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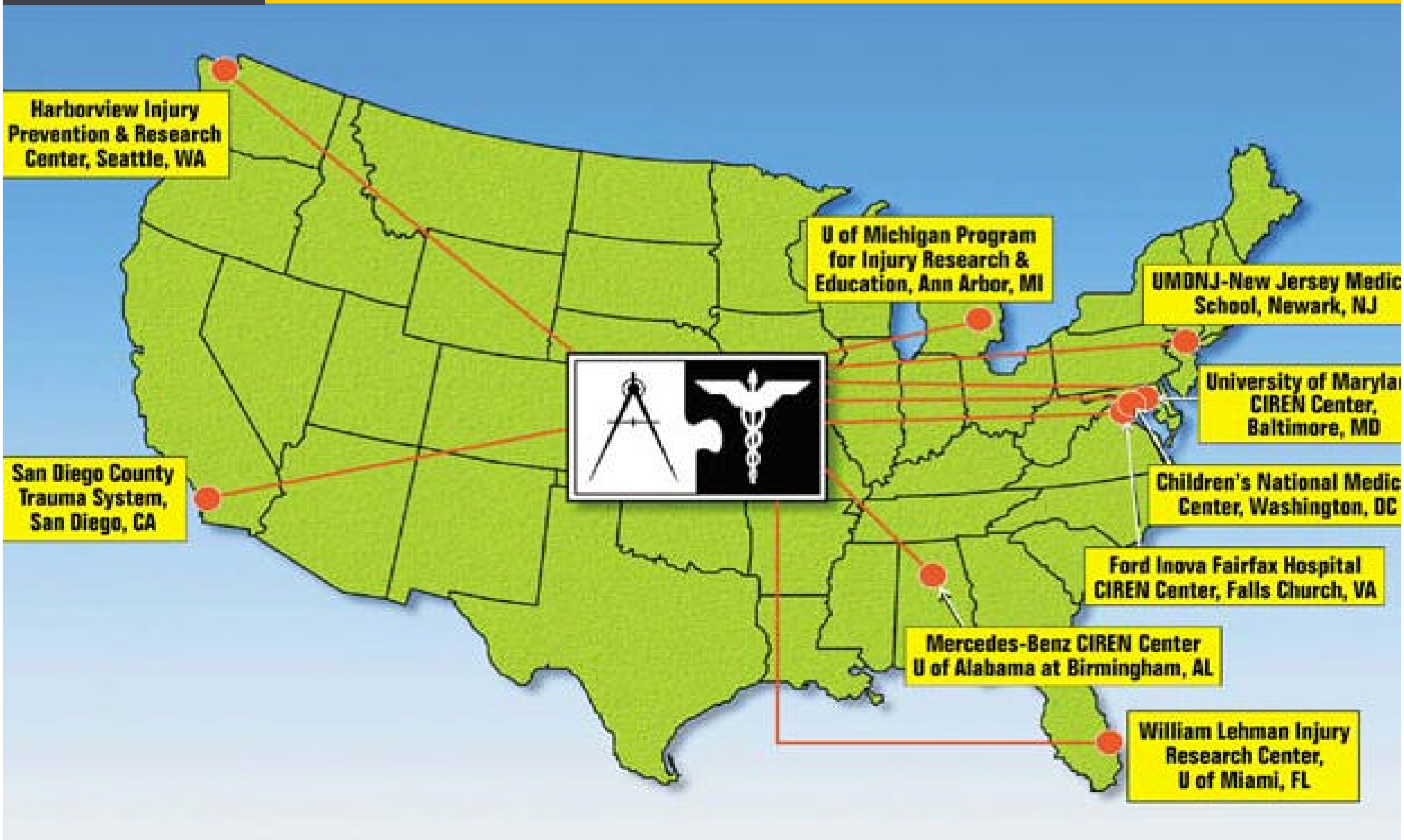
CIREN NETWORK



Diaphragm Injuries

November 30, 2000

Washington, DC

San Diego CIREN Program

Principal Investigators

Gail F. Cooper
A. Brent Eastman, MD, FACS
David B. Hoyt, MD, FACS

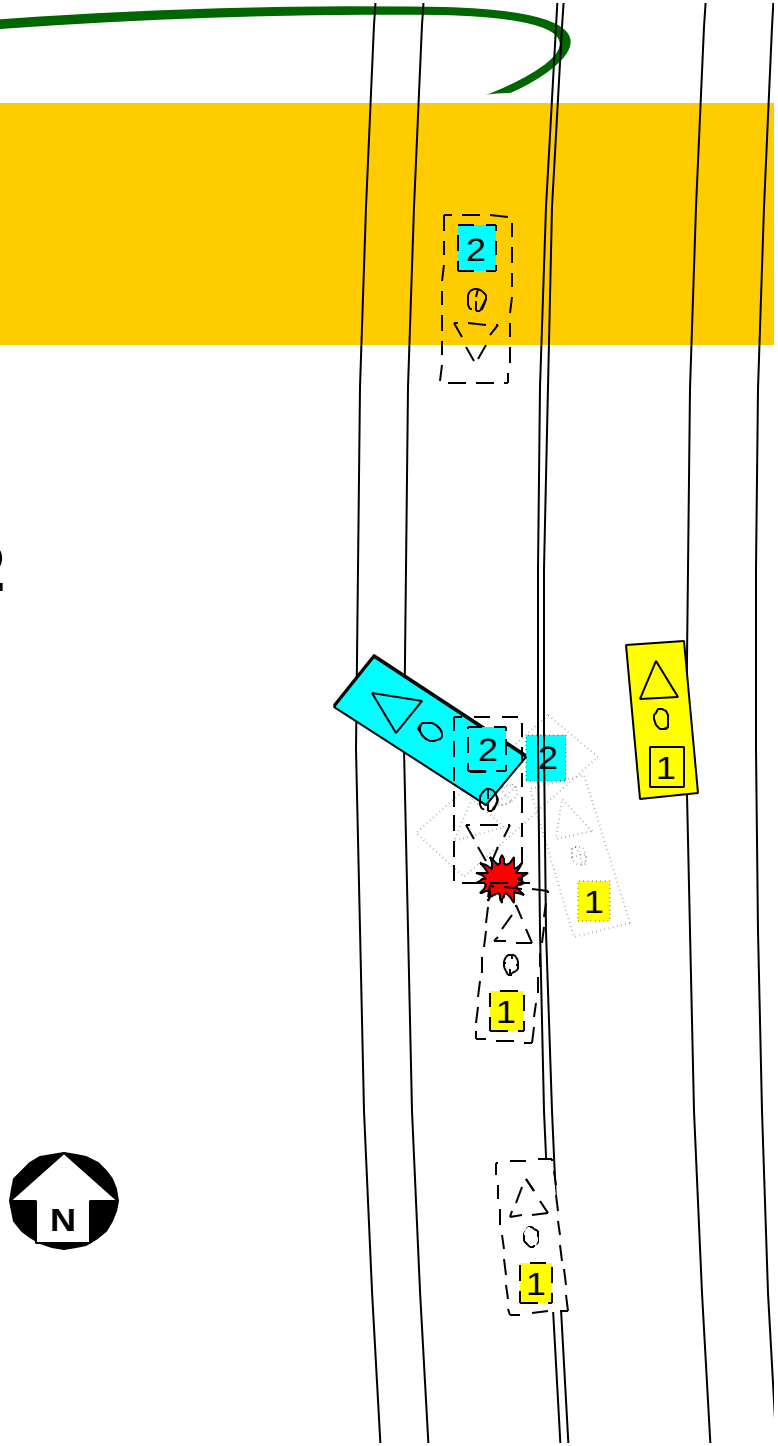
Case #1

Case Vehicle (V1)

1998 Nissan Frontier King Cab 4x2

Opposing Vehicle (V2)

1977 Ford F-350 Standard Cab



Direction Of Travel - Case Vehicle

Pre-Crash

Crash Site

Case Vehicle

PDOF/CDC:

360 degrees/12FDEW4

Delta V/BES:

37 mph (59 kph)/ 37 mph (60 kph)

Opposing Vehicle

PDOF/CDC:

10 degrees/ 12FDEW4

Case Vehicle Interior

Relevant Intrusions:

Center dash and console - 15 cms

Right toe pan - 16 cms

Case Vehicle Interior - Contact Points

Relevant Contact Points:

Center dash / console components - deformed / gear shifter bent to left

Right front lower dash - deformed

Right front passenger air bag - fabric transfer

Vehicle Occupant Case #1

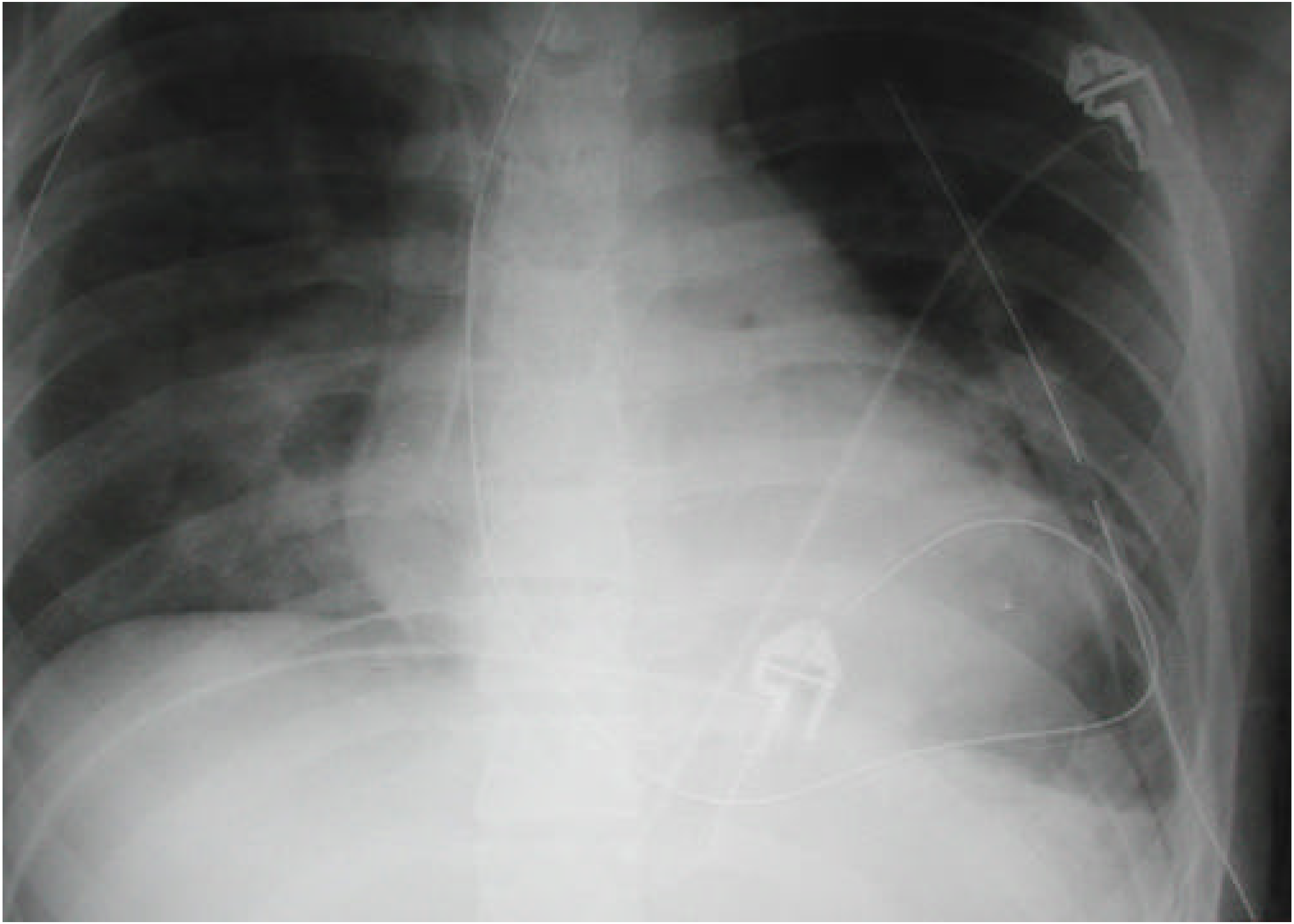
- Right Front Passenger
- 20 Year Old Male
- Six Feet (183 cm)
- 181 Pounds (82 kg)
- Frontal Air Bag Only

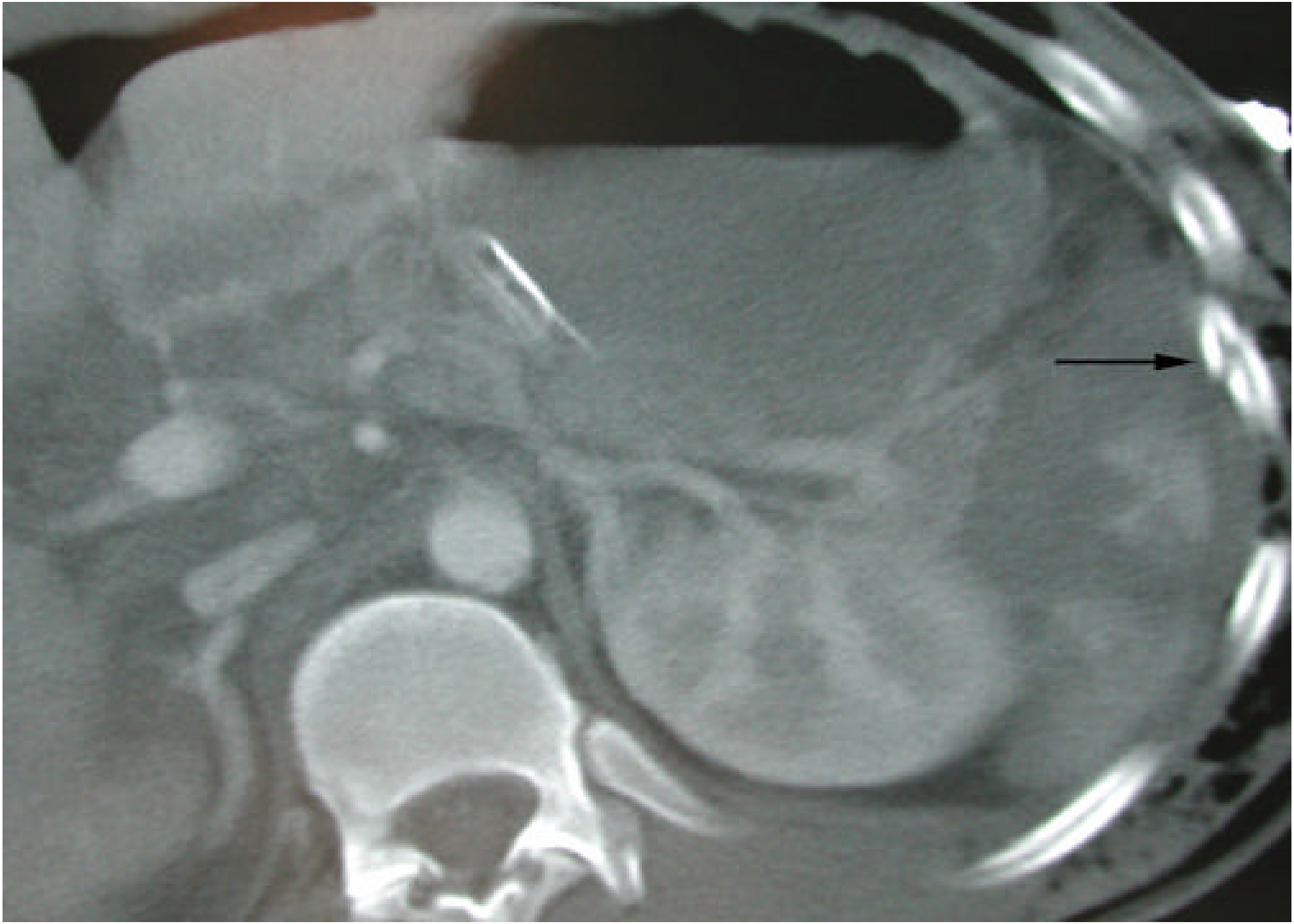
Occupant Injuries Case #1

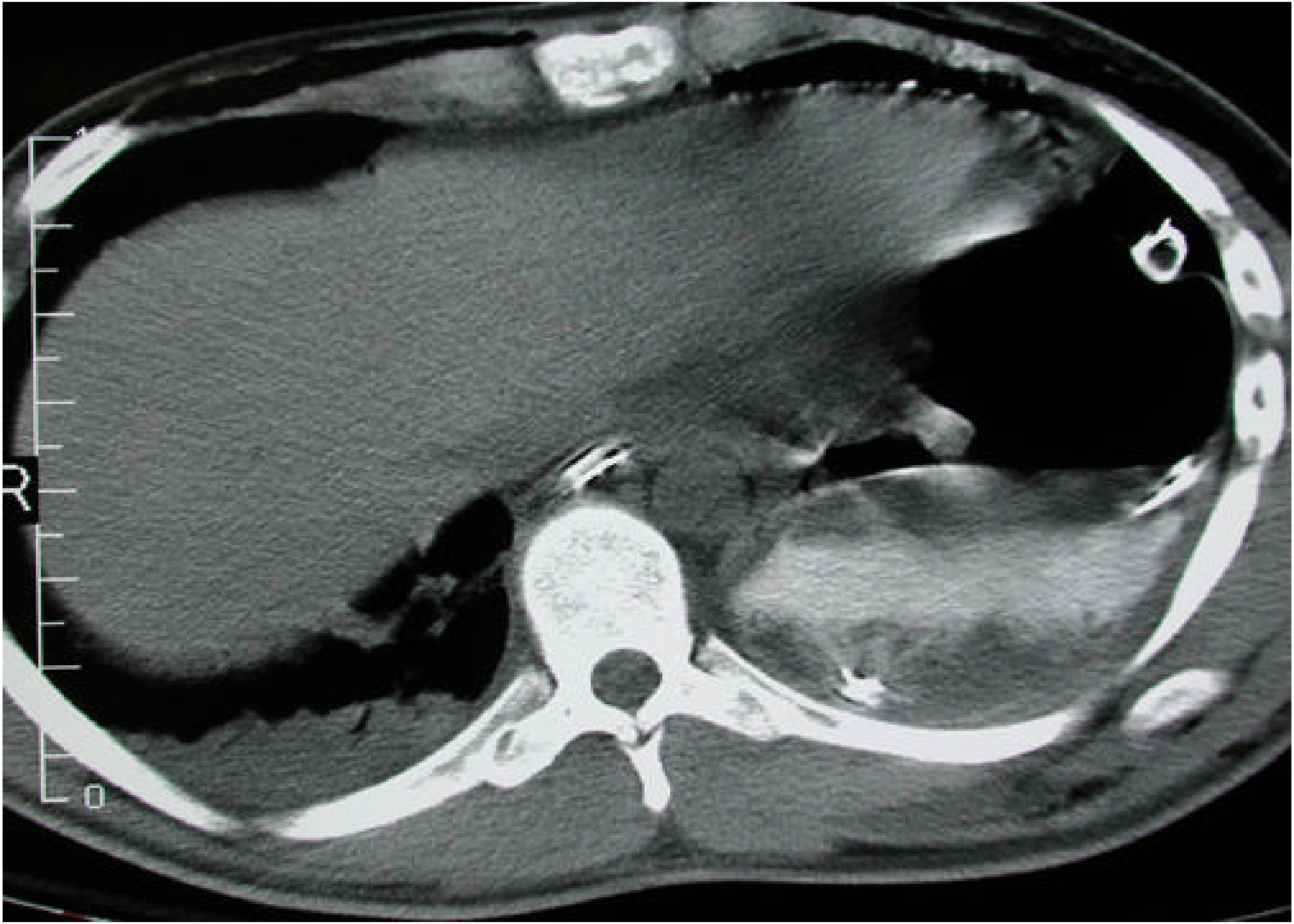
- Facial contusions/abrasions
- Left diaphragm laceration - 6 cm
- Left lateral rib fracture
- Bilateral PTX with right tension PTX
- Right pulmonary contusion
- Splenic laceration; Left flank contusion
- Right anterior pubic rami fx, minimally displaced
- Right SI joint diastasis, minimally displaced
- Left posterior sacrum fx

Patient Treatment Case #1

- Surgery
  - Repair of diaphragm
  - ORIF pelvis
- Ventilator support



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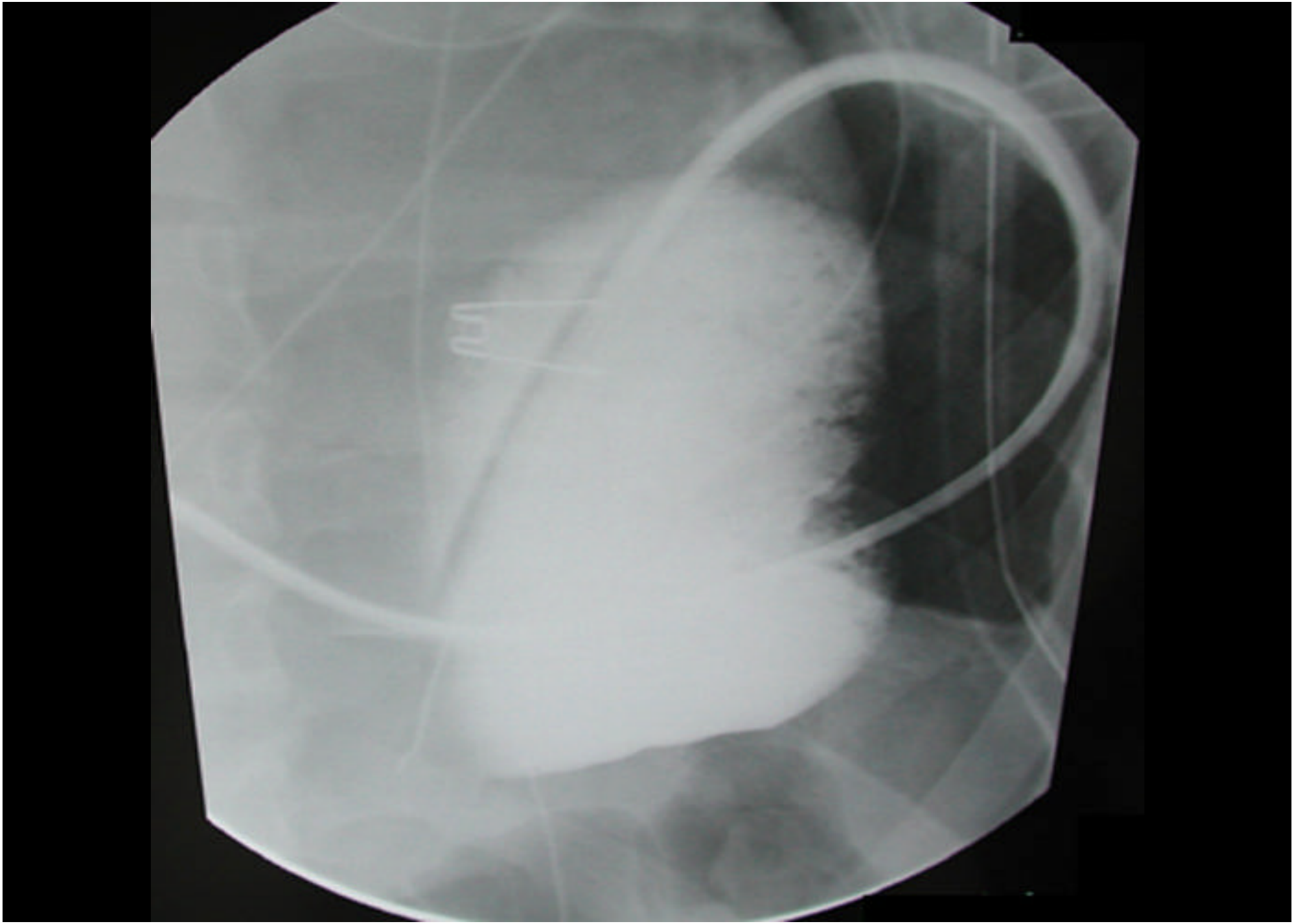

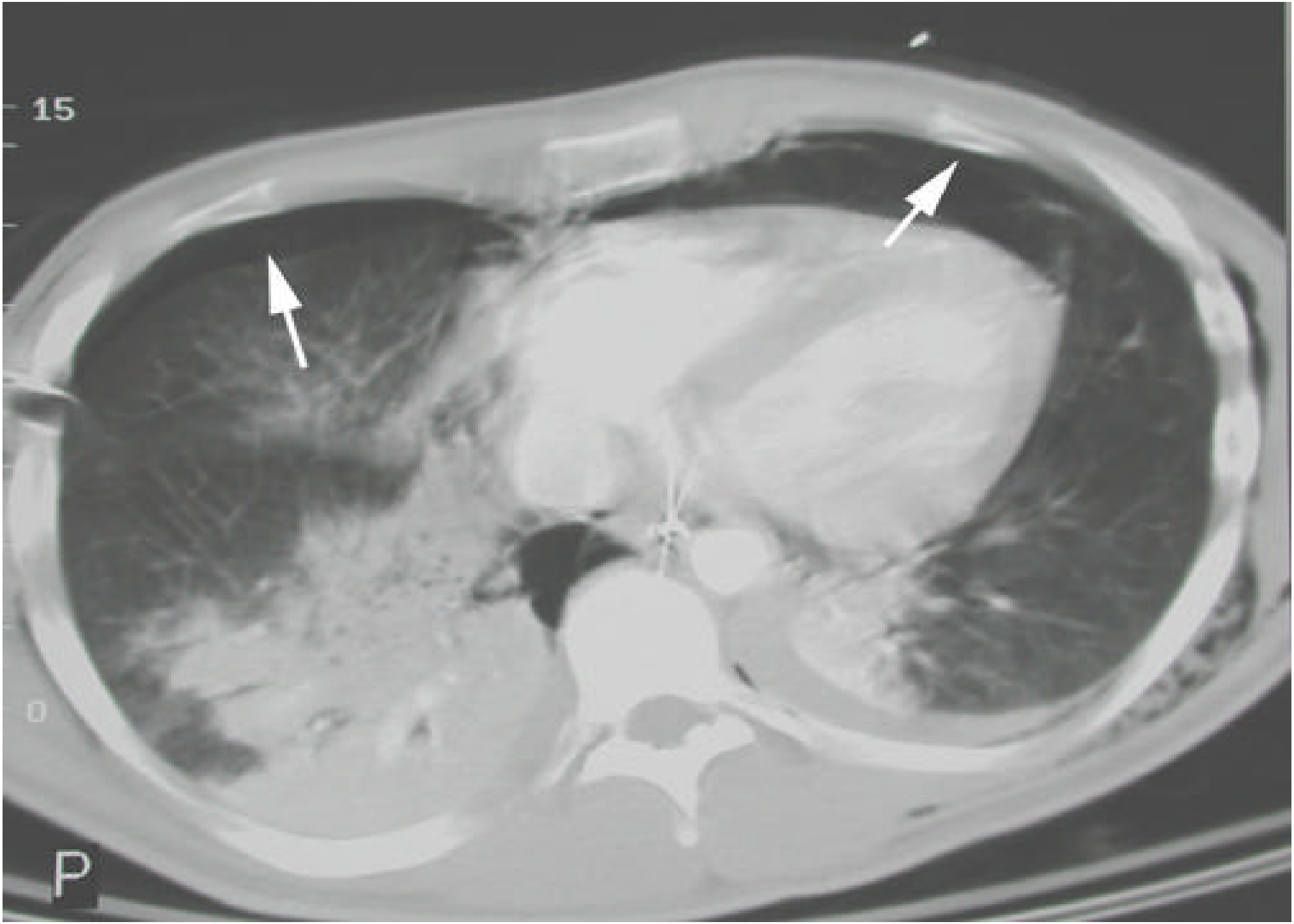
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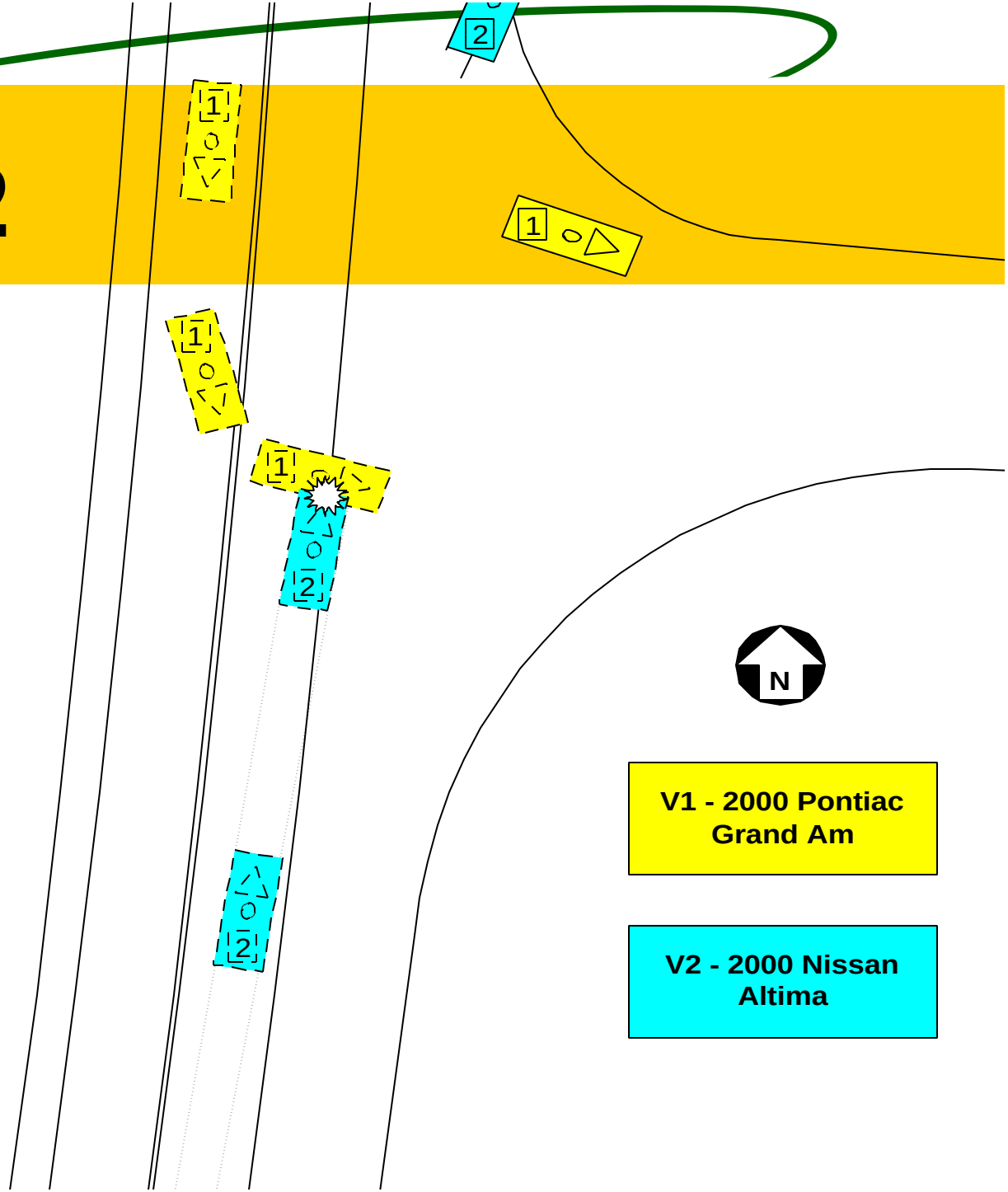
Case #2



Crash Scene

Pre-Crash

Case vehicle

Pre-Crash

Opposing vehicle

Case Vehicle

PDOF/CDC:

80 degrees/03RZEW4

Delta V/BES:

25 mph (41 kph)/29 mph (47 kph)

Case Vehicle Interior - Intrusions

Right front door panel	- 37 cm's
Right "B" pillar	- 32 cm's
Right front roof rail	- 23 cm's
Right front sill	- 29 cm's
Right rear door panel	- 44 cm's

Case Vehicle Interior - Contact Points

Contact Points:

Right front door panel - deformed/broken

Right “B” pillar - scuff/transfer

Vehicle Occupant Case #2

- Right Front Passenger
- 36 Year Old Male
- Five Feet, 11 Inches (180 cm)
- 168 Pounds (76 kg)
- 3-Point Manual Restraint
- Air Bag Deployed

Occupant Injuries Case #2

- Basilar skull fx; subarachnoid hemorrhage; DAI
- Right diaphragm laceration x 2
- Right rib fxs (3 - 8); PTX; bilateral pulmonary contusion (bases)
- Liver lacerations x 2 (4cm & 6cm)
- Splenic & mesentary lacerations
- Greater omentum avulsion
- Right -Sided Contusions - lower rib cage, upper abdomen, flank

Patient Treatment Case #2

- Surgery
  - Repair of diaphragm
  - Repair of liver
  - Splenectomy
- Ventilator Support and ICP Monitoring

A

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L
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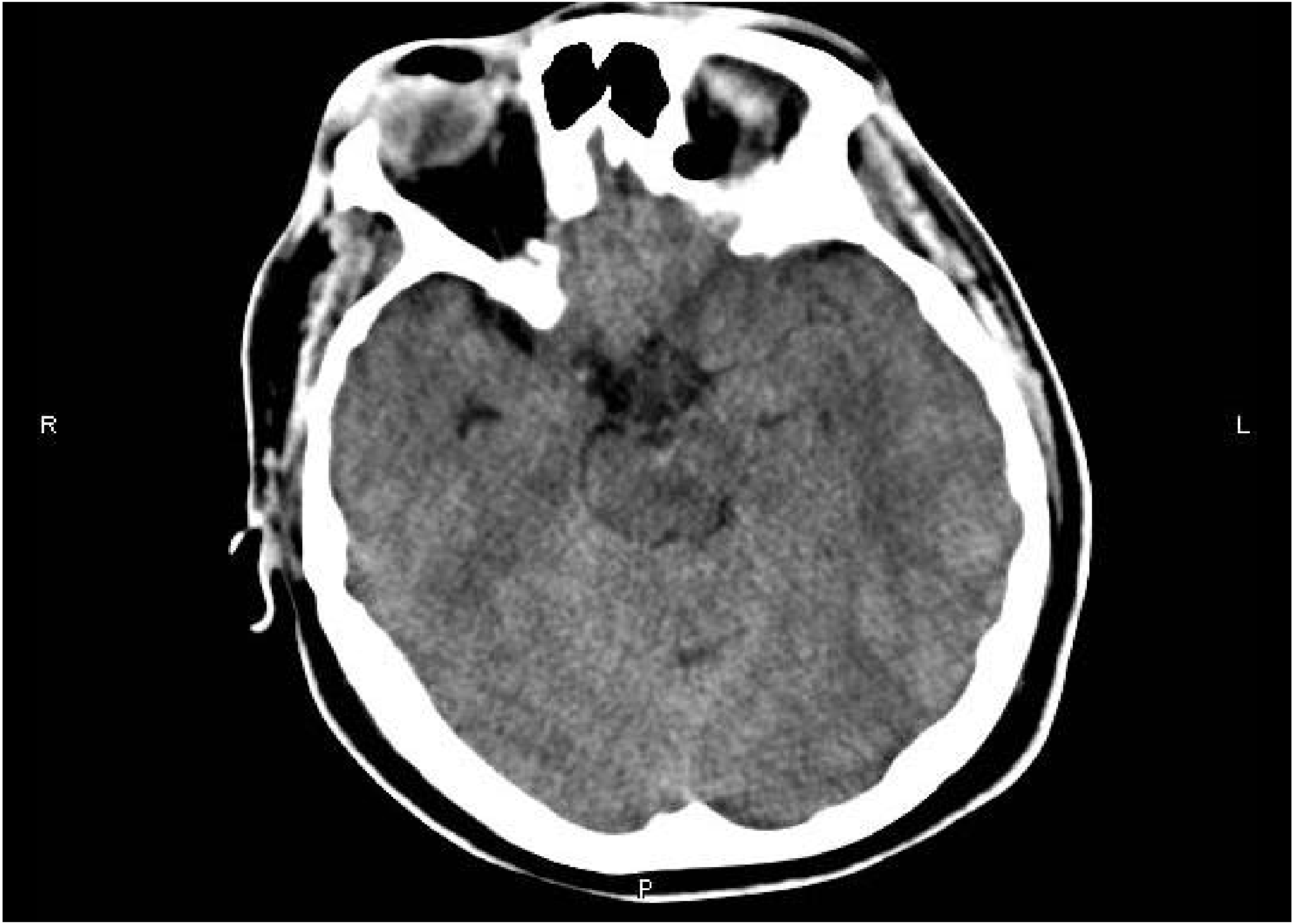
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Diaphragm Injuries - CIREN

- 21 cases from 6 CIREN centers
- Outcome
  - 62% fatal injuries
    - 62% DOS
    - 38% hospital fatalities
  - 38% non fatal injuries

Diaphragm Injuries - CIREN

- Overall Injury Severity
  - Mean ISS 48 (10-75)

Diaphragm Injuries - CIREN

- Age 34.3 (14-73)

Crash Direction - CIREN

- Frontal Crash 33%
- Near Side 62%
- Far Side 5%

Fatalities & Crash Direction - CIREN

- Frontal Crash 71%
- Near Side Crash 54%
- Far Side Crash 100%

Diaphragm Injuries - CIREN

- PDOF
  - Frontal 10,360,360,360,360
  - Side 330,300,290,280,80,290,330,290,220
- Delta V
  - 45 mph (25-104)

Diaphragm Injuries - CIREN

- Restraints
  - LAP/Shoulder 71%
  - Shoulder Only 5%
  - None 24%
- Airbag 57%

Side of Diaphragm Injury - CIREN

- Left 71%
- Right 24%
- Bilateral 5%

Associated Injuries - CIREN

• Rib fractures	67%
• Aortic/heart injuries	43%
• Pulmonary injuries	67%
• Abdominal injuries	86%
• Combined thorax/abdomen	76%
• No abd/chest injuries	5%

Diaphragm Injuries - CIREN

- Associated Injuries
  - Heart/Aorta 9/21 - 43%
  - All Fatal

Diaphragm Injuries - CIREN

- Associated Injuries
  - Rib Fractures
    - Bilateral 29%
    - Right or Left 38%
    - None 33%

Diaphragm Injuries - CIREN

- Associated Injuries
  - Liver 38%
  - Spleen 71%

Diaphragm Injuries - CIREN

- Left Diaphragm Injuries Associated With Splenic Injury
  69% Cases

- Right Diaphragm Injuries Associated With Liver Injury
  100%

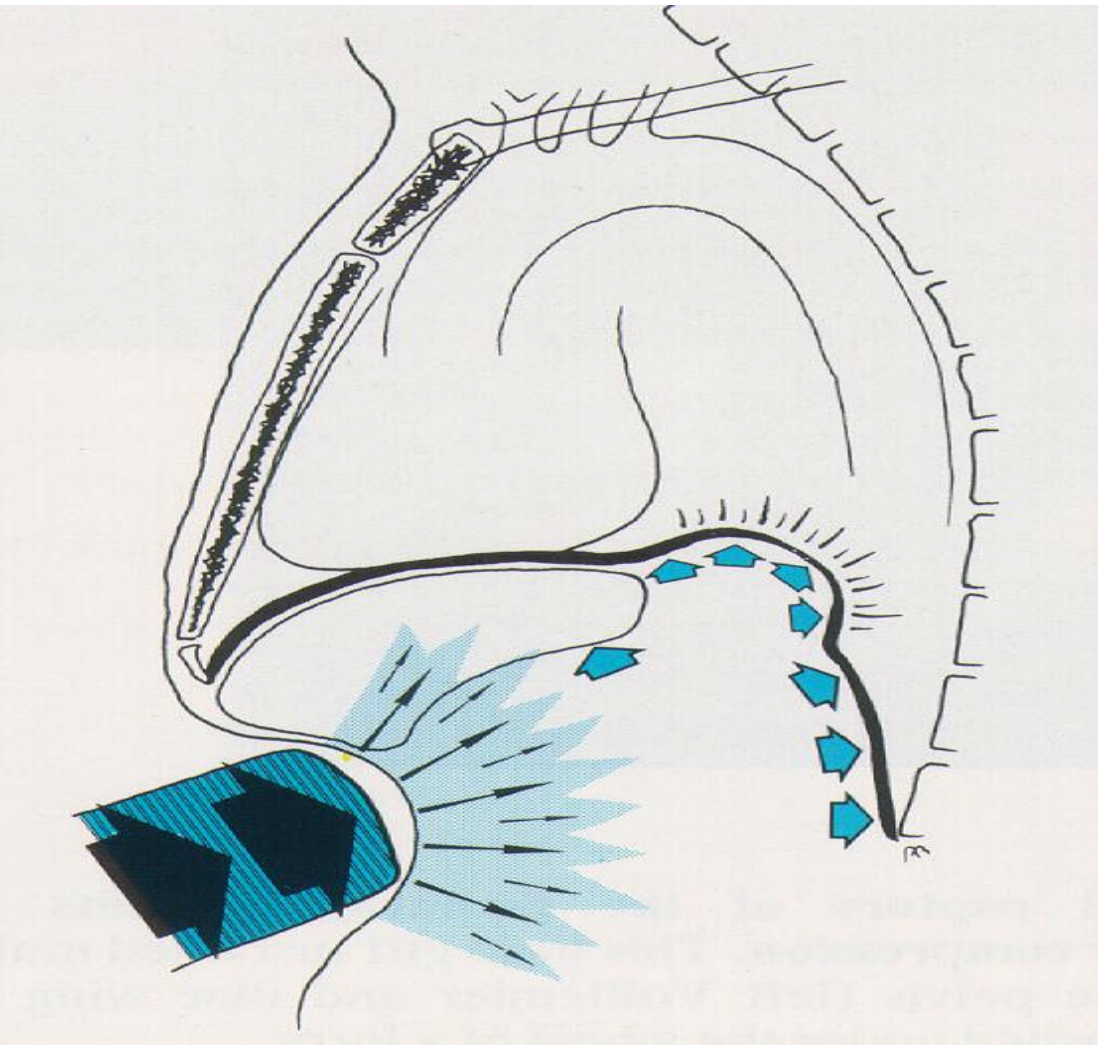
Diaphragm Injuries

- Incidence
  - Poorly described
  - 1-3% of major torso injury
  - No real population based analysis

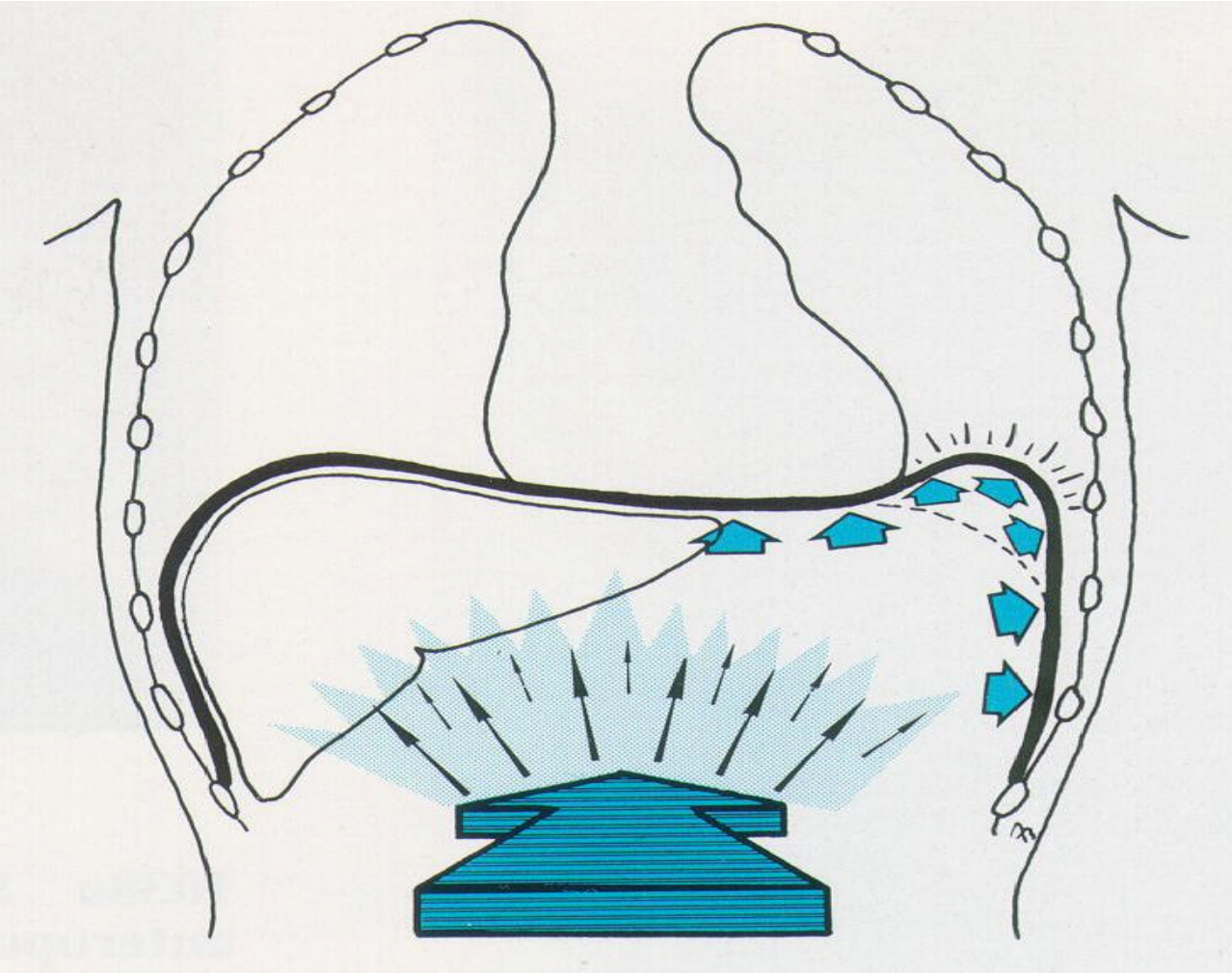
Diaphragm Injuries

- Mechanism of Injury - Unclear
  - Frontal - Increased abdominal pressure
  - Lateral - Shear force from chest wall deformity
- Contributing factors
  - Improperly placed restraints
  - Unrestrained occupants
  - Ejected occupants

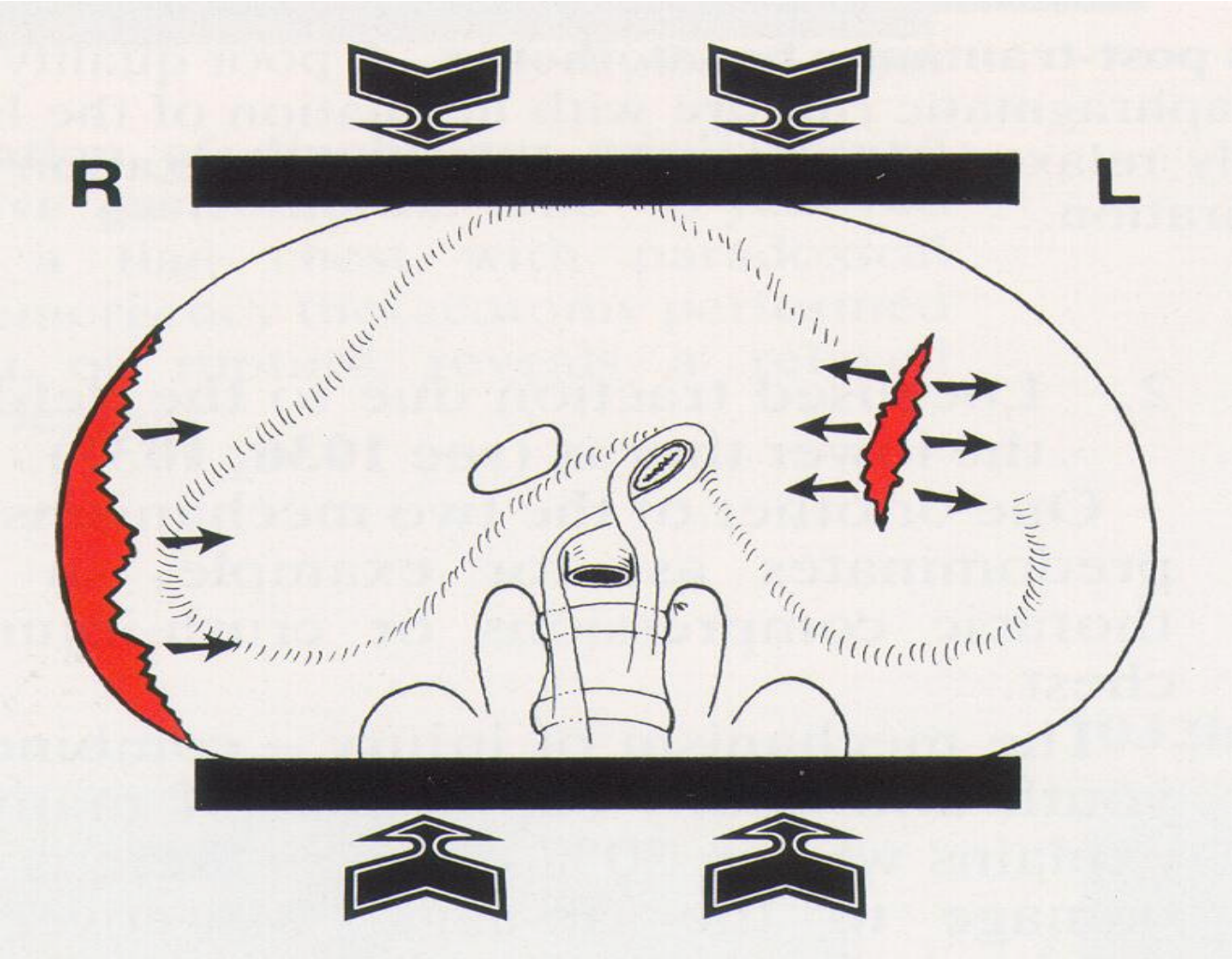
Diaphragm Injuries



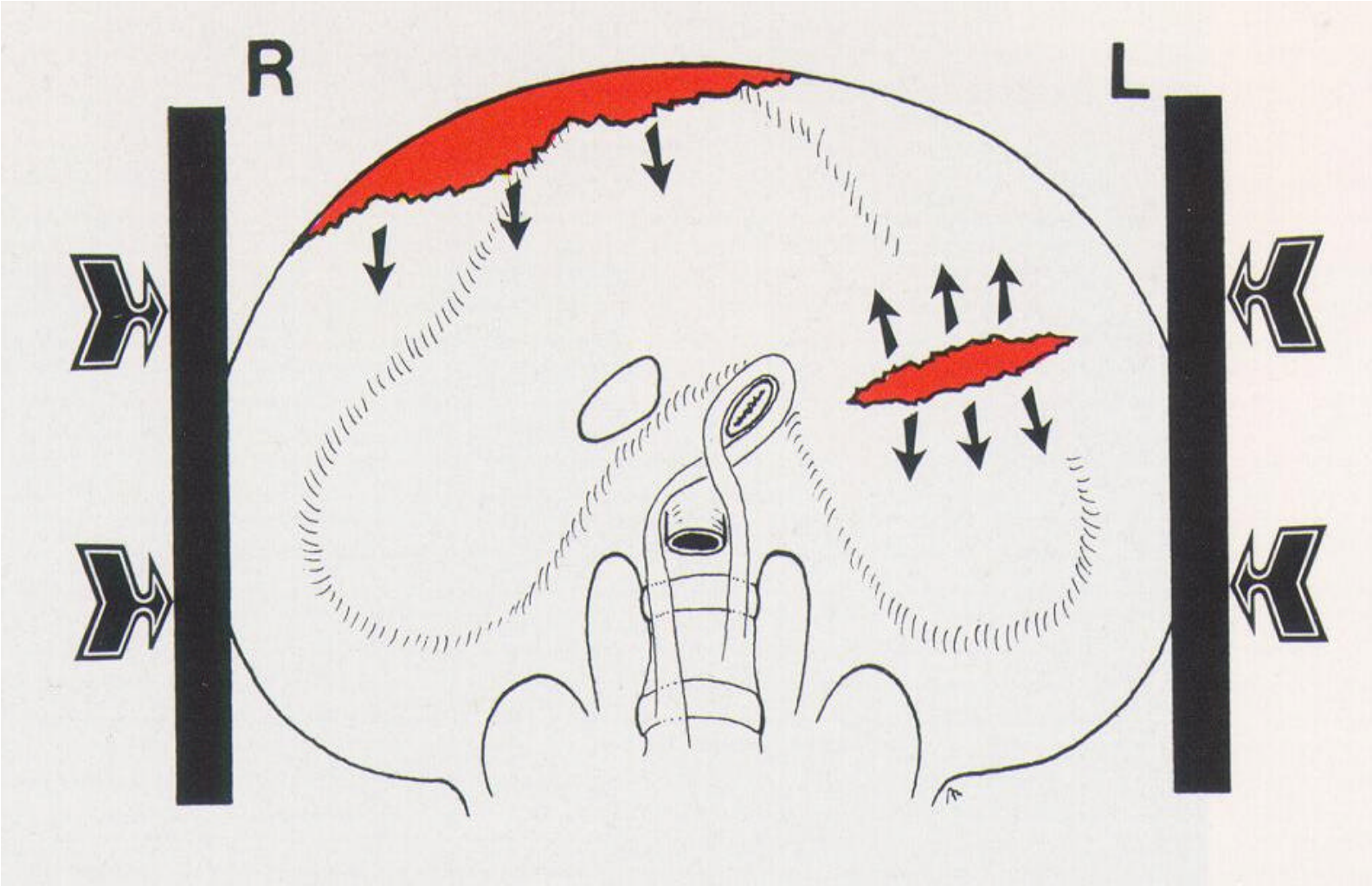
Diaphragm Injuries



Diaphragm Injuries



Diaphragm Injuries



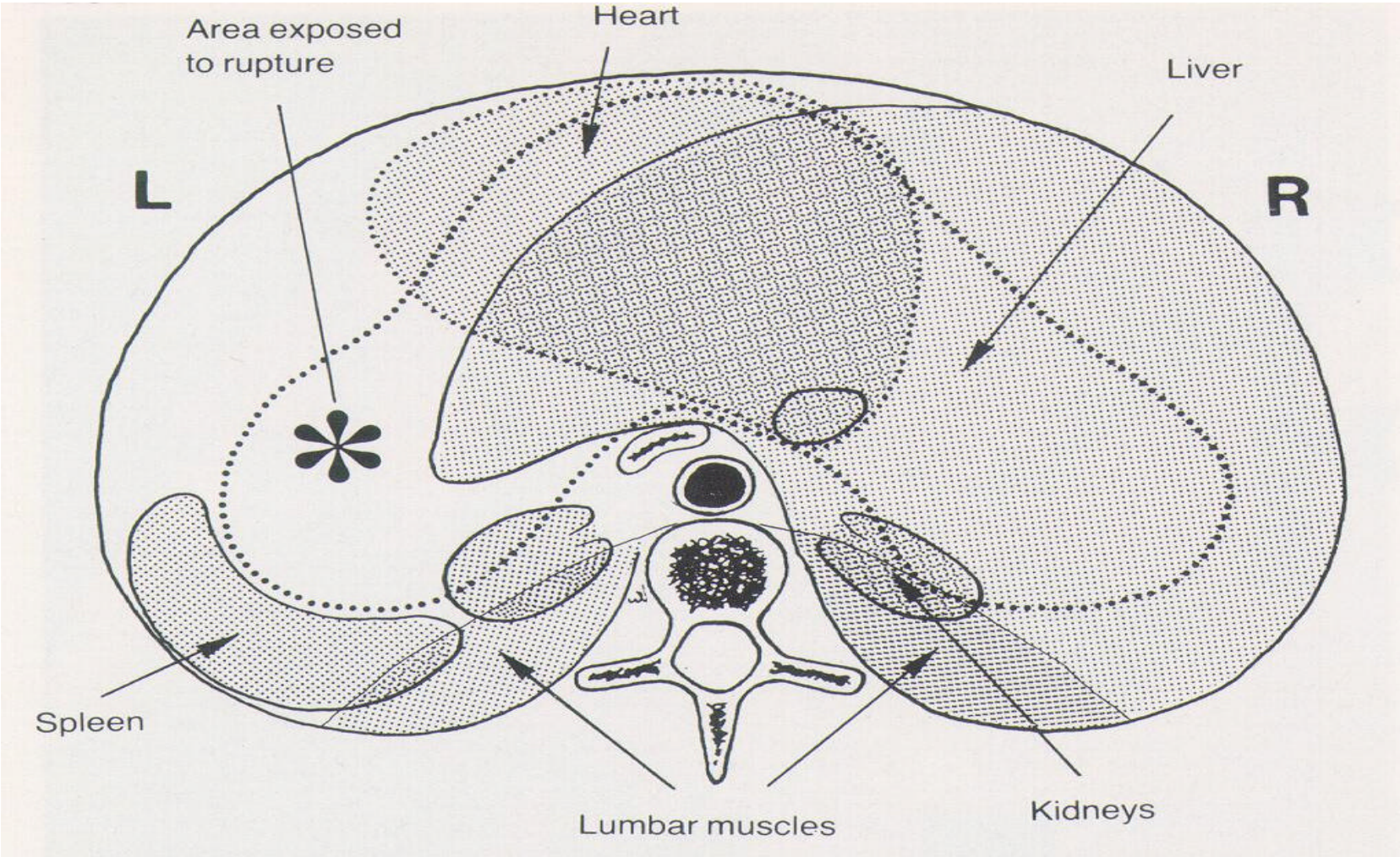
Diaphragm Injuries

- AAST Classification
  - Grade 1 - Contusion
  - Grade 2 - Laceration < 2cm
  - Grade 3 - Laceration 2-10 cm
  - Grade 4 - Laceration > 10cm and tissue loss < $25cm^2$
  - Grade 5 - Laceration with tissue loss > $25cm^2$

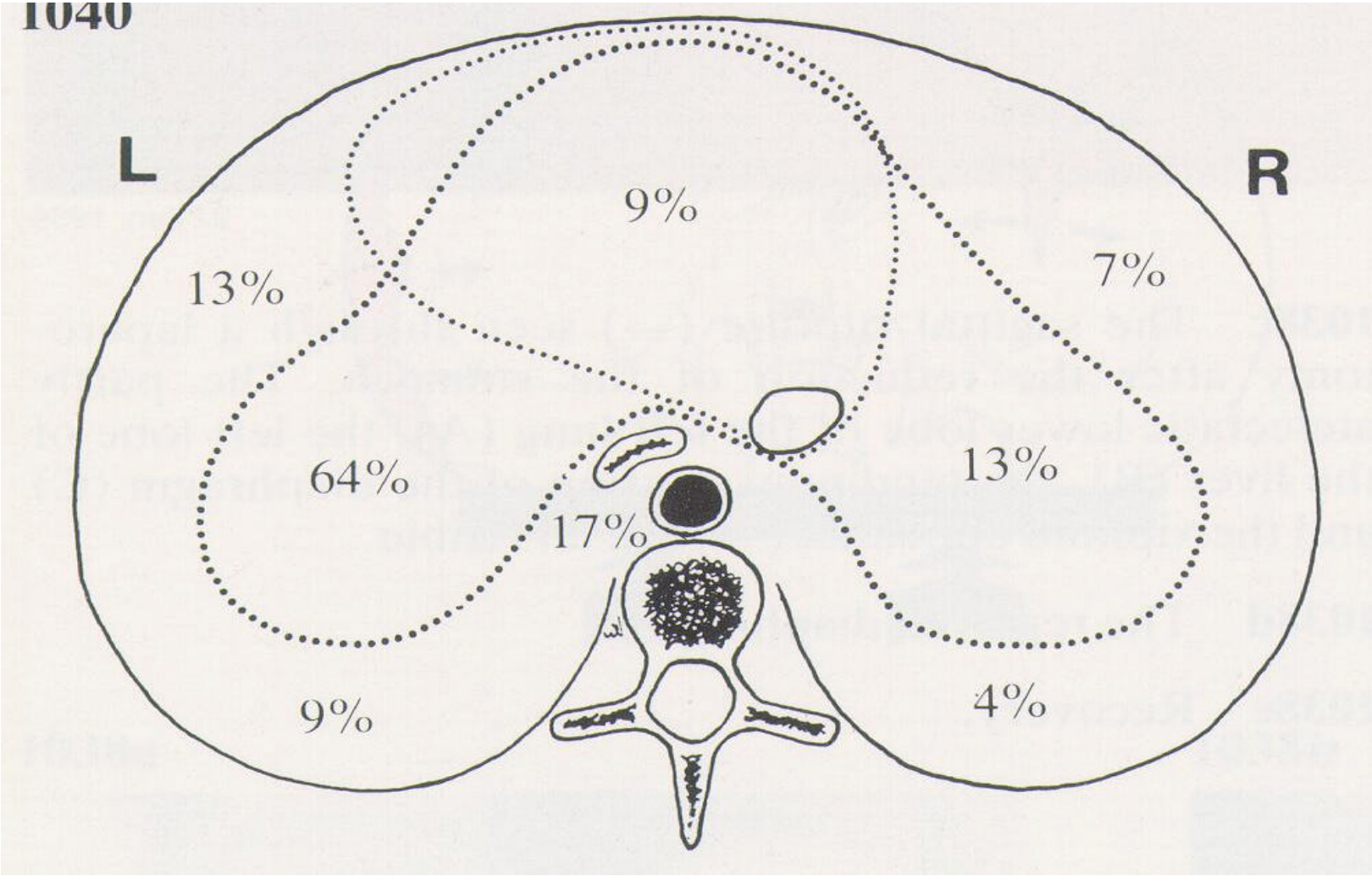
Diaphragm Injuries

- **Pattern of Rupture**
  - **Left sided more common reportedly**
  - **Autopsy series nearly equal**

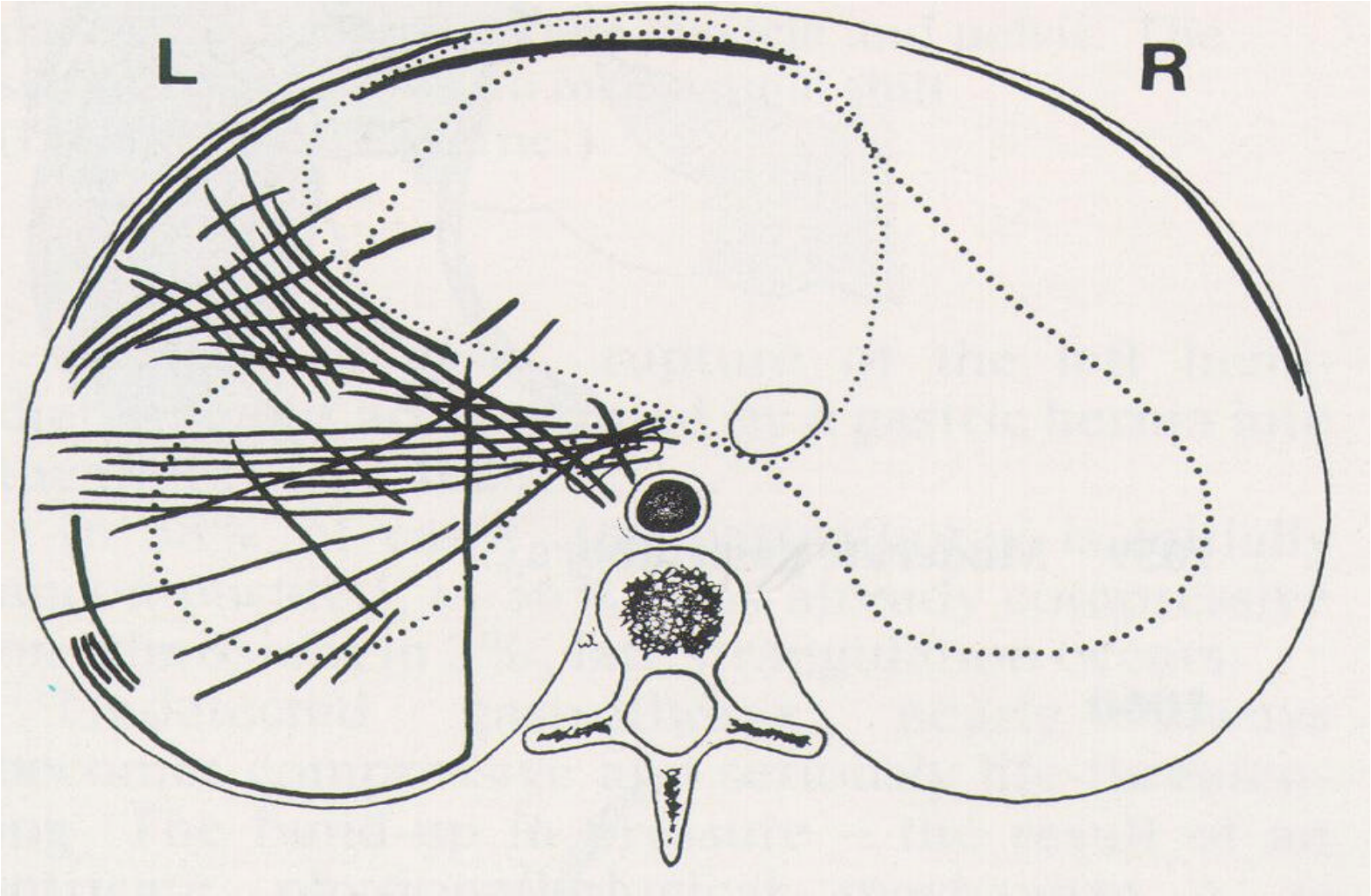
Diaphragm Injuries



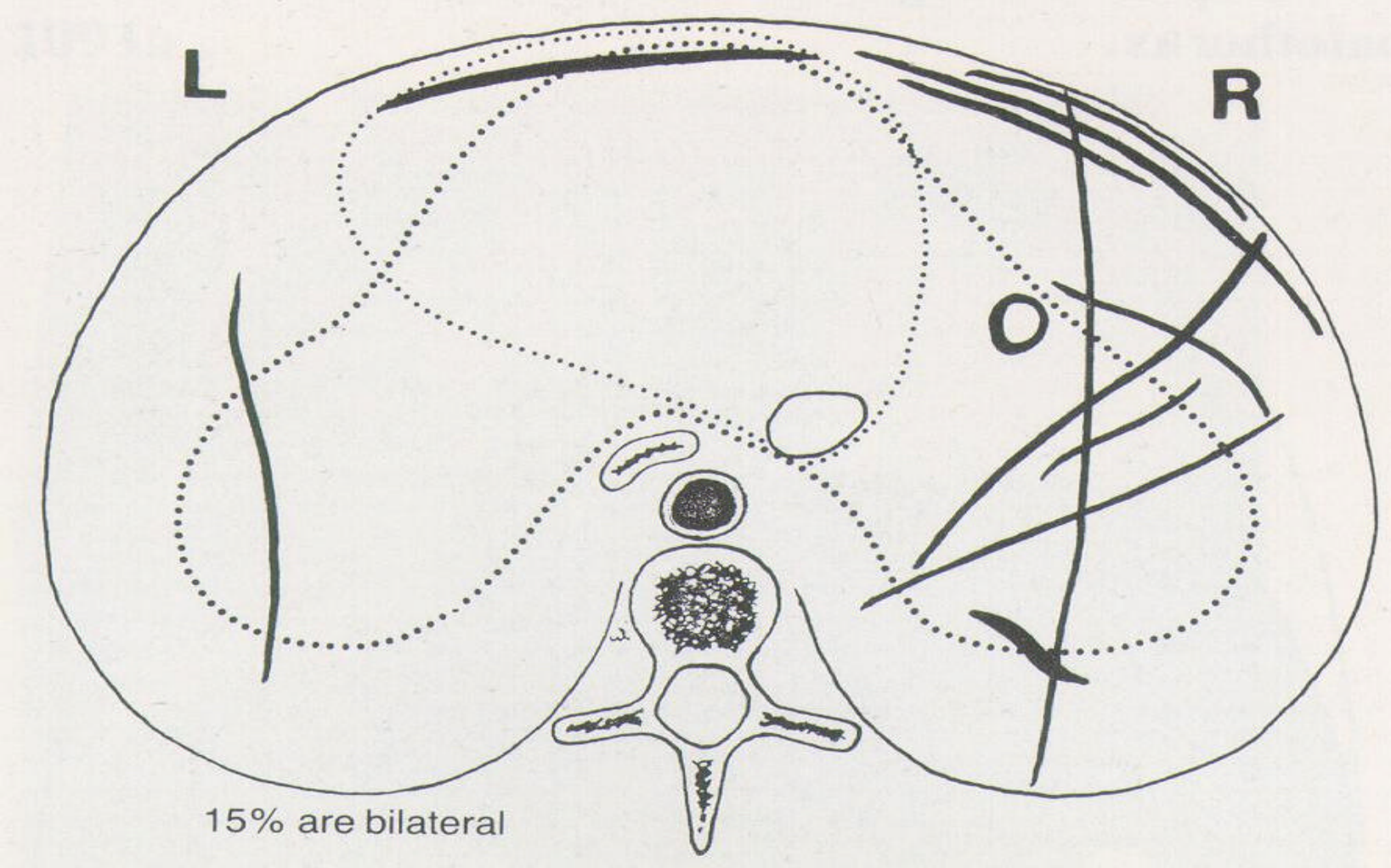
Diaphragm Injuries



Diaphragm Injuries



Diaphragm Injuries



Diaphragm Injuries

- Natural History
  - Pressure gradient from abdomen to thorax
    - Herniation and chronic incarceration
  - Breathing- continuous motion - nonhealing
- Spontaneous closure unlikely

Diaphragm Injuries

- Natural History
  - 73 year old with Gastric Volvulus
    - Thanksgiving Day 1997
  - 1931 - Pedestrian struck MVA age 7
    - Hospitalized 6 weeks and recovered

Diaphragm Injuries

- Diagnosis
  - Misses - false negatives
    - DPL 15%
    - Ultrasound 15%
    - CT Scan 15%
  - Compiled CT Data
    - Sensitivity 33-83%
    - Specificity 76-100%
    - Accuracy 50- 98%
  - Often a Delay in Diagnosis

Diaphragm Injuries

- ISS - high---associated injuries -- 98%
- Multiple series Mean 40 (17-75)
- Typical patterns
  - Head, Neck, CNS 10-40%
  - Cardiothoracic 20-60%
  - Abdominal / pelvic 60-100%
  - Musculoskeletal 30-40%
- Mortality 15-45%
  - Predictors - AGE, ISS, Head AIS (after Brasel)

Diaphragm Injuries

- Associated Injuries
- Abdominal
  - Spleen 20-50%
  - Liver 20-50%
  - Stomach 10-15%
  - Colon 10-15%
- Thoracic
  - Aortic / Diaphragm Complex
    - 10% in some series (2-17%)

Diaphragm Injuries - Conclusions

- Marker for severe injury
- Reflects the severity of the CIREN Cases relative to general literature
- Requires significant energy transfer in either frontal or side