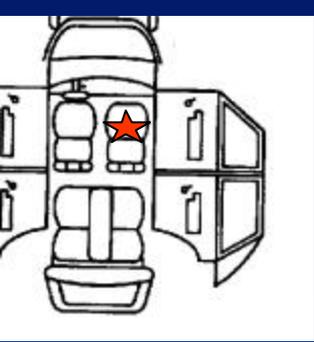
- Blood in Abdomen



- Blood surrounding spleen

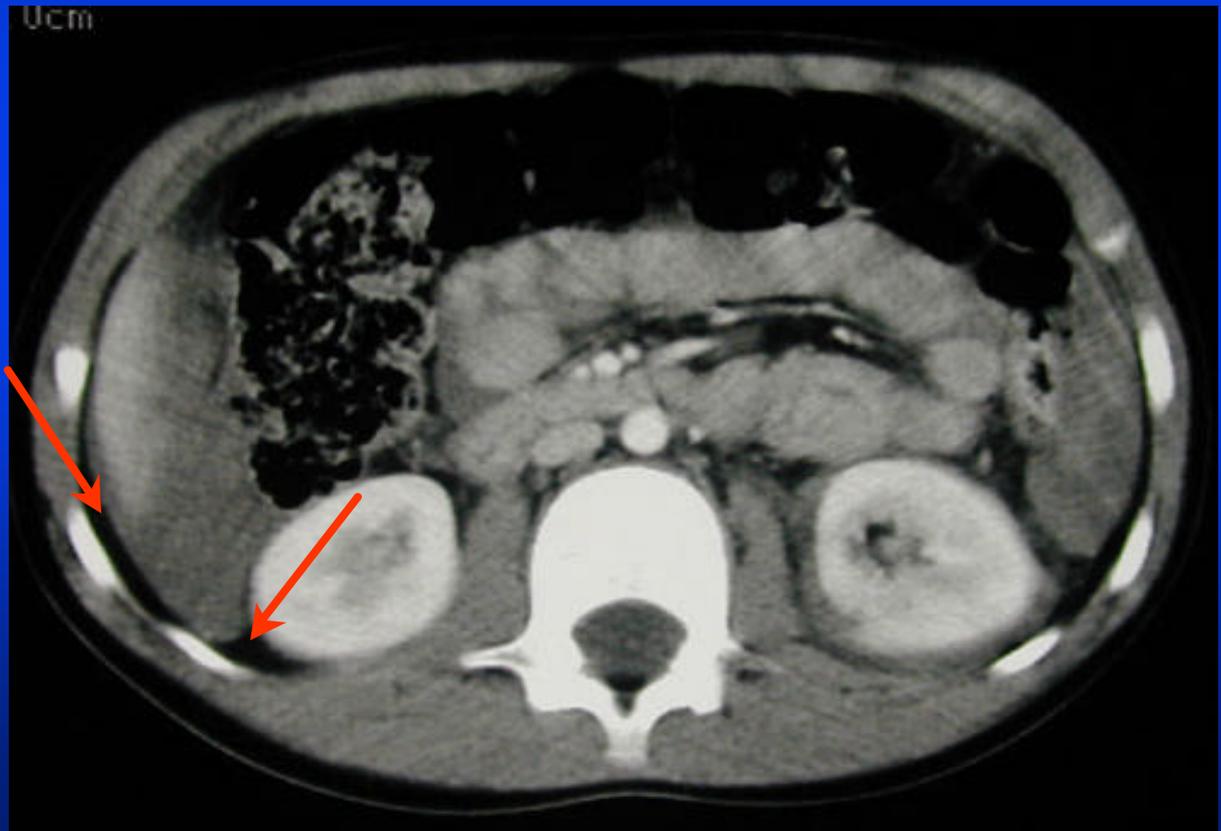


- Spleen Laceration



Kidney Laceration

blood around L kidney





Putting It All Together:



Right Door
Intrusion



Spleen
Laceration

Lateral Impact



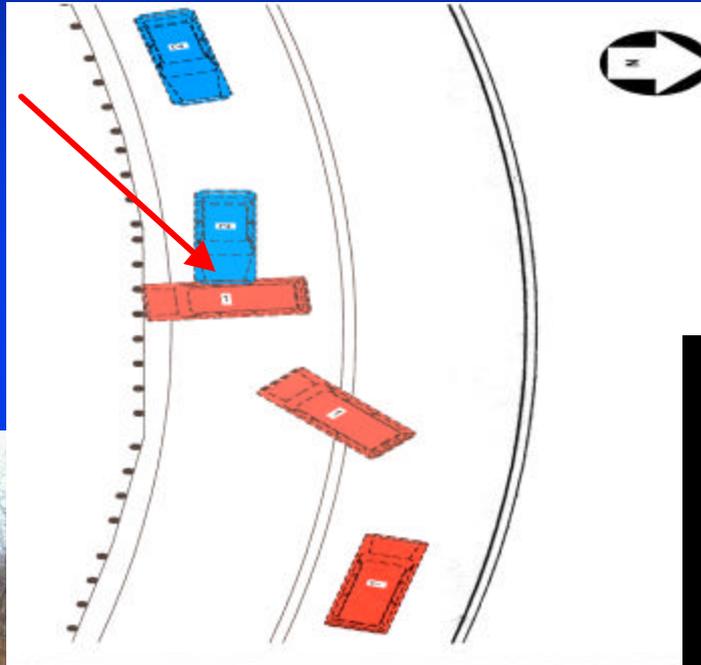


Putting It All Together:

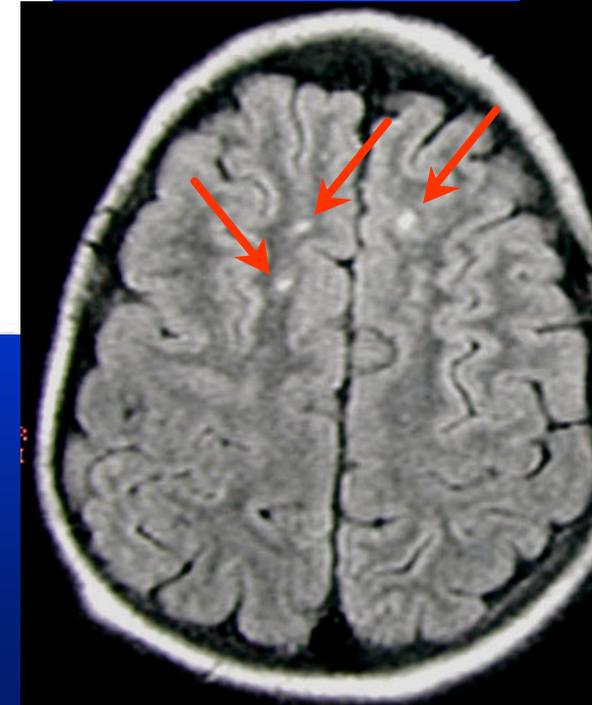


Impact Upon
Rotation

Curved Travel
Path



Brain
Shearing





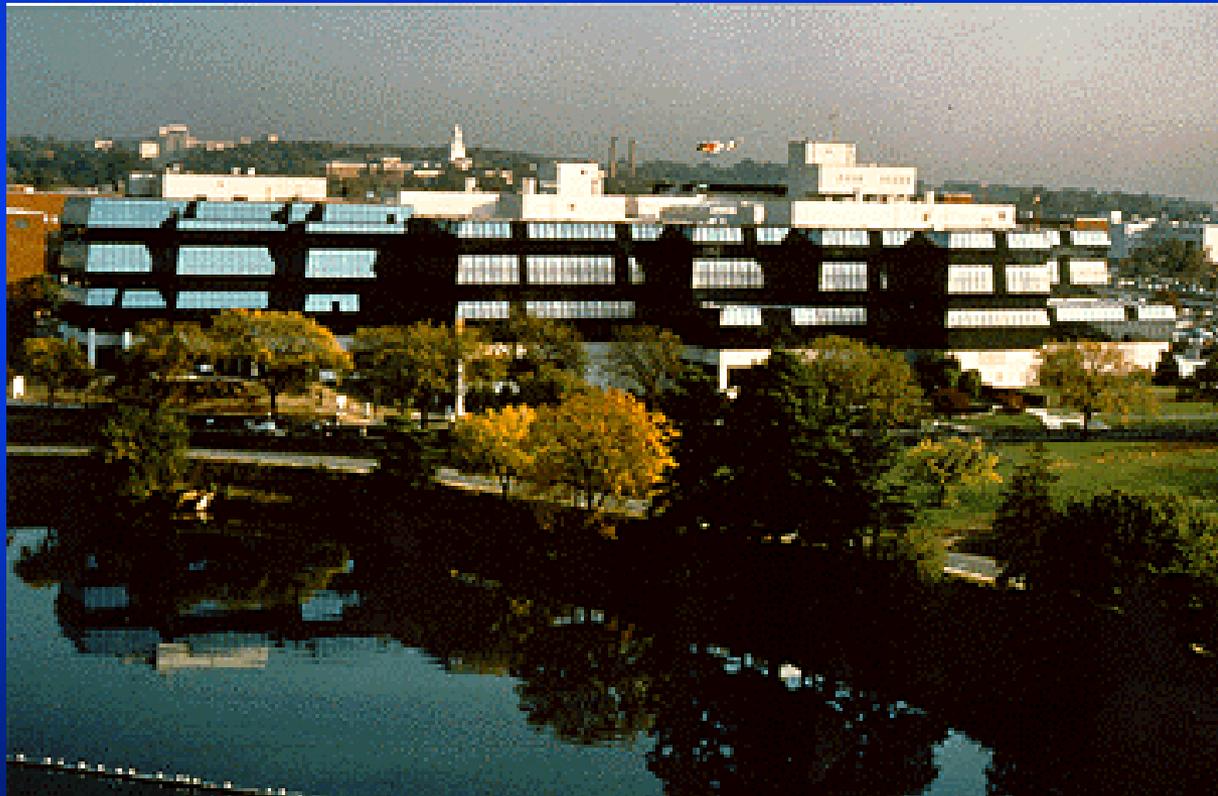
Conclusion



- Child Restraint Selection Appropriate/Correct
- Front vs. Rear Seats Rear seat ↓ ISS
- Seatbelt Injury > for 4-8 yo (40-80 lbs)
- Spinal Injury Frontal ↑ L-Spine
Lateral ↑ C-Spine
- Safety Seat Misuse ↑ ISS & ↑ Rate of Misuse
- Frontal vs. Lateral Lateral: ↑ ISS, Thorax



Children's National Medical Center







Approach

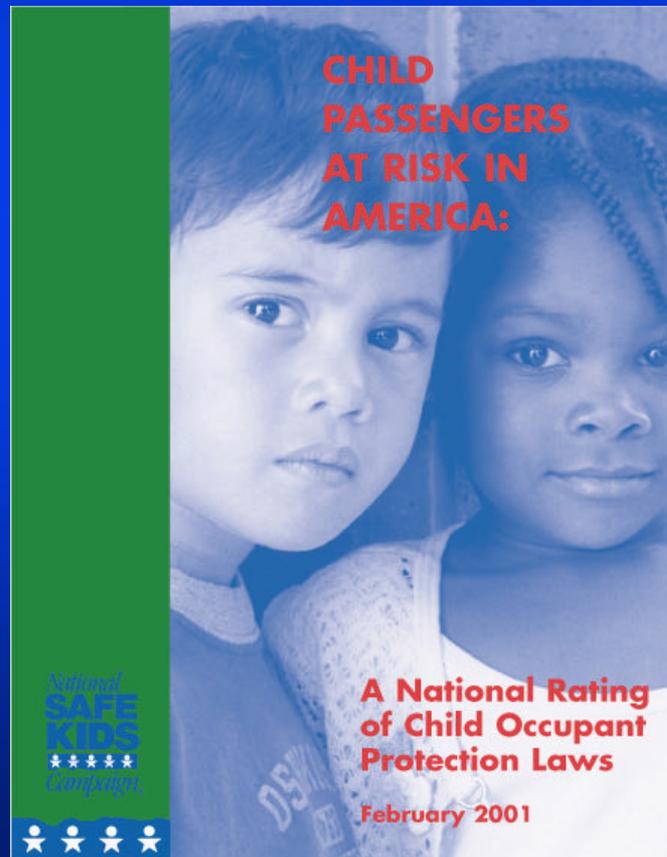
- ◆ **Coalitions**
- ◆ **Education**
- ◆ **Media**
- ◆ **Legislation**
- ◆ **Product design**



High Risk Profiles

- ◆ **Male**
- ◆ **Ages 5 and under**
- ◆ **Poverty**
- ◆ **Rural and urban areas**
- ◆ **Black, Native American, Hispanic**

Child Passengers at Risk in America: A National Rating of Child Occupant Protection Laws





A National Rating of Child Occupant Protection Laws

Overview:

- State evaluation
- Apply SAFE KIDS' model law

- Grade each state accordingly:

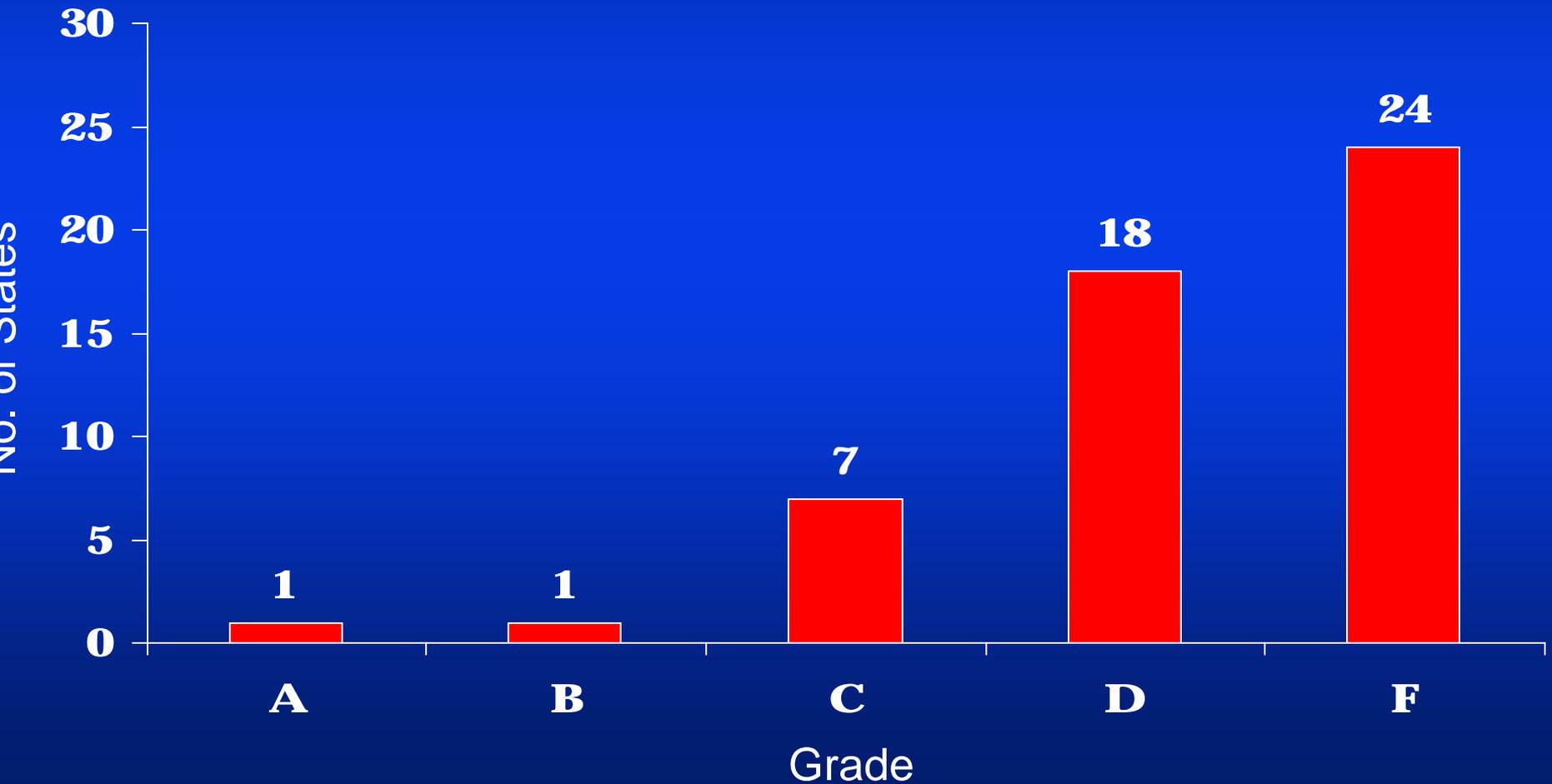
90 – 100	A
80 – 89	B
70 – 79	C
60 – 69	D
59 & below	F

Criteria Model Legislation

- A.) Restraint use required through age 15**
- B.) Appropriate child restraint requirement by age**
- C.) Proper CSS adjustment clause**
- D.) Public education/public fund component**
- E.) Penalty provisions**
- F.) No exemptions for certain drivers/circumstances**
- G.) Other Provisions**

The Bad News...

Almost half failed.



The Good News...

- **All have some restraint protection laws**
- **California as a role model**

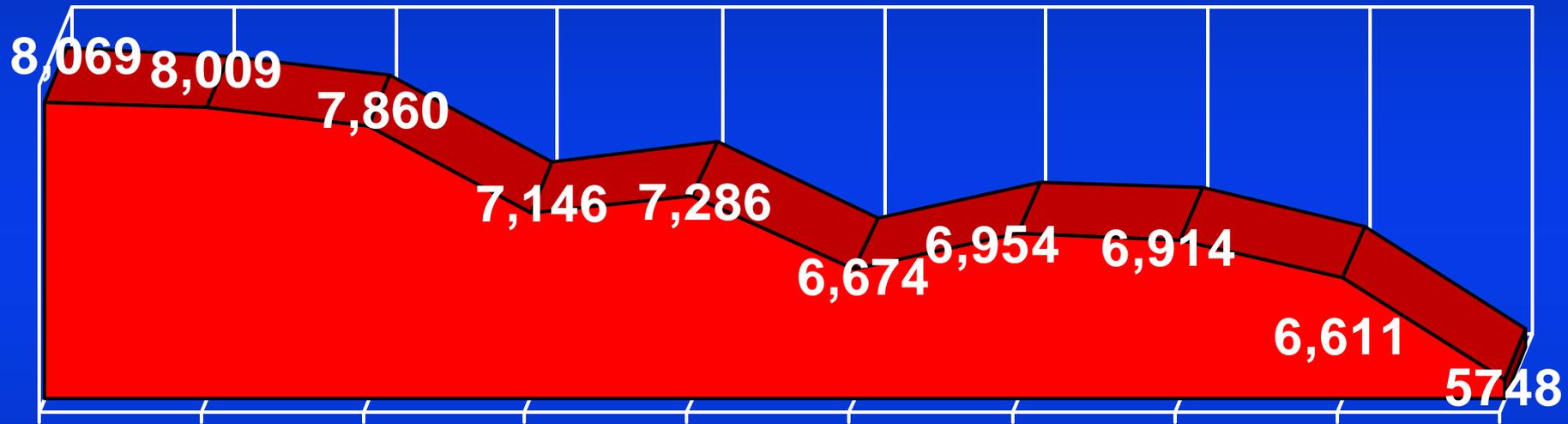


Legislative Successes since...

- 29 states have pending legislation
- 10 states passed new laws
Arkansas, Georgia, Illinois, New Jersey, New Mexico, Oregon, Rhode Island, South Carolina, Tennessee, & Texas.
- 5 states (*Arkansas, New Jersey, Oregon, Rhode Island, & South Carolina*) joined California and Washington as the only states to mandate **booster seat** coverage.



Decline in Childhood Injury Deaths



35% reduction

