Abdominopelvic Injuries in Lateral Motor Vehicle Crashes with Side Airbags: Another Bag?

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CIREN 2009 Public Meeting

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Outline

- Morbidity and mortality of abdominal and pelvic injuries:
  - Solid organs
  - Hollow Viscus Injuries (HVI)
  - Pelvis
- Federal Motor Vehicle Safety Standards (FMVSS 214)
- Current side impact air bag coverage
- Analysis of side impact air bags in the CIREN database

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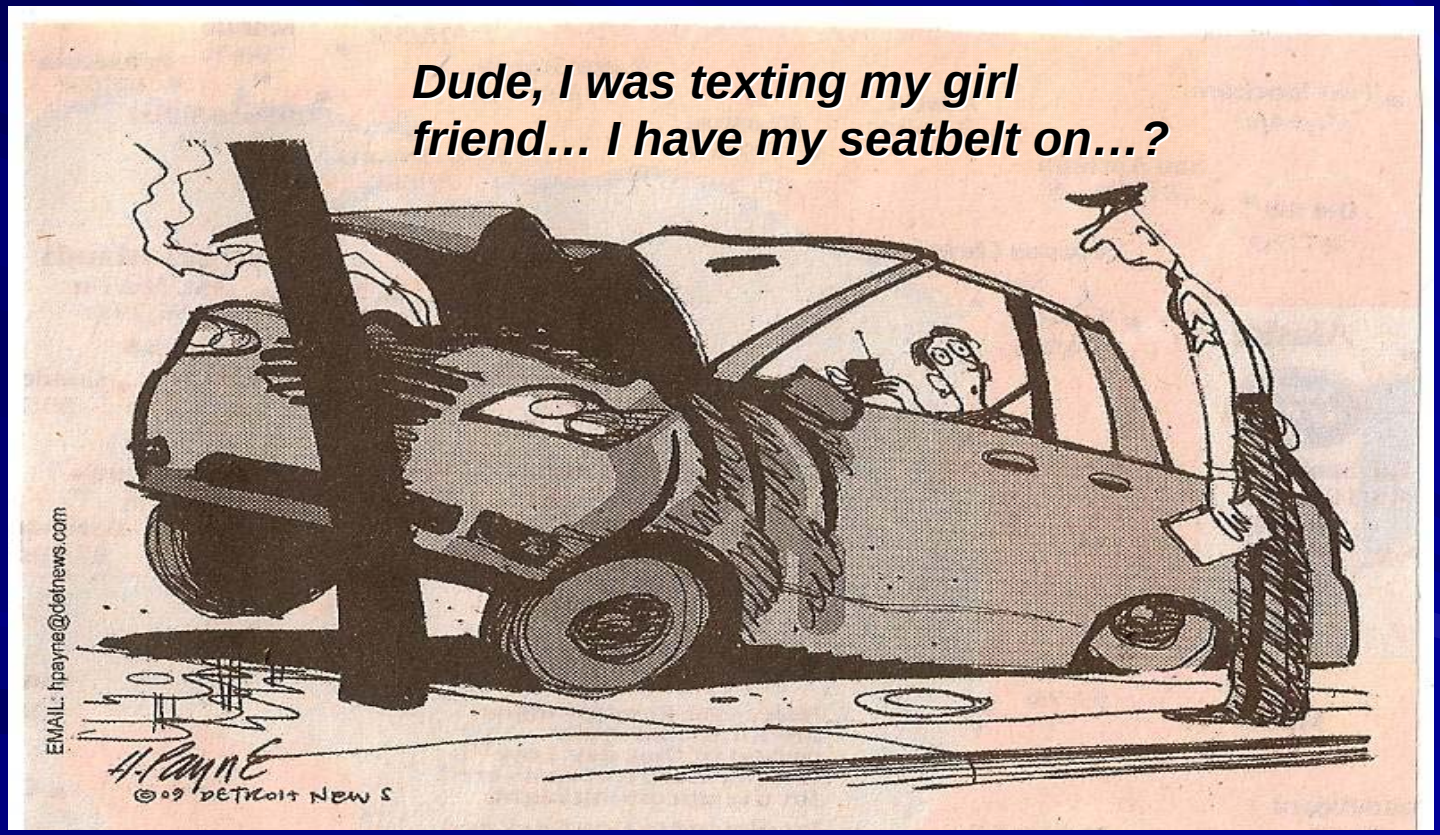
Disclosures

- Nothing to Disclose



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Abstract Accepted For 2010 Eastern Association for the Surgery of Trauma Annual Meeting, Phoenix, AZ

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Background

- Side impacts = 26% of all MVC's
- 32% have AIS 3+ injuries
- Thorax and pelvis most likely to be injured in near-side impacts
- Thorax and pelvic injuries are associated with door intrusion
- NHTSA estimated head and torso SIAB reduce fatality in near side crashes by 24%

Samaha 2003
Lau 1991,Chung 1999,Samaha 2003
Department of Transportation, National Highway Traffic Safety Administration, "Federal Motor Vehicle Safety Standards; Side Impact Protection; Side Impact Phase-In Reporting," Federal Register, Vol. 72, No. 175, Tuesday, September 11, 2007.

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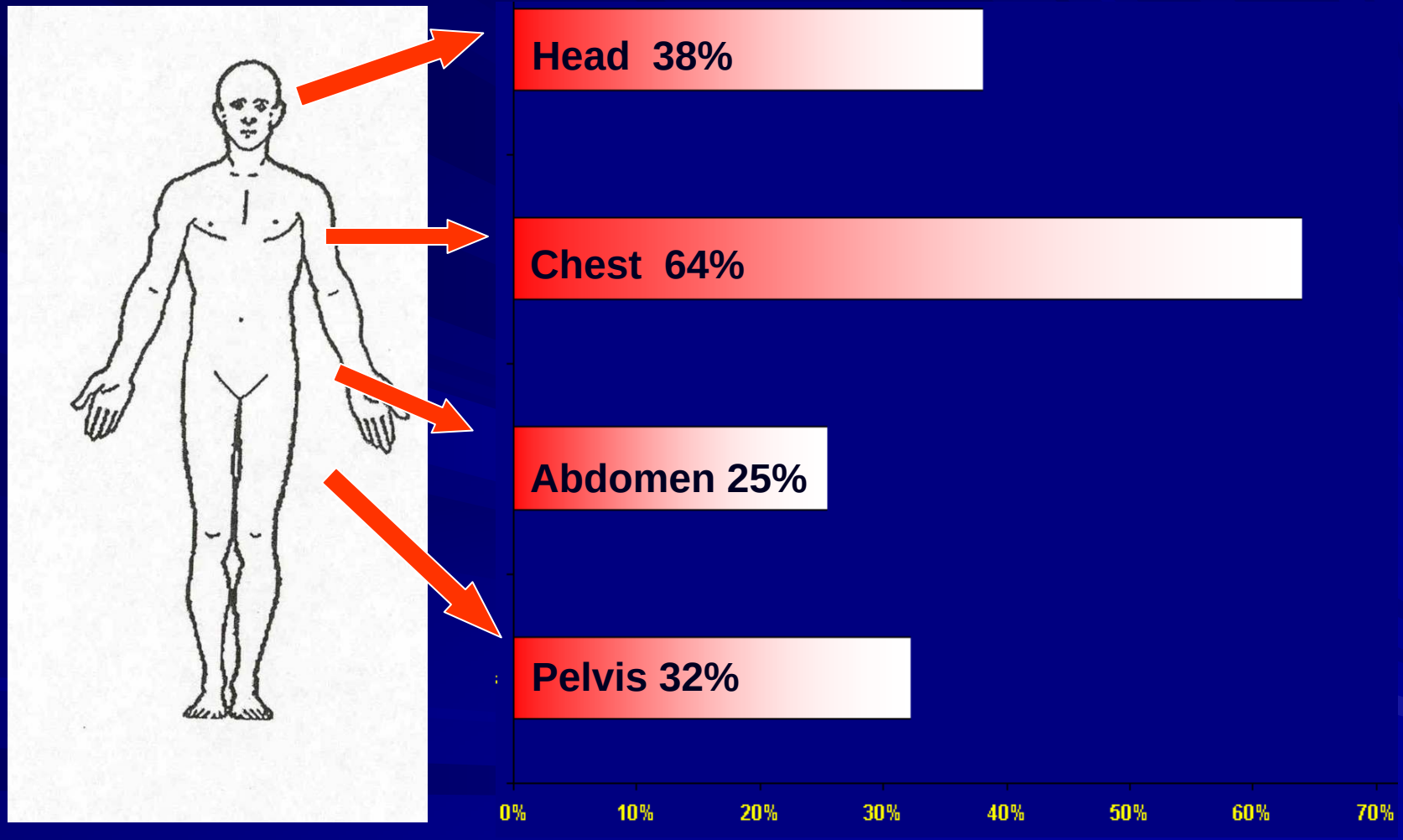
Injury Distribution in Near Side Crashes with AIS≥3 Injuries



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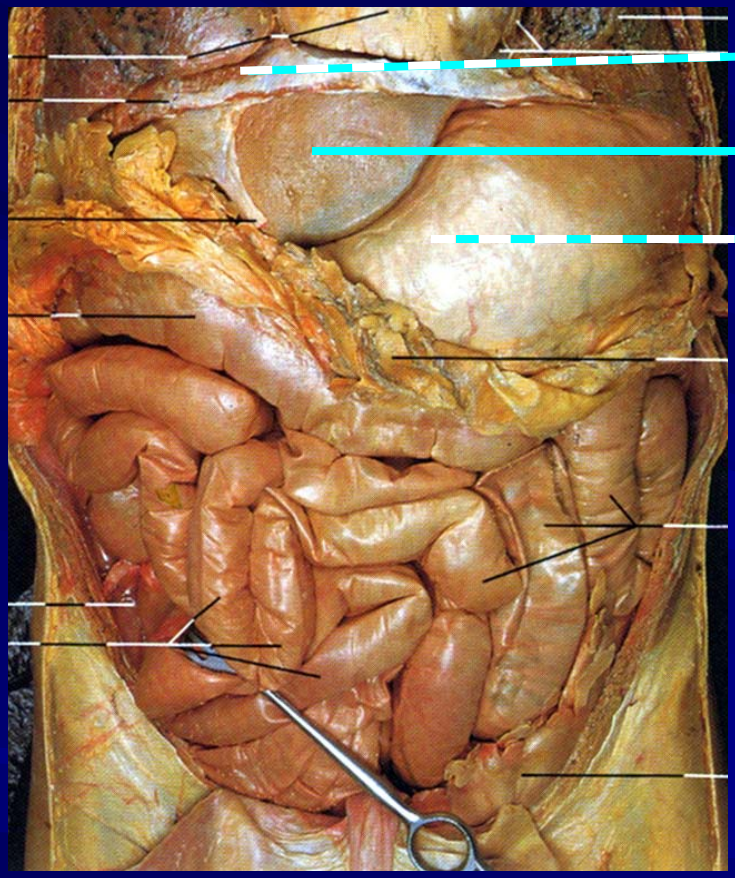
Aldaghlas 2009

Abdominal Pelvic Contents

- Peritoneal organs
  - diaphragm, liver, spleen, stomach, small bowel and transverse colon
- Retroperitoneal
  - aorta, vena cava, pancreas, kidneys, ureters and portions of duodenum and colon
- Pelvis
  - rectum, bladder, iliac vessels, internal genitalia of women

Abdominal Anatomy



Diaphragm

Liver

Stomach

Spleen

Kidney

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Solid Organ Injuries

- Spleen most commonly injured (60%), mortality 6-10%
- Liver second most commonly injured, mortality 8-10%
- Mechanism: direct compression, rate of compression, rib fractures, acceleration

Hollow Viscus Injuries (HVI)

- Small bowel injury relatively uncommon (<1% of all trauma admissions)
- Intestine = 3rd most commonly injured abdominal organ in blunt trauma (5-15%)
- Mechanism: sudden rise in intraluminal pressure, compression, acceleration

East, J Trauma 2003

Pelvic Organ Injuries

- Pelvic structure protects various organs
- Pelvic fractures : GU, GI and vascular injuries
- Mechanism: direct compression, acceleration, laceration from bone fragments

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Pelvic Fractures

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Mechanism of Pelvic Ring Fractures

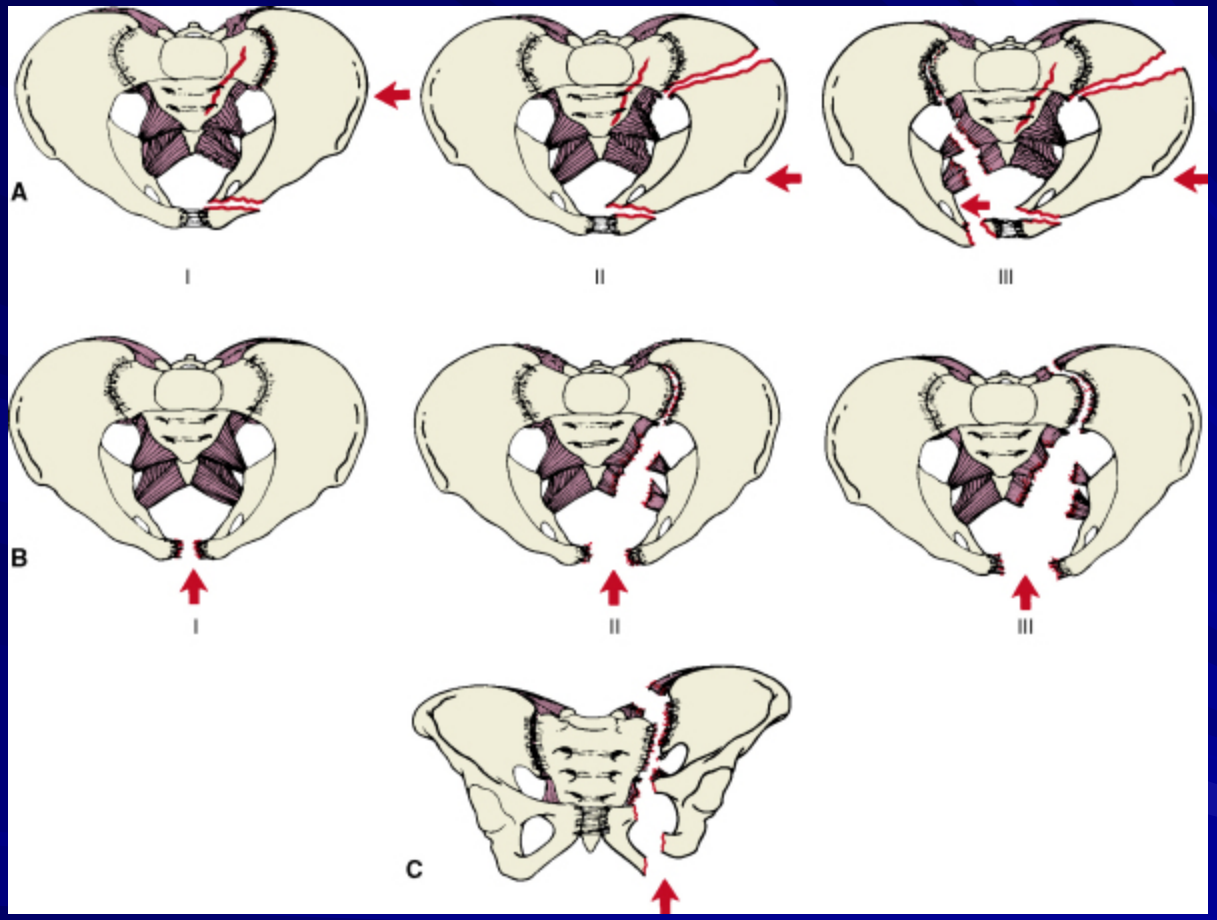
Table

Study	Lateral Compression, %	AP Compression, %	Vertical Shear, %	Complex Forces, %
Young et al [5]	57	15	6	22
McCort and Mindelzun [8]	70	16	7	7
Tile [9]	71	13	16	0

Pelvic Fracture Classification

- Tile and Young-Burgess:
  - Both based on direction of injurious force
  - Relates to type of treatment required and prognosis

Young-Burgess (YB)



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Injury Types Based on YB Classification

- AP compression
  - Based on direction of injurious force
  - Pubic diastasis with or without SI joint disruption
  - Causes external rotation of either hemipelvis or both
  - External rotation increased volume: increased bleeding

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Injury Types Based on YB Classification

- Lateral compression
  - Sacral buckle and horizontal pubic rami fractures
  - Causes internal rotation of either hemipelvis or both
  - Internal rotation creates decreased volume: less bleeding

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Injury Types Based on YB Classification

- Vertical shear injury
  - A vertical force to hemipelvis (by femur)
  - Hemipelvis is displaced in a cranial direction
- Complex fracture
  - Forces applied > one primary vector
- Most MORBID injury

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Pelvic Fractures Mortality

- Associated with high mortality
  - Overall mortality 16%
  - Uncontrolled pelvic hemorrhage 39%
  - Open fractures 45%

Grotz 2005

Dente 2005

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Pelvic Fractures
Morbidity

- Infection, pain, nerve damage (10-15%), malunion or nonunion, DVTs and PEs
- Complications in women: urinary tract (21%), lower GI symptoms (8%)
- Long term disability: <50% of patients who are operated return to their preinjury level of function
- Mechanism: direct compression, tension, bending, shear

Huittinen 1972

Weis 1984

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Timeline of Federal Safety Rules

- 1966 DOT created
- 1968 Front seat shoulder belts
- 1995 Passive restraints in all cars
- 1997 Dual frontal AB in all cars
- 2000s Performance requirements added to decrease injuries in side impact crashes

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FMVSS No. 214

- Protect occupants in near side crashes
- Side impact requirements for passenger cars: October of 1990
- Defined minimum requirements for thoracic and pelvic protection
- New requirements in 2010: criteria for abdominal and pelvic regions

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Current Testing for Side Impact

- HIC (Head Injury Criterion)
- TTI (Thoracic Trauma Index)
- Maximum Pelvic Acceleration Criteria (130g)
- No current abdominal criteria

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Air Bag Deployment Review

- 726 near side crashes reviewed
- 586 near side crashes without SIAB installed
- 28 SIAB did not deploy
- 112 vehicles with SIAB deployment
  - 61 deployments with head coverage
  - 111 deployments with thorax/abdomen coverage
  - 4 deployments with pelvic coverage

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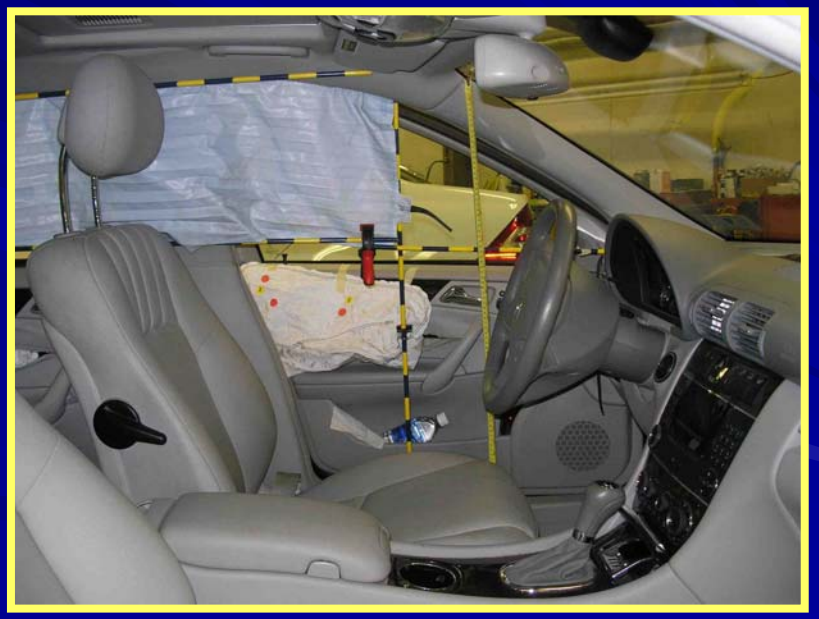
Types of Side Impact Air Bags

Torso and head: Roof rail and door mounted



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Types of Side Impact Air Bags

Torso and head: roof rail and seat mounted

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Head Injuries

Crash_Severity	Air Bag Type	Head Injury		
		None	Minor	Severe (>3)
Minor - Zone 1	Side air bags with head coverage	0.0%	0.0%	0.0%
	Side air bags without head coverage	0.0%	0.0%	0.0%
	No side air bags	25.0%	25.0%	50.0%
Moderate - Zone 2-3	Side air bags with head coverage	7.8%	1.4%	0.8%
	Side air bags without head coverage	2.9%	2.1%	2.1%
	No side air bags	37.5%	17.5%	29.1%
Severe - Zone >4	Side air bags with head coverage	2.1%	1.3%	2.1%
	Side air bags without head coverage	0.9%	1.7%	1.7%
	No side air bags	25.2%	19.2%	47.4%

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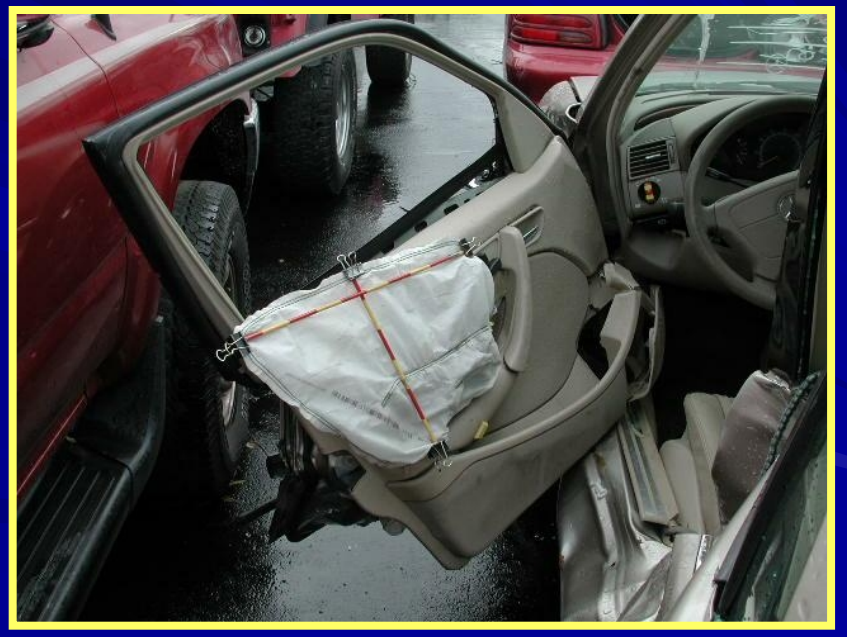
Types of Side Impact Air Bags

Torso: seat and door mounted



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Chest Injuries

Crash_Severity		Chest Injury		
		None	Minor	Severe (>3)
Minor - Zone 1	Side air bags with chest coverage	0.0%	0.0%	0.0%
	Side air bags without chest coverage	0.0%	0.0%	0.0%
	No side air bags	50.0%	25.0%	25.0%
Moderate - Zone 2-3	Side air bags with chest coverage	7.4%	0.4%	7.2%
	Side air bags without chest coverage	0.0%	0.8%	0.8%
	No side air bags	27.2%	4.1%	52.8%
Severe - Zone >4	Side air bags with chest coverage	2.1%	0.4%	5.6%
	Side air bags without chest coverage	0.0%	0.0%	0.0%
	No side air bags	22.6%	3.0%	66.2%

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Abdominal Injuries

Crash_Severity		Abdominal Injury		
		None	Minor	Severe (>3)
Minor - Zone 1	Side air bags with abdominal coverage	0.0%	0.0%	0.0%
	Side air bags without abdominal coverage	0.0%	0.0%	0.0%
	No side air bags	75.0%	0.0%	25.0%
Moderate - Zone 2-3	Side air bags with abdominal coverage	9.3%	2.1%	3.7%
	Side air bags without abdominal coverage	0.2%	0.2%	0.2%
	No side air bags	52.8%	13.2%	18.1%
Severe - Zone >4	Side air bags with abdominal coverage	3.0%	0.9%	4.3%
	Side air bags without abdominal coverage	0.0%	0.0%	0.0%
	No side air bags	47.4%	16.2%	28.2%

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Types of Side Impact Air Bags

Torso and pelvis: seat mounted

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Pelvic Injuries

Crash_Severity		Pelvic Injury		
		None	Minor	Severe (>3)
Minor - Zone 1	Side air bags with pelvic coverage	0.0%	0.0%	0.0%
	Side air bags without pelvic coverage	0.0%	0.0%	0.0%
	No side air bags	75.0%	25.0%	0.0%
Moderate - Zone 2-3	Side air bags with pelvic coverage	0.2%	0.2%	0.0%
	Side air bags without pelvic coverage	7.8%	5.4%	5.4%
	No side air bags	45.8%	12.6%	25.8%
Severe - Zone >4	Side air bags with pelvic coverage	0.0%	0.0%	0.4%
	Side air bags without pelvic coverage	2.1%	3.4%	3.4%
	No side air bags	40.6%	20.1%	31.2%

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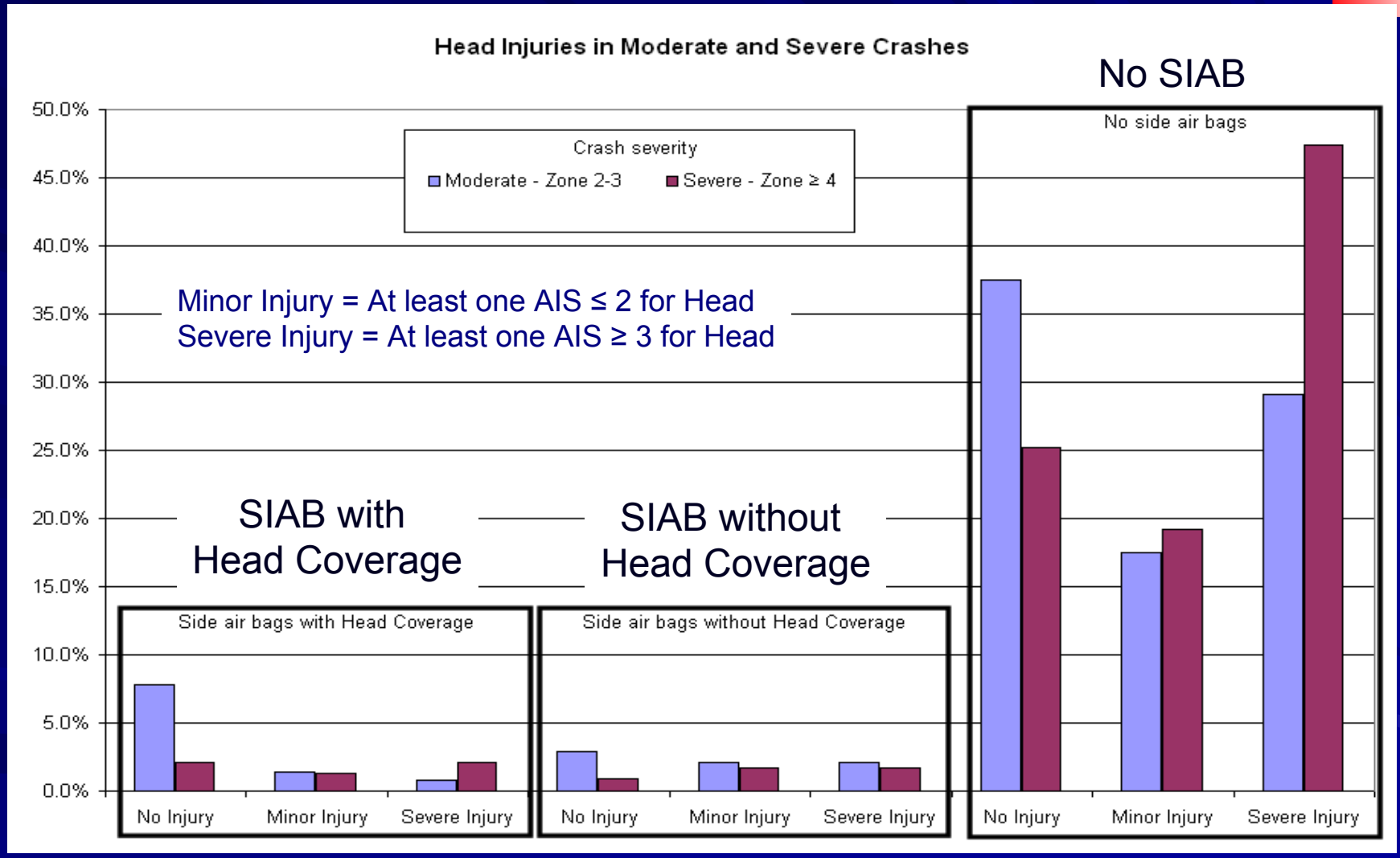
Head injury vs. SIAB coverage



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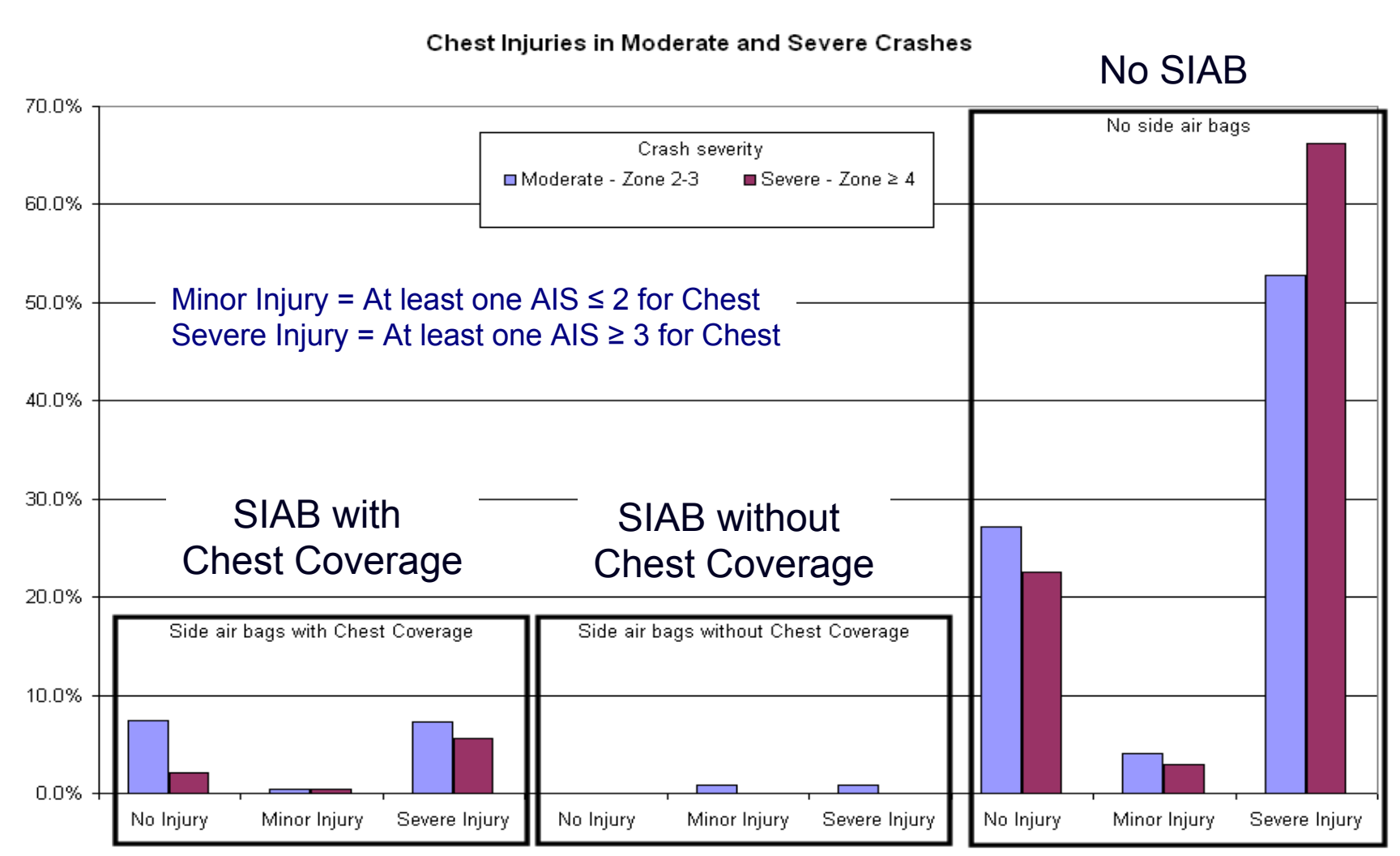
Chest injury vs. SIAB coverage



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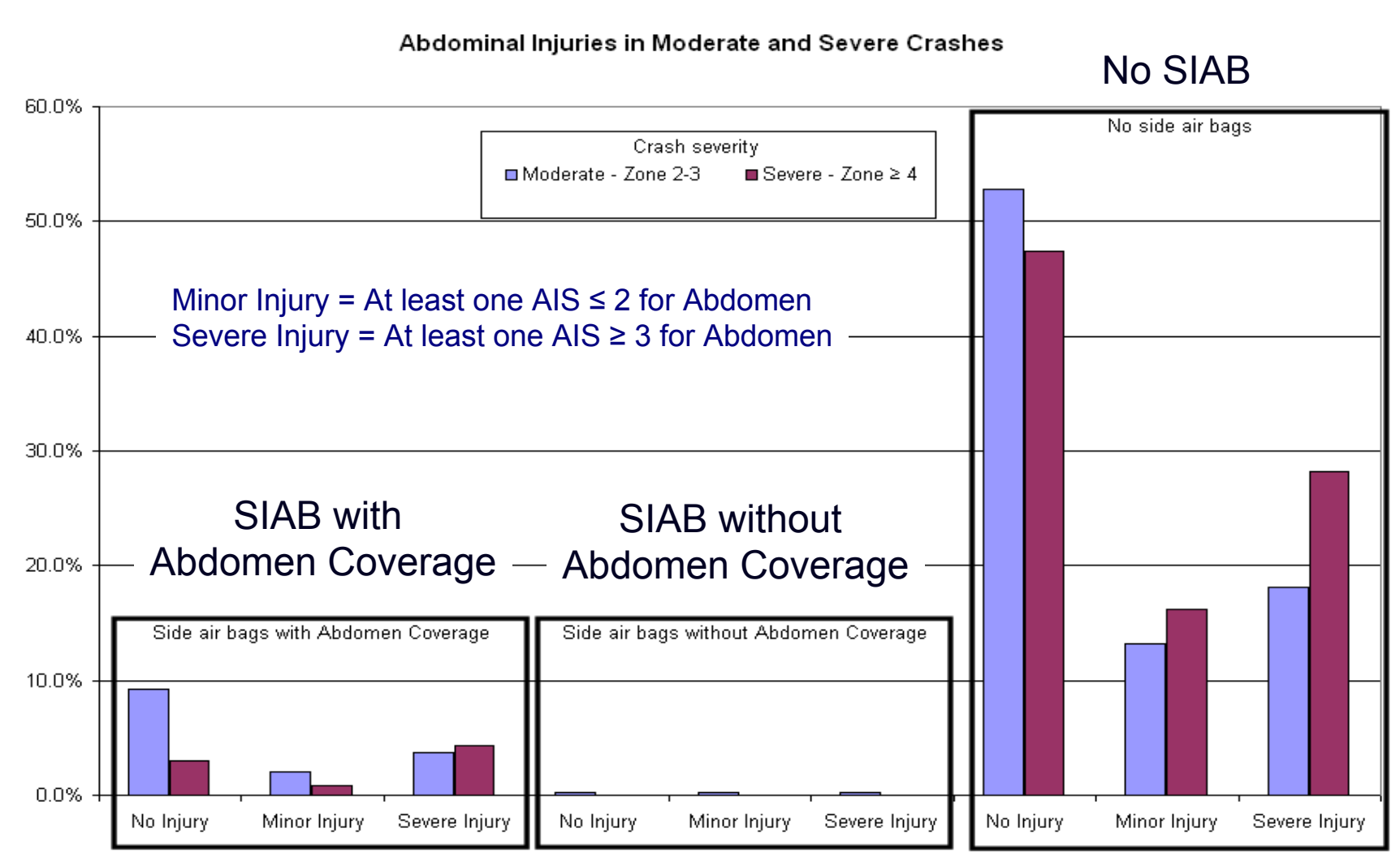
Abdominal injury vs. SIAB coverage



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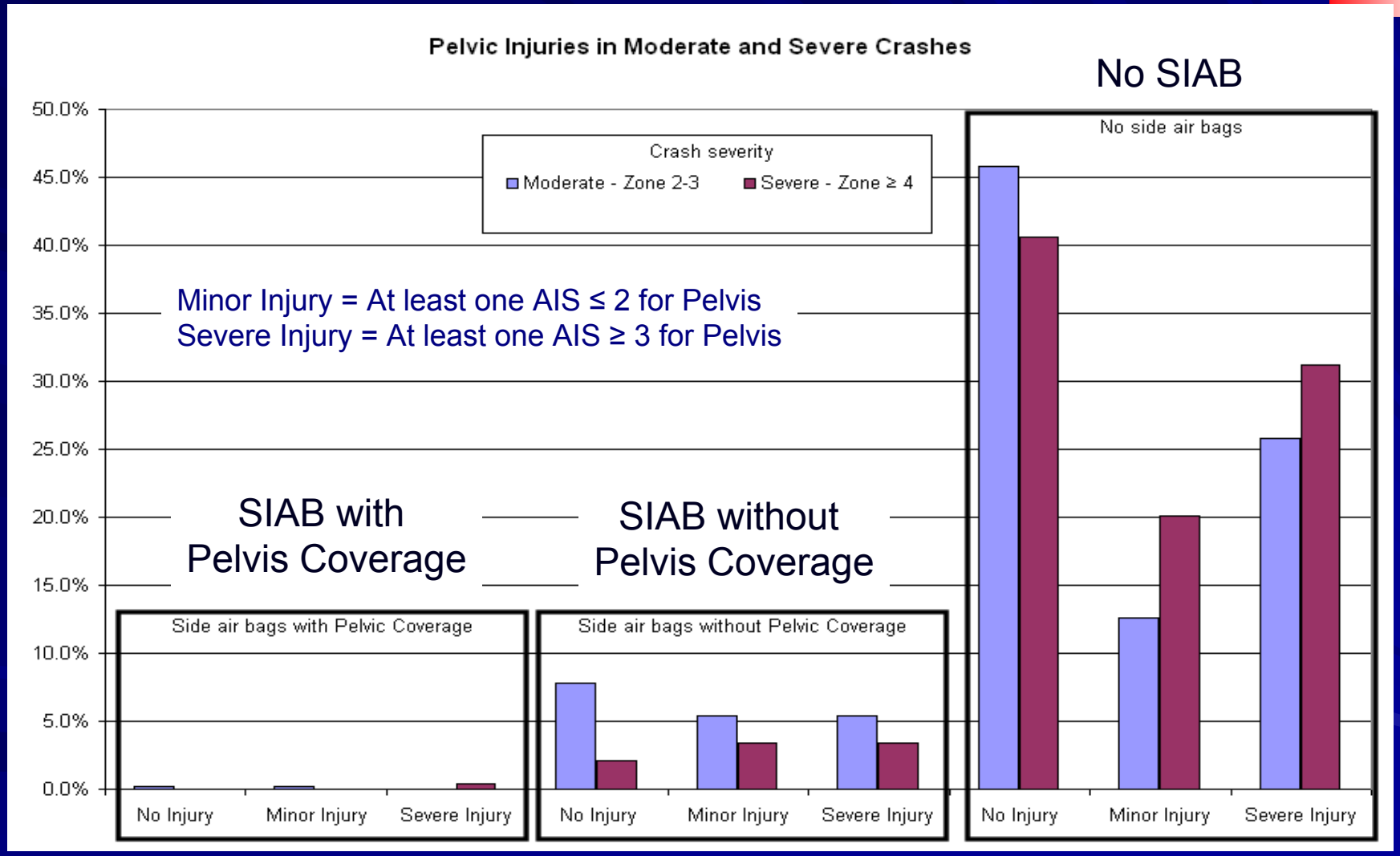
Pelvic injury vs. SIAB coverage



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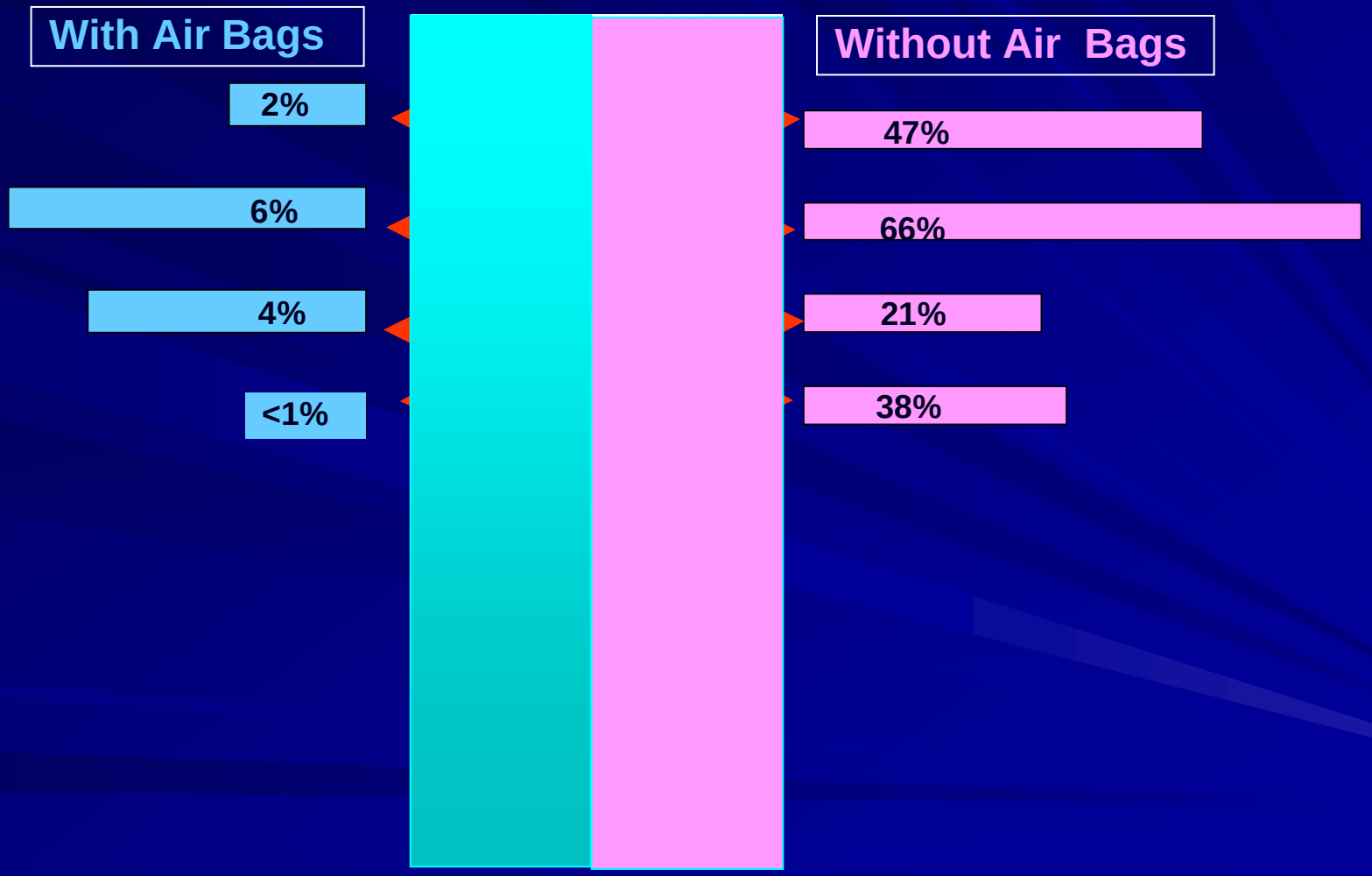
Injury Distribution in Severe Near Side Crashes with AIS≥3 Injuries



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Conclusion

- Current side air bag coverage focuses on the head and torso
- SIAB (head, chest, abdomen) extend protective benefits to other body regions: EXCEPTION
  - Pelvis
  - Lesser extent abdominal organs
- Few SIAB extend to the pelvic region, leaving pelvis unprotected in a majority of crashes

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Conclusion
Future Horizons

- Additional data variables describing side air bag coverage zones in crash research databases would enable researchers to focus more specifically on reduction in injuries to the AP region

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Conclusion
Future Horizons

- The new injury criteria for FMVSS 214 in 2010 for the protection of AP regions will reduce injuries and disabilities from side impact crashes
- Recommendations: Pelvic AB coverage
  - Structural Integrity Change

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Limitations

- Limited details on SIAB coverage area available for research
- Small sample size of current pelvic SIAB
- Abdominal organ mechanisms of injury need more study

Questions?

"No need to wear your seatbelt, son. If you crash my car, you won't *want* to live."

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