Risk Factors Associated with Pulmonary Contusions Sustained in Motor Vehicle Collisions

Cases, Characteristics and Coding

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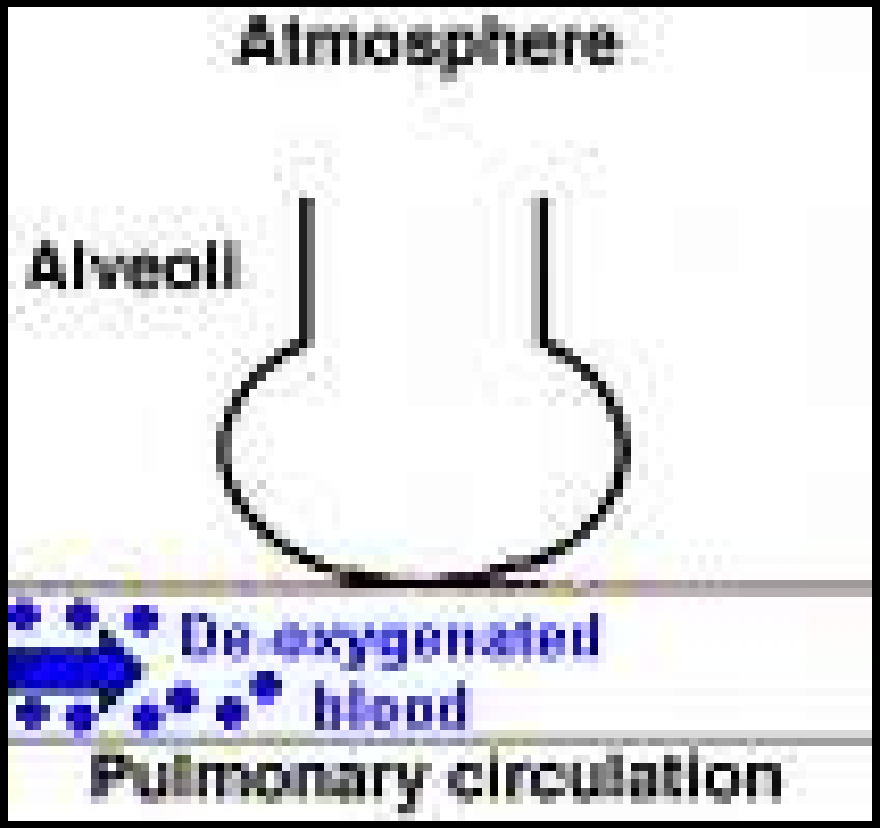
Pulmonary Contusion (PC)
What we think we know

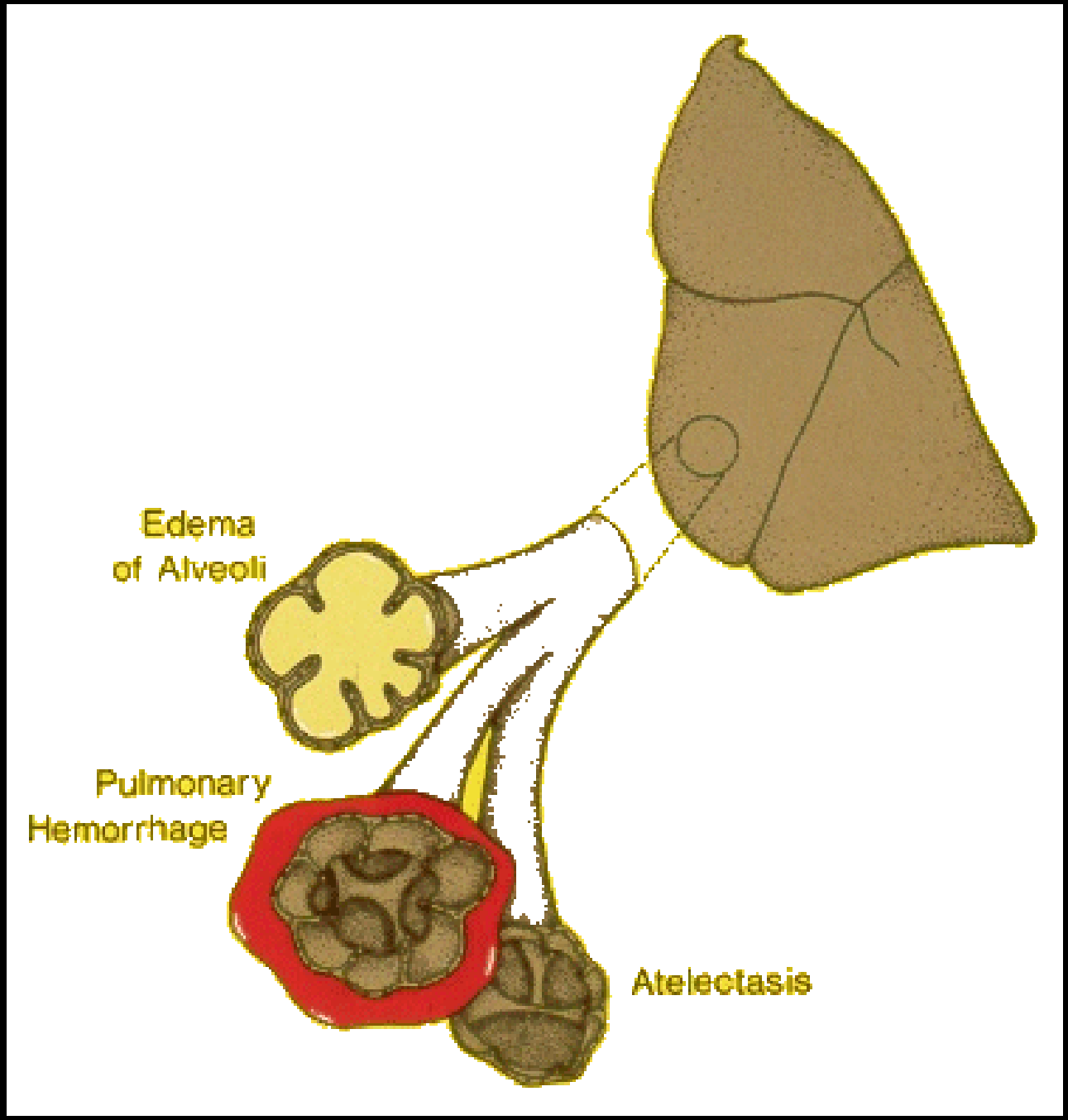
- Alveolar hemorrhage and edema
- Common after blunt chest trauma
- Time course
- Hypoxemia, shunt, mismatch, loss of compliance all lead to increase work of breathing
- Imaging studies
- Treatment

Cohn: J of Trauma 1997

Pulmonary Contusion
Mechanisms

- Rapid deceleration
- Direct impact
- Compression and rate of compression
- Shear forces
- Inertial forces


Atmosphere
Alveoli
De-oxygenated
blood
Pulmonary circulation


Edema
of Alveoli
Pulmonary
Hemorrhage
Atelectasis

Pulmonary Contusion

- Outcome of isolated PC in blunt trauma
- 94 patients, 68% MVC, no mortality
- Factors predisposing to morbidity: PC on admission CXR, >2 rib fractures, chest tube, hypoxemia on admission
- Only p/F ratio was independent predictor of morbidity

Hoff et al: Amer Surg 1993

Outcome After Pulmonary Contusion

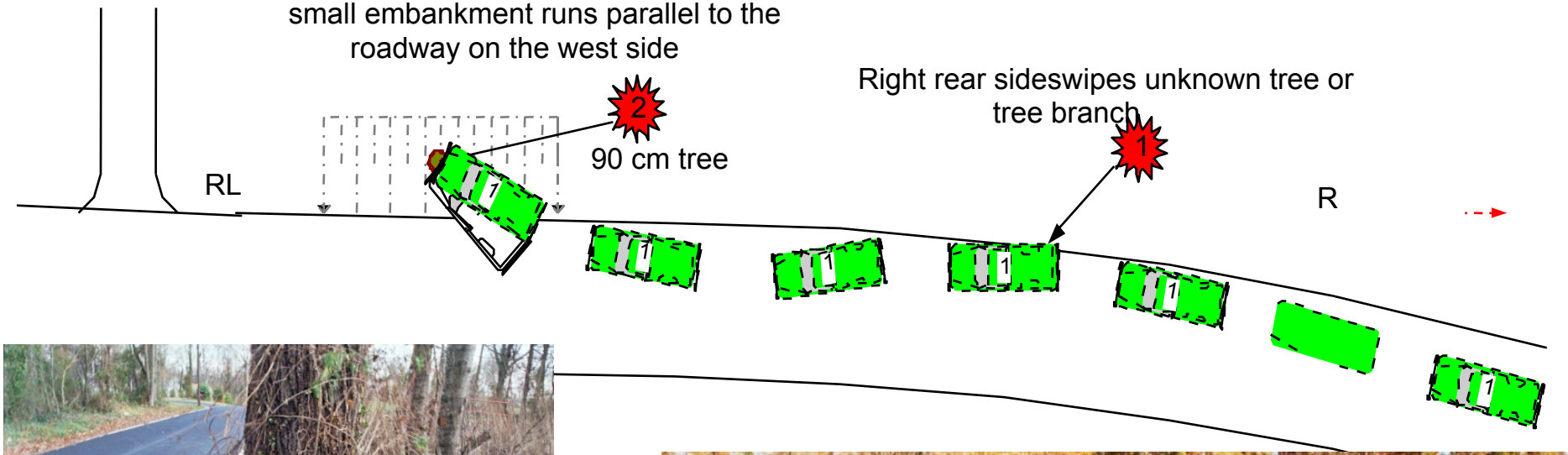
- 86 patients, 76% MVC, 13% mortality
- ISS> 25, GCS <8, transfusion > 3 units predicted mortality and need for ventilation
- p/F ratio best predictor of severity of pulmonary injury
- Good study – it's from Wisconsin

Johnson et al; J of Trauma 1986

CASES

Case 1 Summary

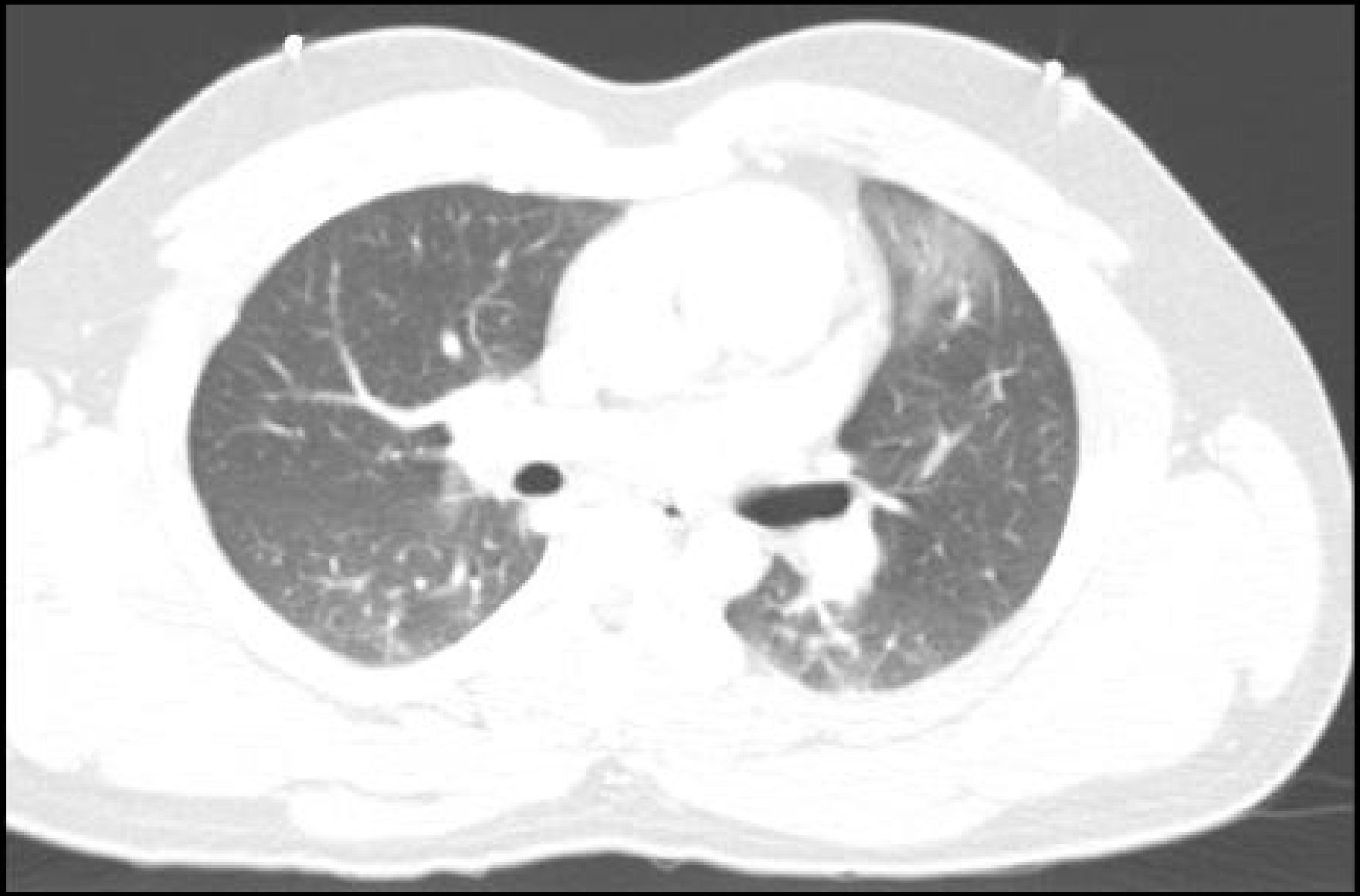
Vehicle:	**2002 Ford Ranger vs. tree 90 cm (35 in) dia.**	
Case Occupant:	**17 y/o male driver**	**63 in / 160 cm** **180 lbs / 82 kg**
Restraint Use:	**3-point lap & shoulder belt, driver's frontal impact air bag deployed, buckle pretensioner.**	
Total Delta V-	**56.0 kph (34.8 mph)**	
CDC-	**12FDEW3**	
PDOF-	**0 degrees**	
Max. Crush-	**65 cm (25.6 in) at the C3 position**	


small embankment runs parallel to the roadway on the west side
Right rear sideswipes unknown tree or tree branch
2
90 cm tree
1
RL
R

Case 1 - Injuries

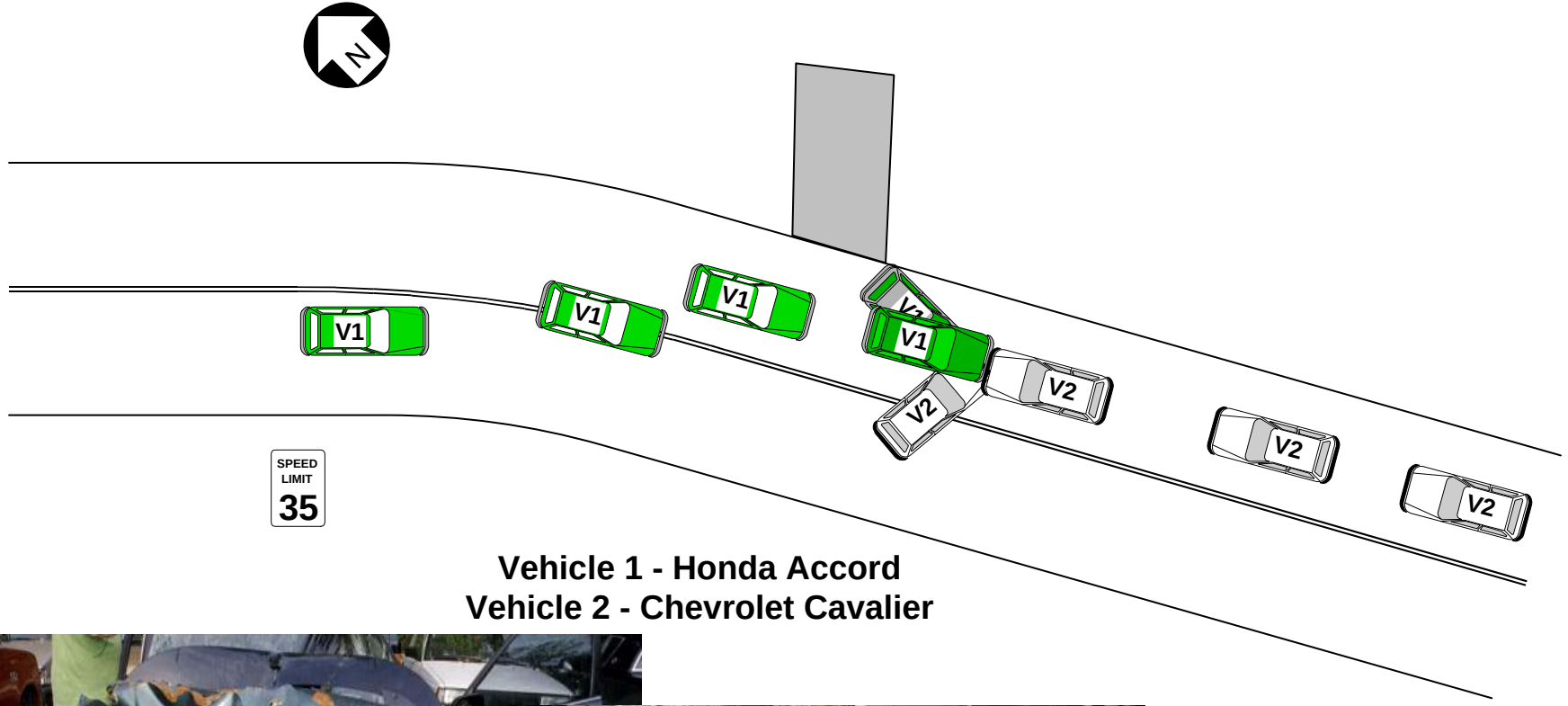
- Left pulmonary contusion
- Grade II splenic laceration
- Right femoral shaft fracture
- ISS = 22
- LOS = 3 days

Case 1 – CT Scan



Case 2 Summary

Vehicle:	**2002 Honda Accord vs. 2003 Chevrolet Cavalier**
Case Occupant:	**26 y/o male driver 70 in / 178 cm 155 lbs / 70 kg**
Restraint Use:	**3-point lap & shoulder belt, driver's frontal impact air bag deployed.**
Total Delta V-	**58.0 kph (36 mph)**
CDC-	**01FDEW5**
PDOF-	**20 degrees**
Max. Crush-	**102 cm (40.2 in) at the C6 position**

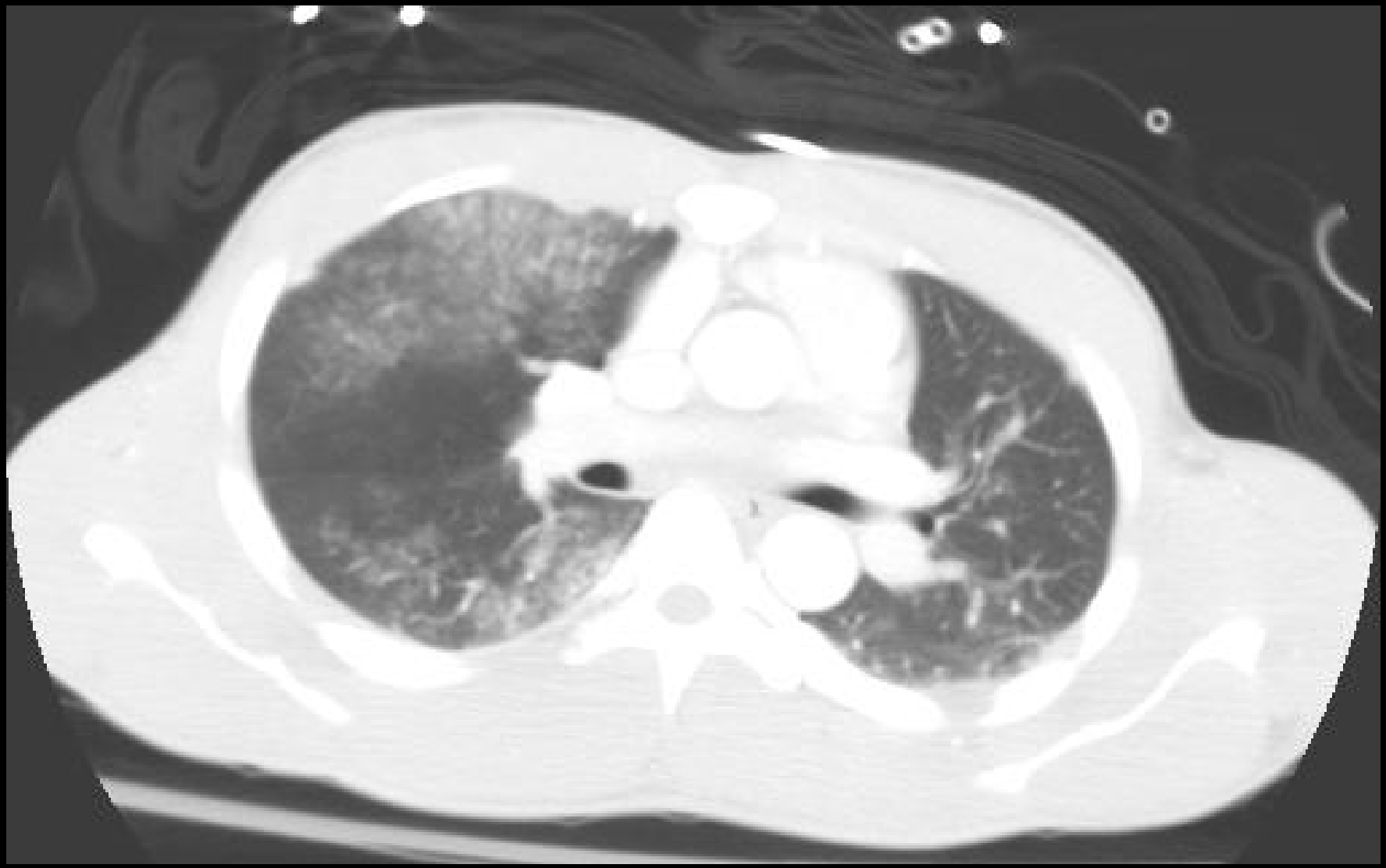


Vehicle 1 - Honda Accord
Vehicle 2 - Chevrolet Cavalier

Case 2 - Injuries

- Right pulmonary contusion
- Right clavicular fracture
- Grade I liver laceration
- Left open patella fracture
- ISS = 17
- LOS = 4 days

Case 2 – CT Scan



Objective

To evaluate both the epidemiological and biomechanical risk factors associated with pulmonary contusions by using the CIREN database.

CHARACTERISTICS

Study Population

- As of July 2006, the CIREN database contained data on 3,000 case occupants
  - Case occupants under the age of 15 were excluded
  - Only frontal and lateral crashes were included for analysis
- Total study population for our initial review of the data was 2,389 case occupants
  - 205 far-side lateral crashes were eliminated from further analysis
- 2,184 case occupants formed the basis of analysis

Statistical Methods

- Pearson's chi-square statistic
- Multivariate logistic regression
- $p \leq 0.05$ for statistical significance

Blunt Chest Trauma: CIREN

- 2,184 Study Population
  - 1,131 (52%) had blunt chest trauma
    - 379 (34%) pulmonary contusions
      - 114 (30%) with associated rib fractures
- Among those with PC, occupants older than age 50 had significantly higher incidence of rib fractures than younger occupants

(45% vs. 25%, $p < 0.001$)

Characteristics of Case Occupants

- 2,184 occupants in frontal or near-side lateral crashes
  - Median age = 38 years
  - Median BMI = 26
  - 80% drivers
  - 50% women
  - 51% belted
  - 16% fatally injured
- 17% had a pulmonary contusion

Case Occupants: Crash Characteristics (N=2,184)

- Median Delta V = 38 kph
- Vehicle type
  - 74% passenger cars
  - 11% SUVs
  - 9% light trucks
  - 6% vans
- 72% frontal deformation
- 68% collision with another vehicle

Case Occupants: Injury Characteristics (N=2,184)

- Median ISS = 17
- Distribution of AIS 3 or higher injuries
  - 24% head injury
  - 10% spinal injury
  - 40% thoracic injury
  - 19% abdominal injury
  - 13% upper extremity injury
  - 34% lower extremity injury

Percent of Occupants with Pulmonary Contusions: Occupant Characteristics
(N=2,184)

		% Pulmonary Contusions	p value
Age (years)	15-24	25	
	25+	15	<0.001

Percent of Occupants with Pulmonary Contusions: Occupant Characteristics

(N= 2,184)

		% Pulmonary Contusions	p value
Age (years)	15-24	25	
	25+	15	<0.001
Gender	Female	16	
	Male	19	0.04

Percent of Occupants with Pulmonary Contusions: Occupant Characteristics (N=2,184)

		% Pulmonary Contusions	p value
Age (years)	15-24	25	
	25+	15	<0.001
Gender	Female	16	
	Male	19	0.04
ISS	9-15	4	
	16-24	23	
	25+	34	<0.001

Percent of Occupants with Pulmonary Contusions: Occupant Characteristics (N=2,184)

		% Pulmonary Contusions	p value
Age (years)	15-24	25	
	25+	15	<0.001
Gender	Female	16	
	Male	19	0.04
ISS	9-15	4	
	16-24	23	
	25+	34	<0.001
Fatality	Yes	26	
	No	16	<0.001

Percent of Occupants with Pulmonary Contusions: Crash Characteristics

(N=2,184)

		% Pulmonary Contusions	p value
Delta V (kph)	≤ 45	15	
	46+	21	0.002

Note: Barrier Equivalent Speed was substituted for 15% of cases with a missing Delta V

Percent of Occupants with Pulmonary Contusions: Crash Characteristics
(N=2,184)

		% Pulmonary Contusions	p value
Delta V (kph)	≤ 45	15	
	46+	21	0.002
Deformation Location*	Frontal	14	
	Near-side	26	<0.001

* Most severe event

Note: Barrier Equivalent Speed was substituted for 15% of cases with a missing Delta V

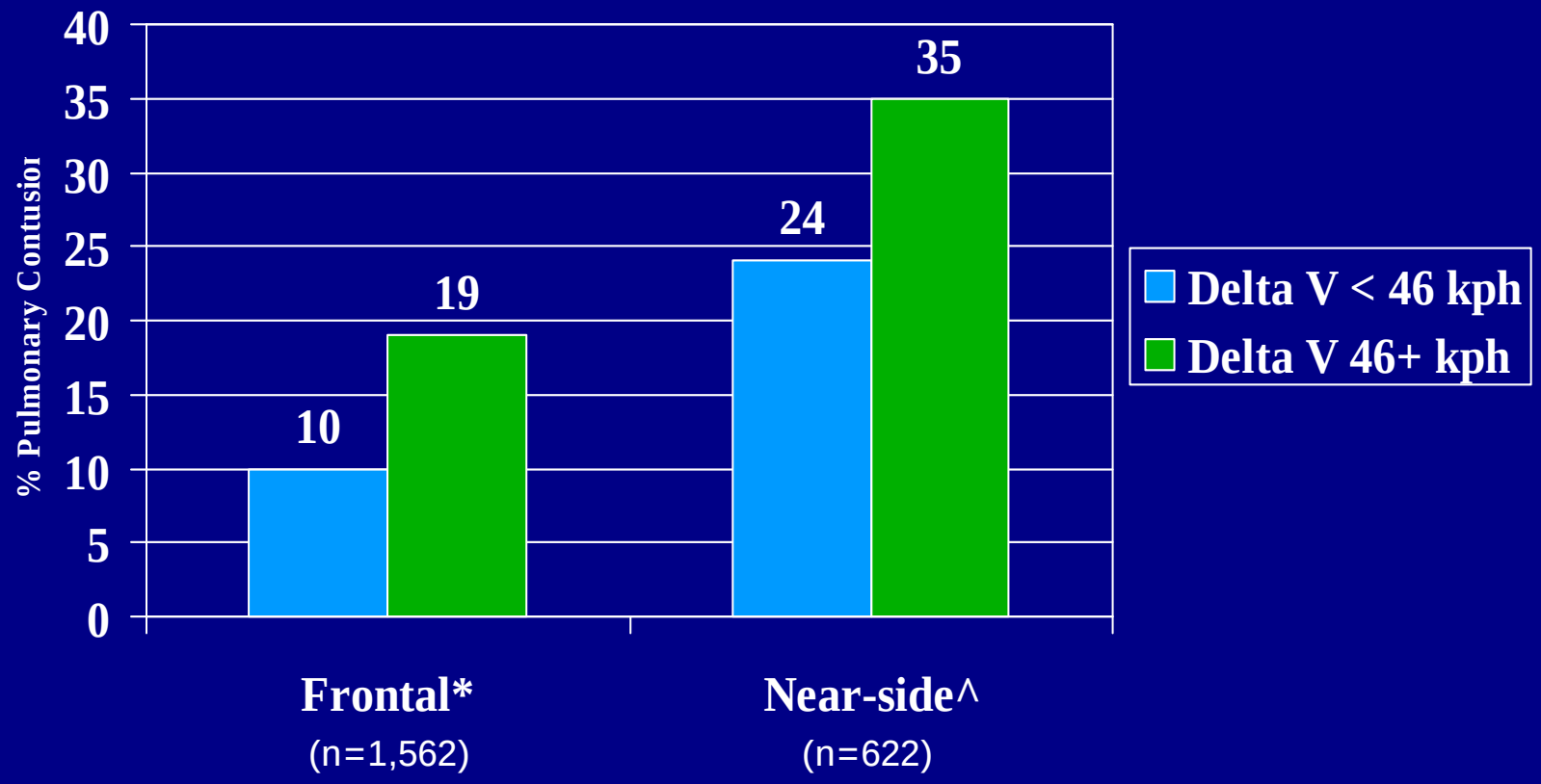
Percent of Occupants with Pulmonary Contusions: Crash Characteristics
(N=2,184)

		% Pulmonary Contusions	p value
Delta V (kph)	≤ 45	15	
	46+	21	0.002
Deformation Location*	Frontal	14	
	Near-side	26	<0.001
Collision Type*	Vehicle	15	
	Fixed Object	22	<0.001

* Most severe event

Note: Barrier Equivalent Speed was substituted for 15% of cases with a missing Delta V

Percent of Occupants with Pulmonary Contusions by Delta V:
Frontal and Near-side Lateral Crashes



* p < 0.001

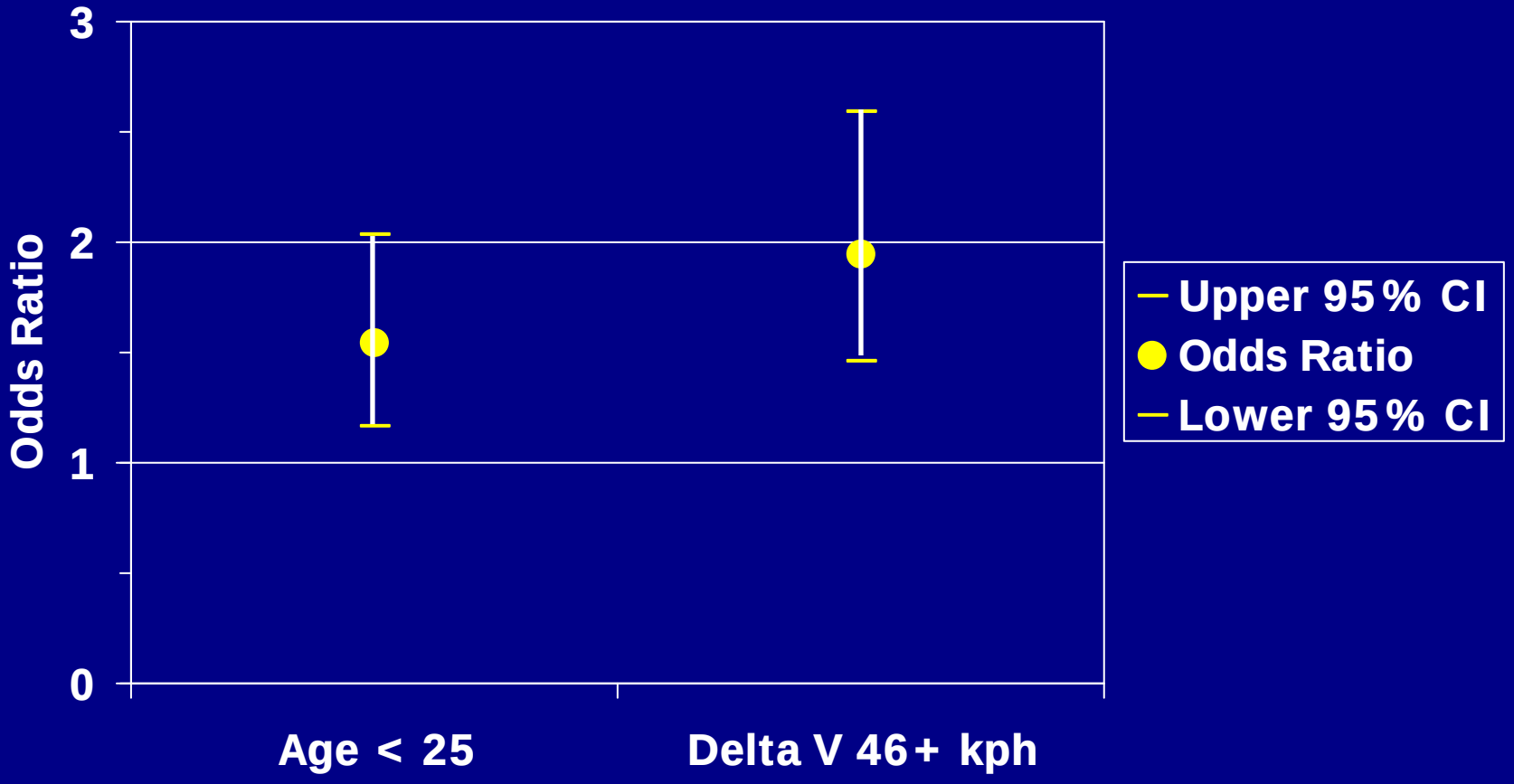
^ p = 0.05

Multivariate Analysis Model I

- Outcome = *Incidence of pulmonary contusion*
  - Independent variables
    - Age
    - Gender
    - BMI
    - Belt use
    - Object struck
    - Delta V
    - Deformation location

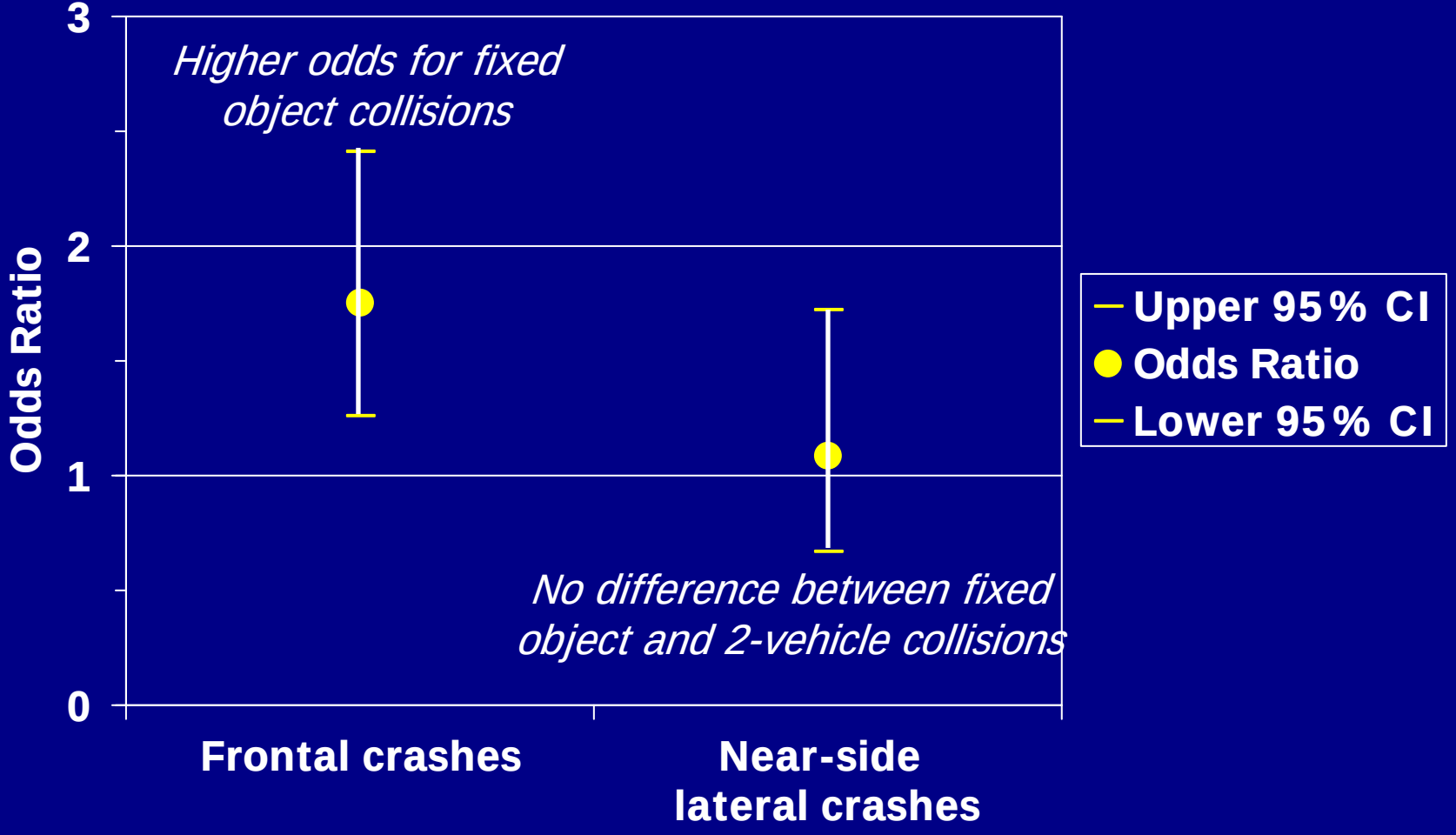
Airbag deployment excluded due to missing values (31%)

Risks For Pulmonary Contusions:
Younger Age and Higher Delta V



Odds of Pulmonary Contusion for Fixed Object *vs.* 2-Vehicle Collision:

Frontal and Near-side Lateral Crashes



Multivariate Analysis Model II

- Outcome = *Incidence of mortality*
  - Independent variable
    - Pulmonary contusion
  - Covariates (AIS 3 or higher)
    - Head injuries
    - Spinal injuries
    - Abdominal injuries
    - Upper extremity injuries
    - Lower extremity injuries
  - Stratification levels
    - No other AIS 3+ thoracic injury
    - At least 1 other AIS 3+ thoracic injury

Multivariate Model II Results

- Pulmonary contusion is *not* a risk factor for mortality
  - Whether or not other AIS 3+ thoracic injuries are present
  - After controlling for head, spinal, abdominal, and extremity injuries of severity AIS 3+

CODING

AIS = 3

AIS = 3

AIS = 3

Conclusions

- Crashes are relatively severe
  - ISS, fatalities, Delta V
- Occupants under 25 years of age are 1.5 times as likely as older drivers to sustain a *pulmonary contusion*
- Delta V was significantly associated with the risk of *pulmonary contusion* for all crashes (OR=1.9 for delta v = 46+ kph)

Conclusions

- Among frontal crashes, fixed object collisions are 1.8 times as likely as two vehicle collisions to result in *pulmonary contusion*
- Risk of *pulmonary contusion* is greatly increased in near-side lateral crashes
- Among near side lateral crashes, fixed object and two vehicle collisions are equally as likely to result in *pulmonary contusion*
- *Pulmonary contusion* is **not** a risk factor for mortality when controlling for other AIS 3+ injuries

Limitations

- Not population-based
- Availability of airbag deployment data
- AIS ?

Disclaimer

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- Views expressed are those of the authors and do not represent the views of the NHTSA

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