The William Lehman Injury Research Center

Frontal Crashes
Narrow Centerline Object Impacts

September 15, 1998

C.I.R.E.N. Conference

Ann Arbor, Michigan

The William Lehman Injury Research Center
University of Miami/Jackson Memorial Medical Center

Goals

- Convey Significance of HARM Associated With Narrow Object Impacts
- Improve Understanding and Recognition Of Injury Potential In Narrow Centerline Crashes

The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

Compelling Injury:

Those Which are Time-Critical

The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

Cars in Tow-away Crashes:

- **2,850,000 Occupants**
- **58,000 Occupants with Compelling Injuries**

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How Do You Find the Time-Critical Occupants?

The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

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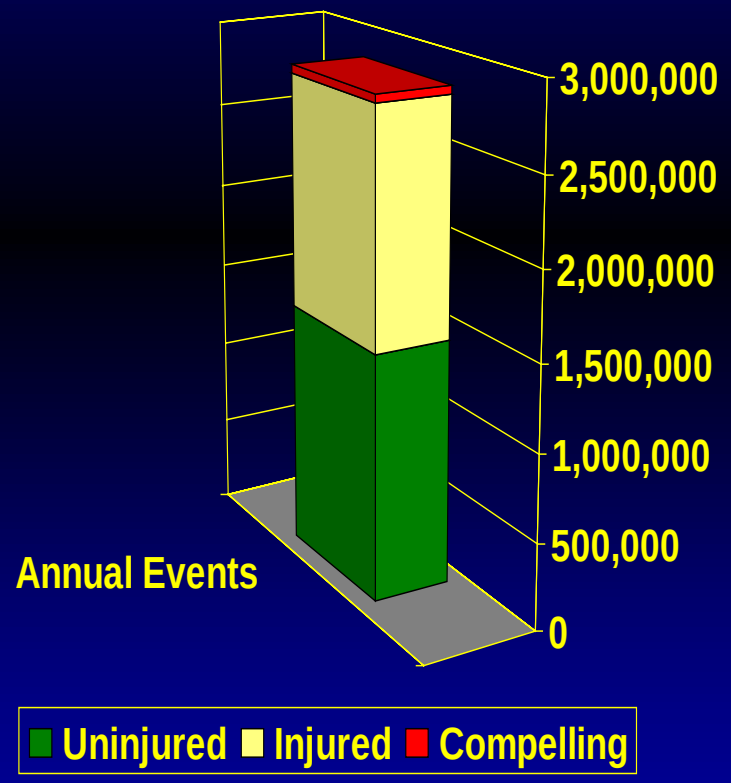
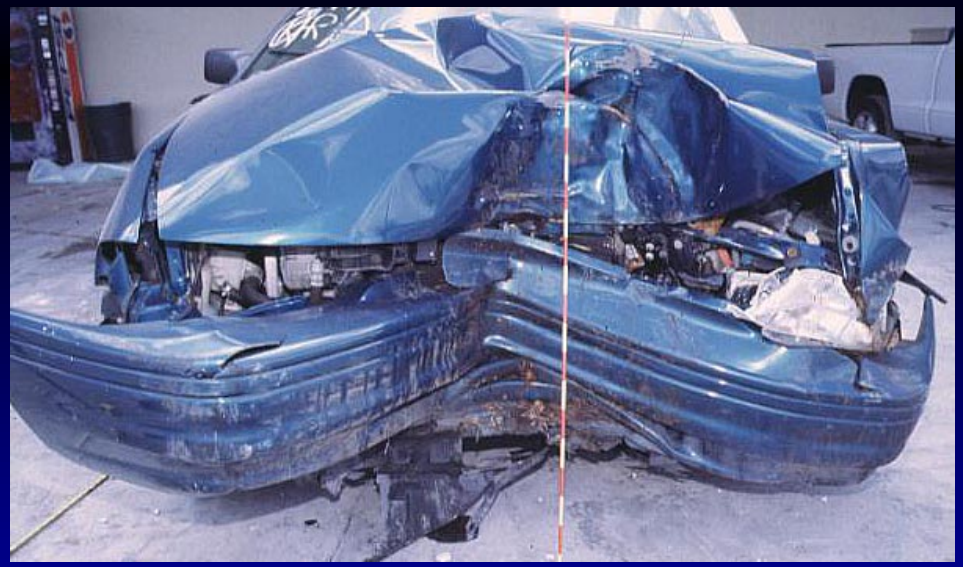


How Do You Find the Time-Critical Occupants?

2% of Tow-away Crashes

The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

Crash Severity (delta-V) Has Been Used as a Criteria -



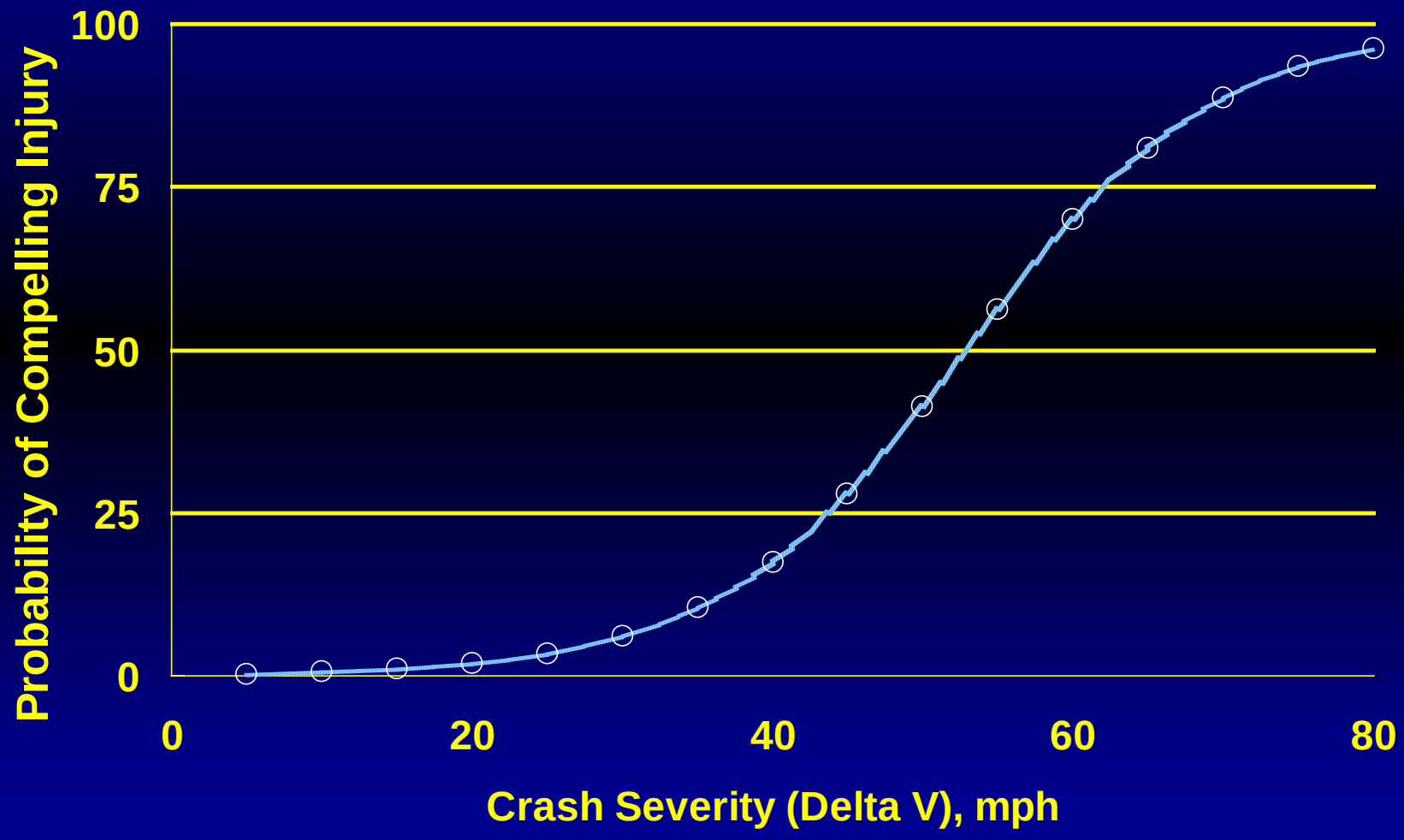
Vehicle Damage of 25 Inches of Crush

The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

Crash Severity (delta-V) Has Been Used as a Criteria -

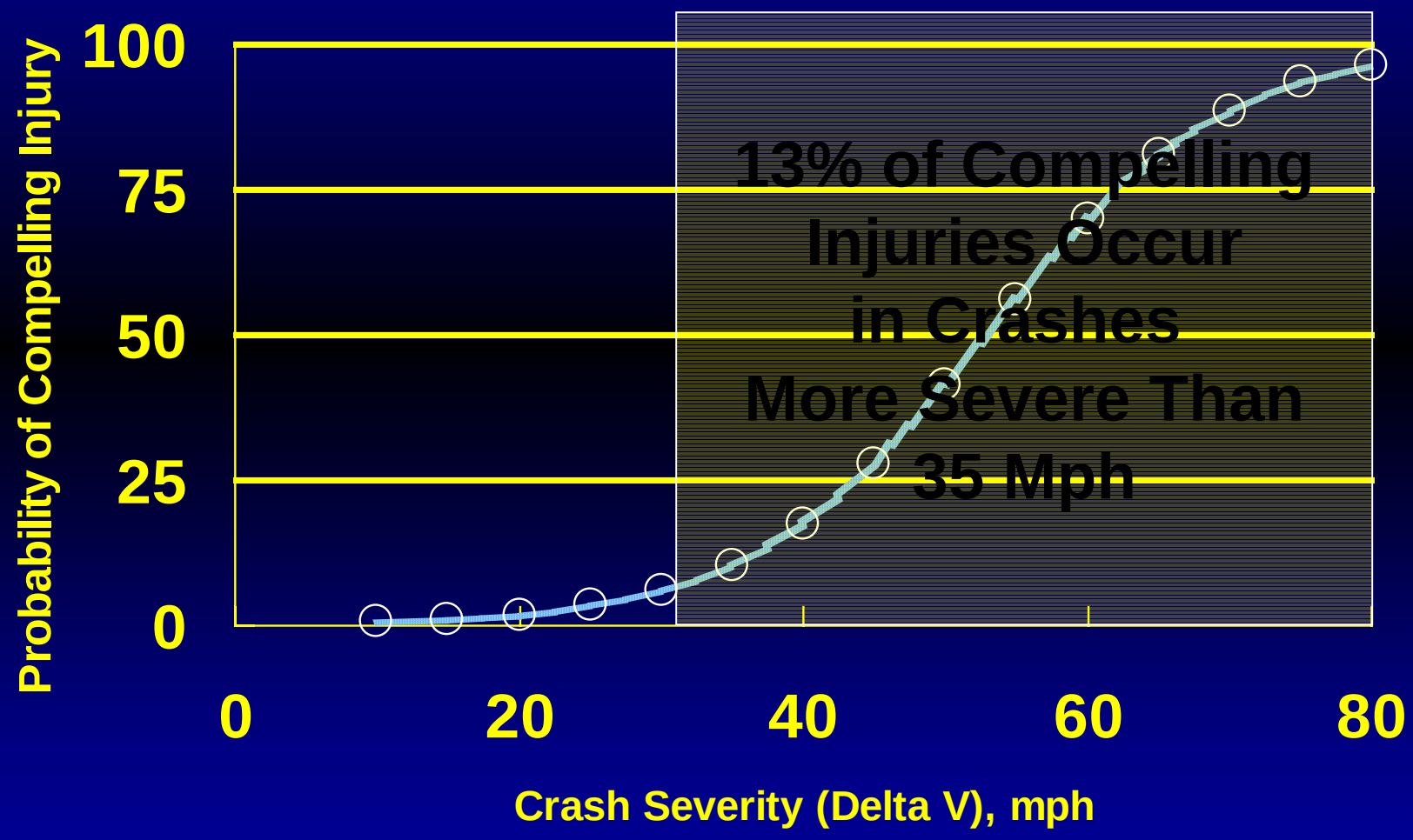
Additional Criteria Needed for Lower Severity Crashes

Risk of Compelling Injury Vs. Car Crash Severity



The NASS/CDS 1988-1995

Risk of Compelling Injury Vs. Car Crash Severity



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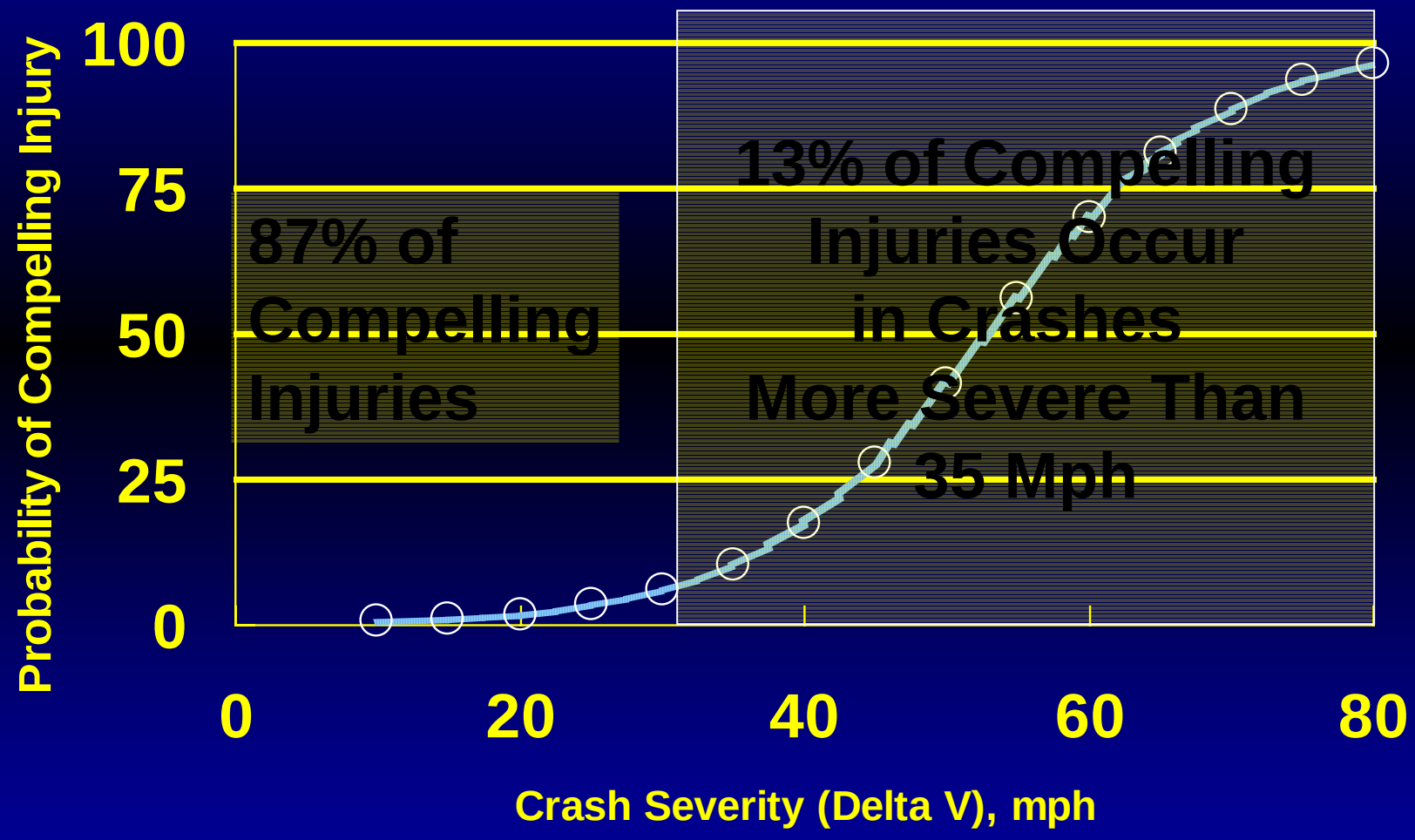
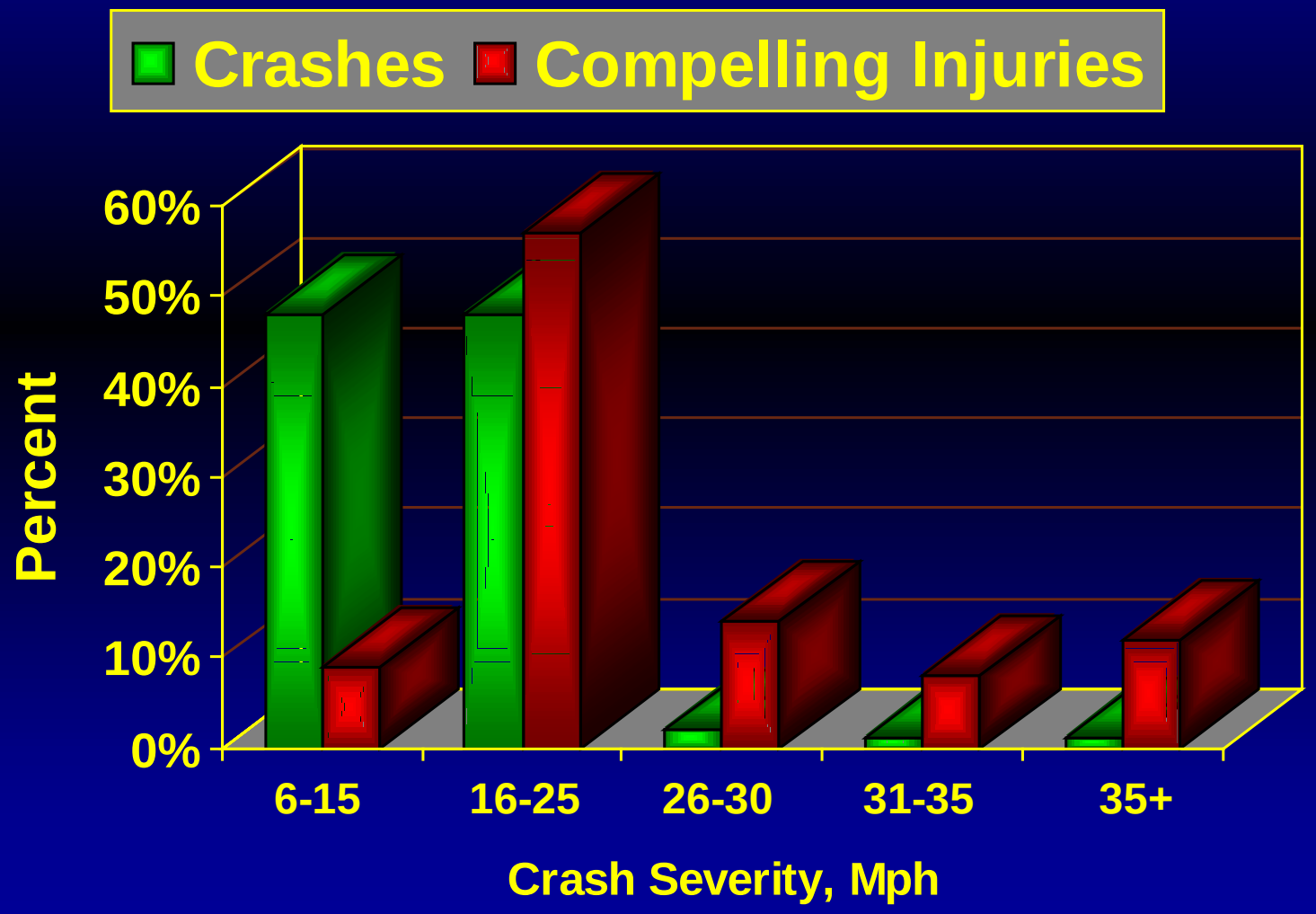
Risk of Compelling Injury Vs. Car Crash Severity

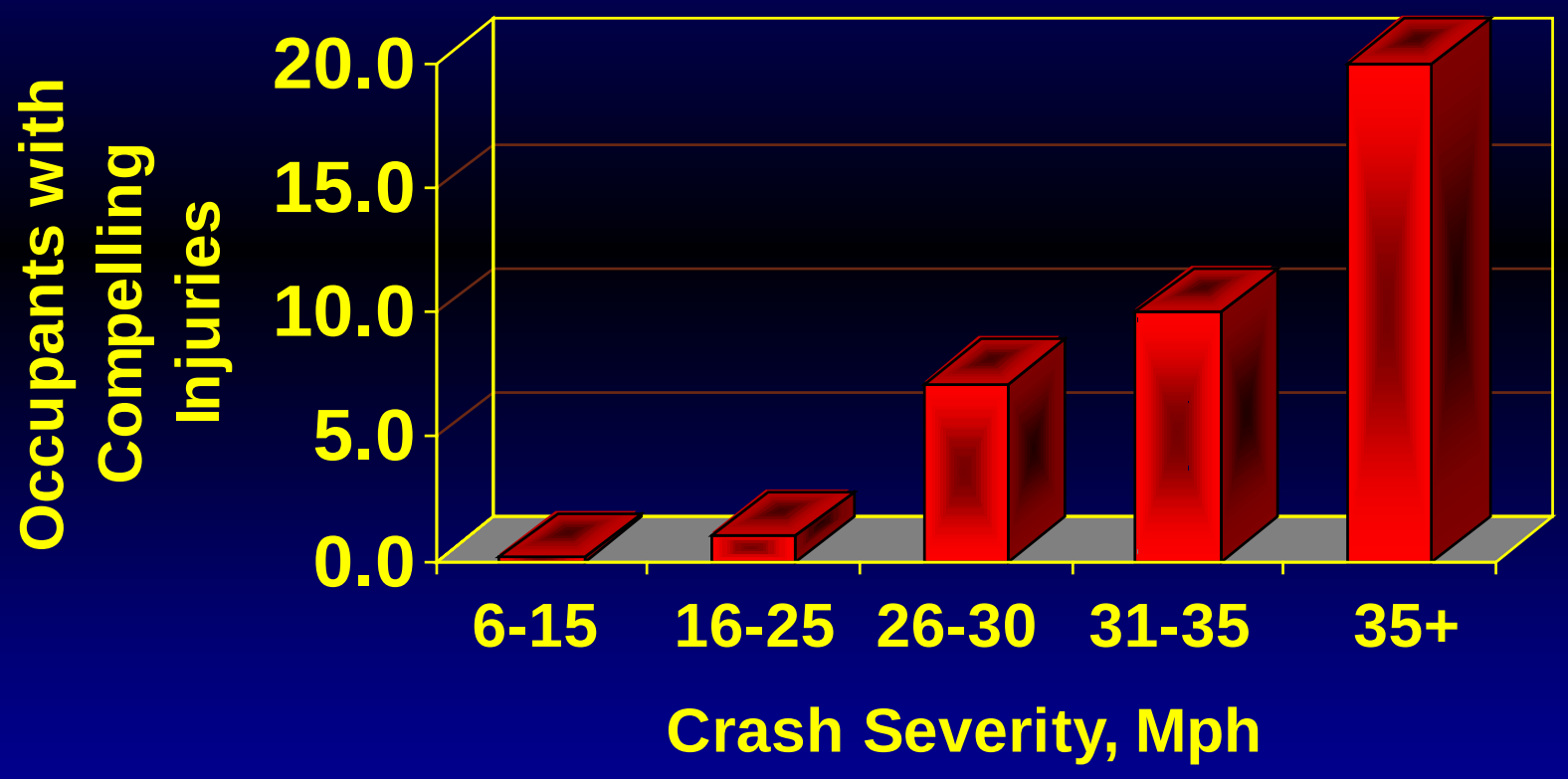


The NASS/CDS 1988-1995

Distribution of 2,850,000 Occupants 58,000 Compelling Injuries



Risk of Compelling Injury per 100 Crash Exposed



The Challenge of Using Crashed Vehicle Data to Predict Compelling Injuries

- Additional Criteria Needed
- Collisions with Narrow Objects Have Higher Injury Risks

- We Will Examine Injury Risks for Centerline Collisions with Narrow Objects and Present Representative Cases of Injuries

Outline

- Statistical Overview - Narrow Object Impacts
- Crash Tests
- Representative Case Presentations
- Modeling of Injury Mechanisms
- Summary and Conclusions

Statistical Overview

Crash Types by Crash Partner

- Other Motor Vehicles
- Single Vehicles
  - Non-Narrow Objects
    - Ground (rollover), Buildings
  - Narrow Objects
    - Trees, Poles, etc.
  - Long Narrow Objects
    - Guardrails, Crash Cushions, etc.

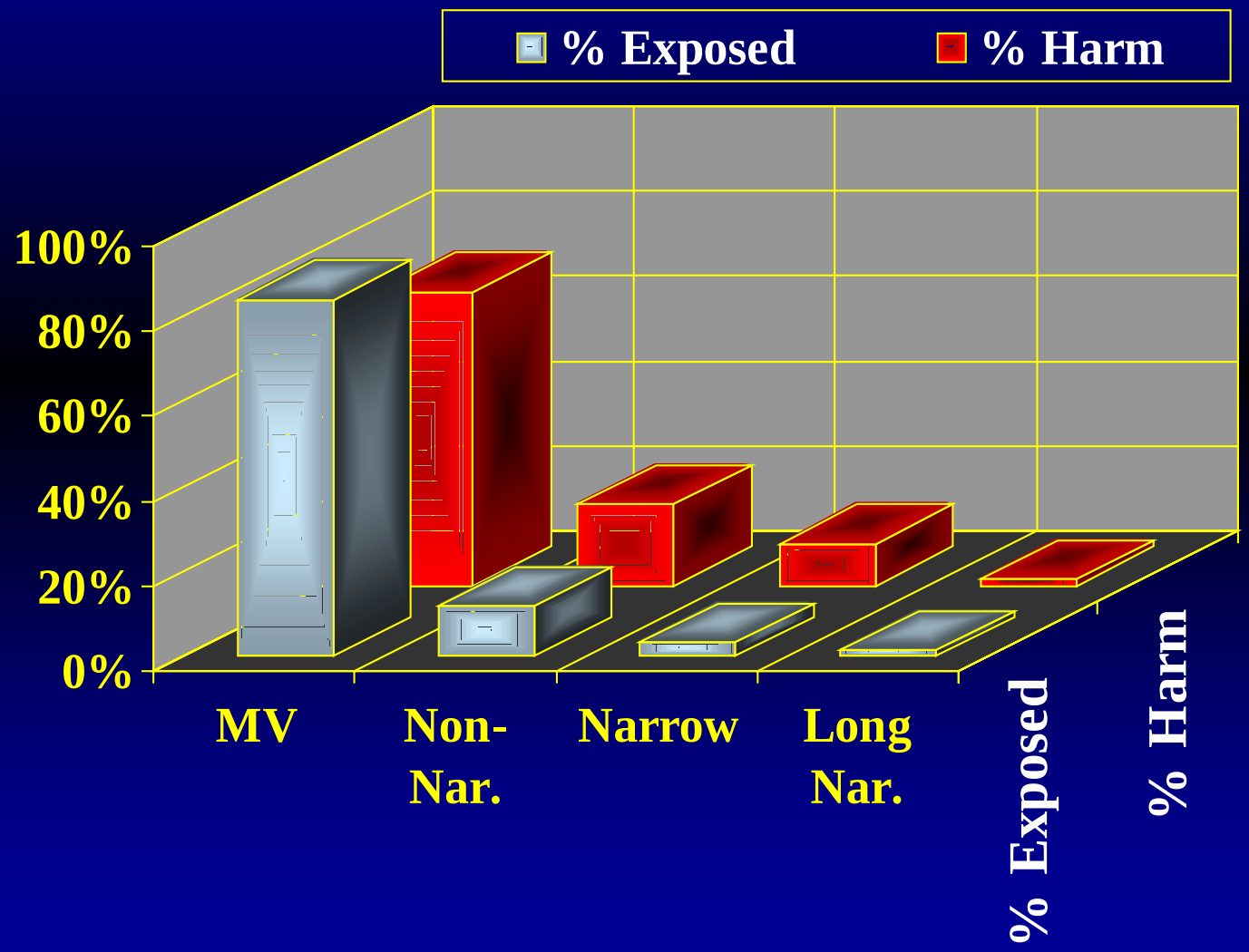
Distribution of Passenger Vehicle Collisions

Crash Partner	# Crashes/Yr.	% Exposed
Motor Vehicle	854,556	83.8%
Non-Narrow Object	120,360	11.8%
Narrow Object	*32,232*	*3.2%*
Long Narrow Object	12,954	1.3%

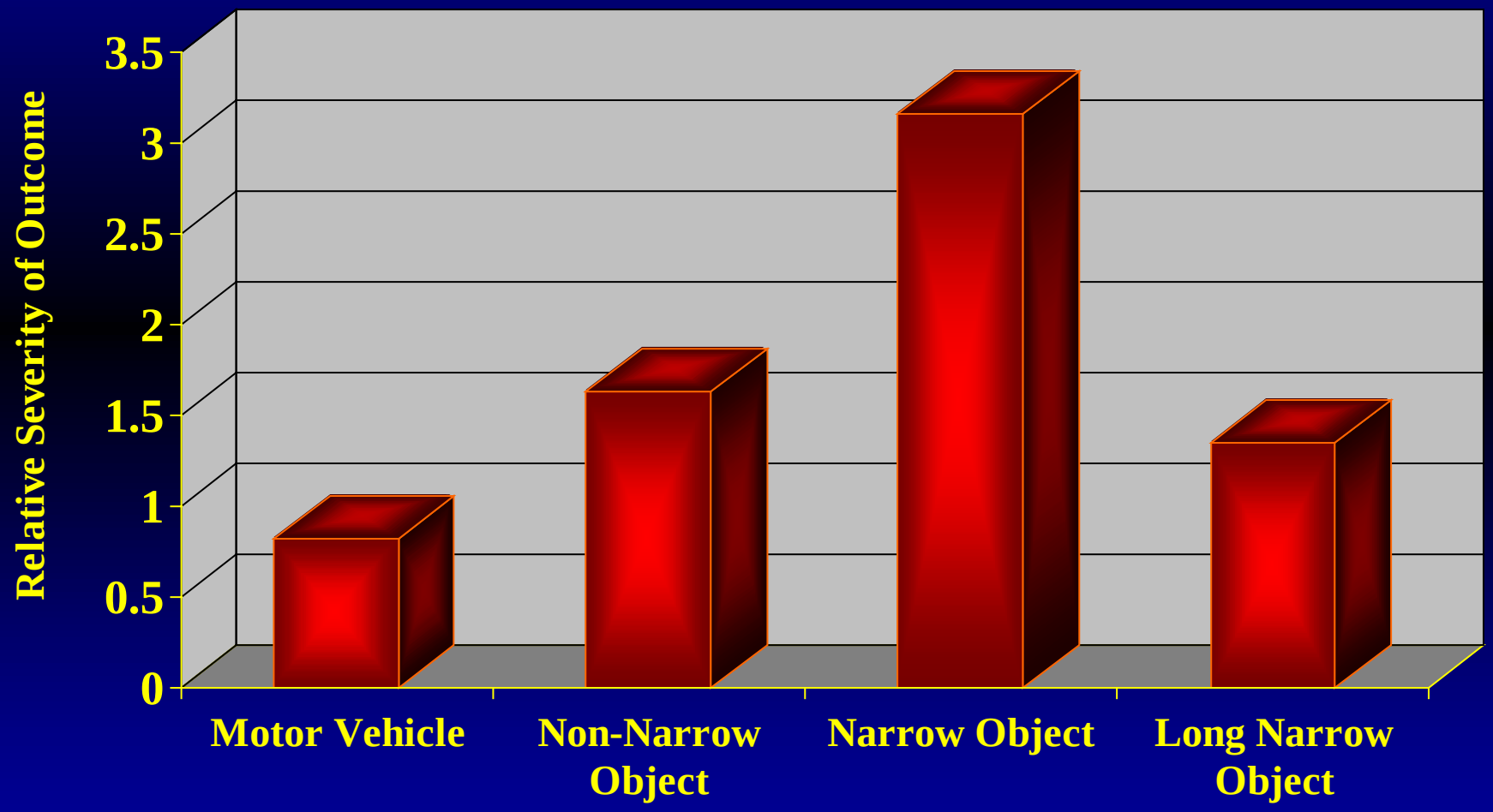
Narrow Object Statistics

Crashes	Harm	Lehman Cases	FARS Fatals	Lehman Fatals
3.2%	10.0%	22.0%	16.1%	24.3%

Exposure and Harm - Passenger Vehicle Crashes



Relative Harm by Crash Type



Observations From Crash Statistics

Narrow Object Impacts

- Frequency is Low
- Higher Risk of Severe Injury

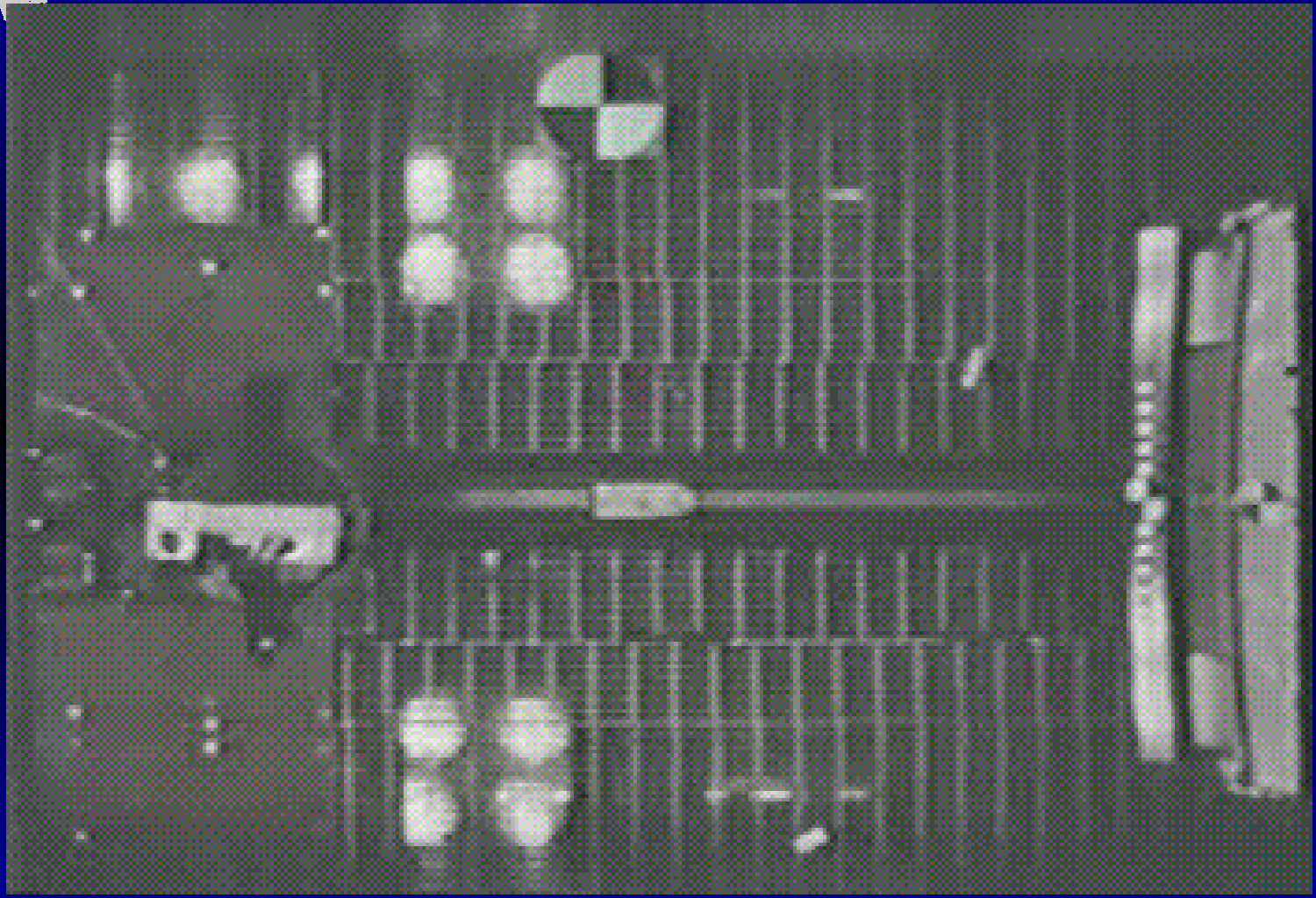
Crash Tests

30 MPH

Small Car into Centerline Pole

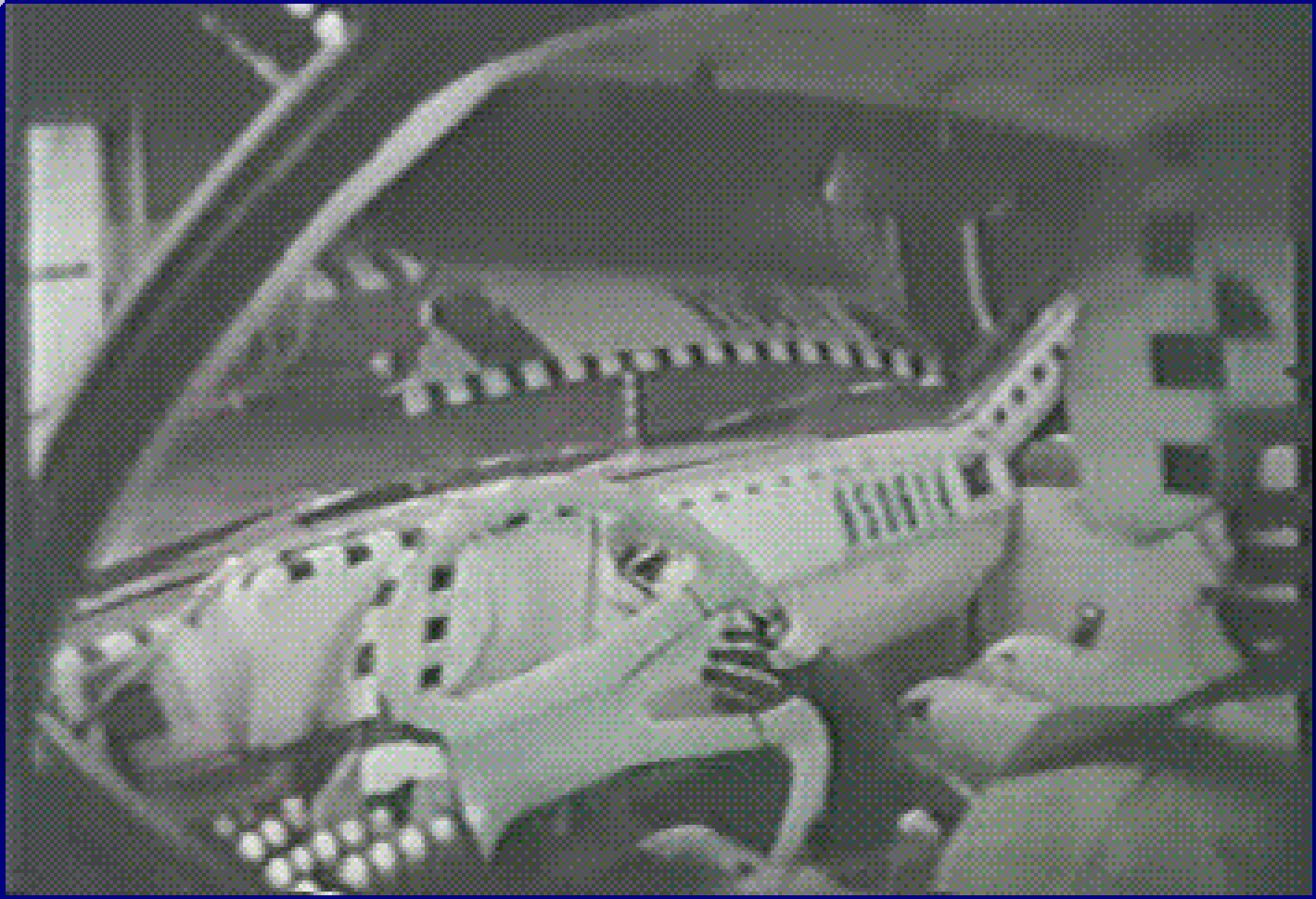
(Not Federally Mandated)

30 MPH Pole Crash



Overhead Video

30 MPH Pole Crash



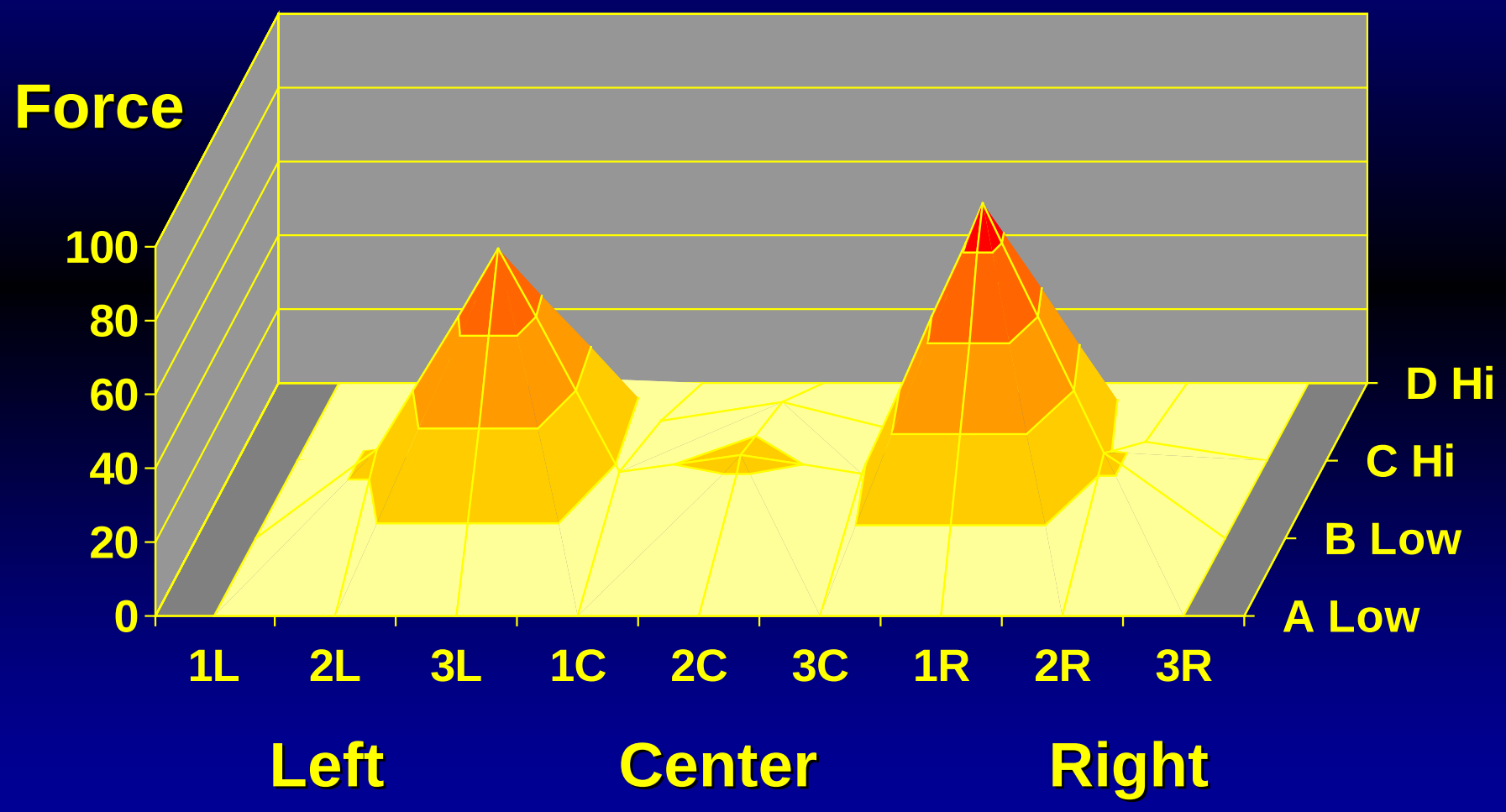
Driver Side Video

NCAP Tests - 35 MPH

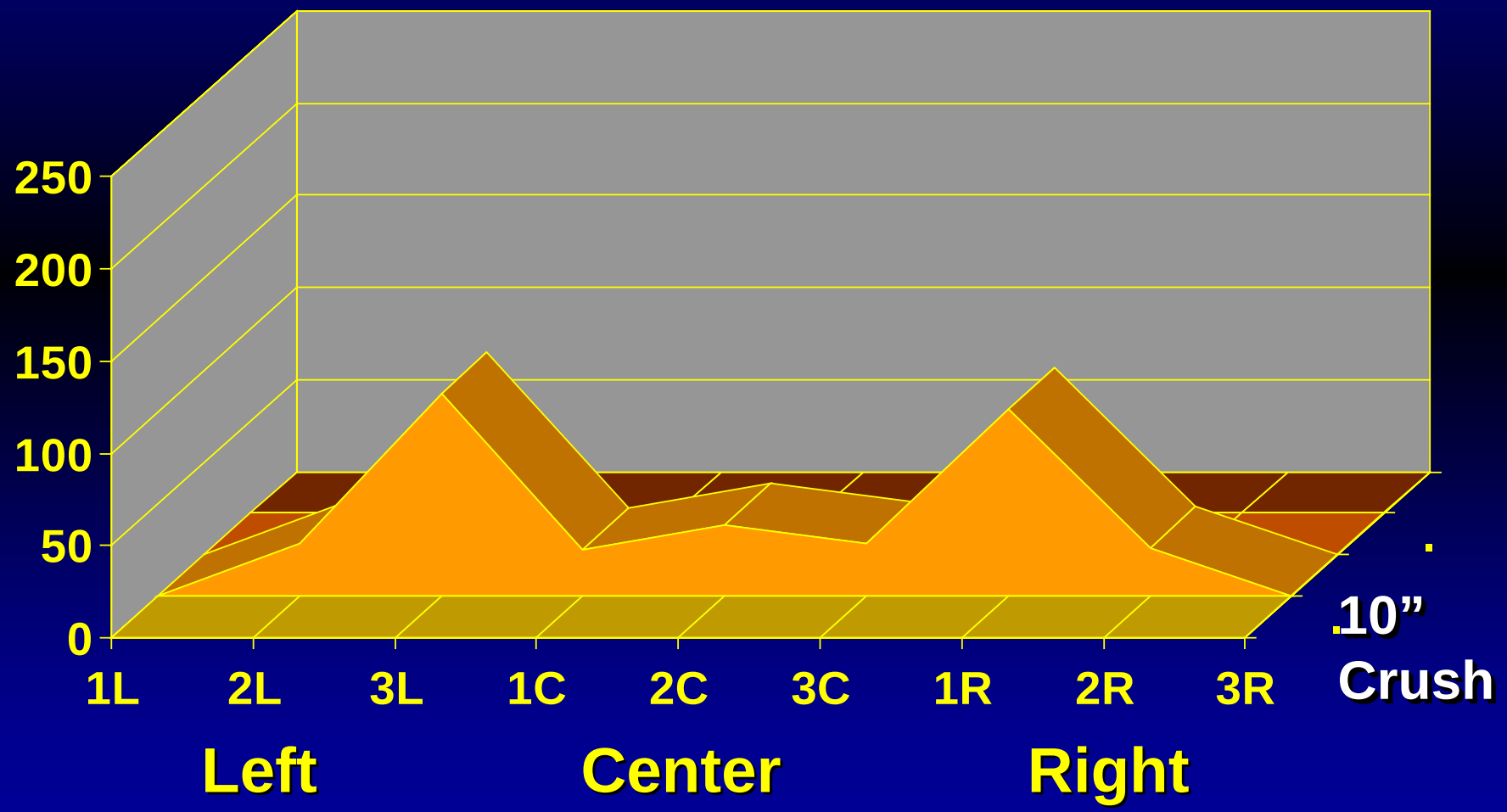
Distribution of Forces on the Barrier are Measured

Contour Plot of Barrier Force

Vehicle Crush = 10 inches



Barrier Force - Vehicle Width



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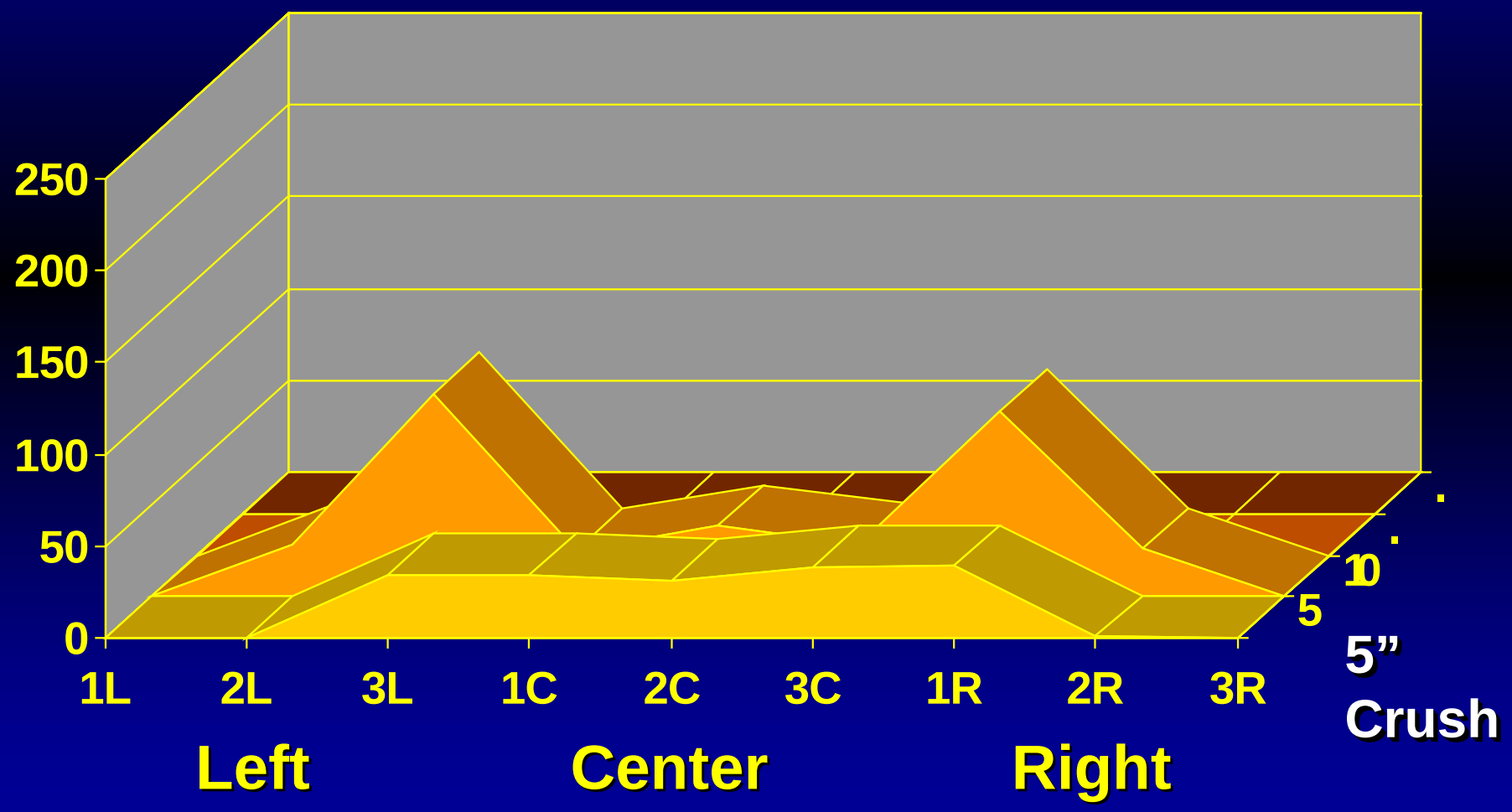

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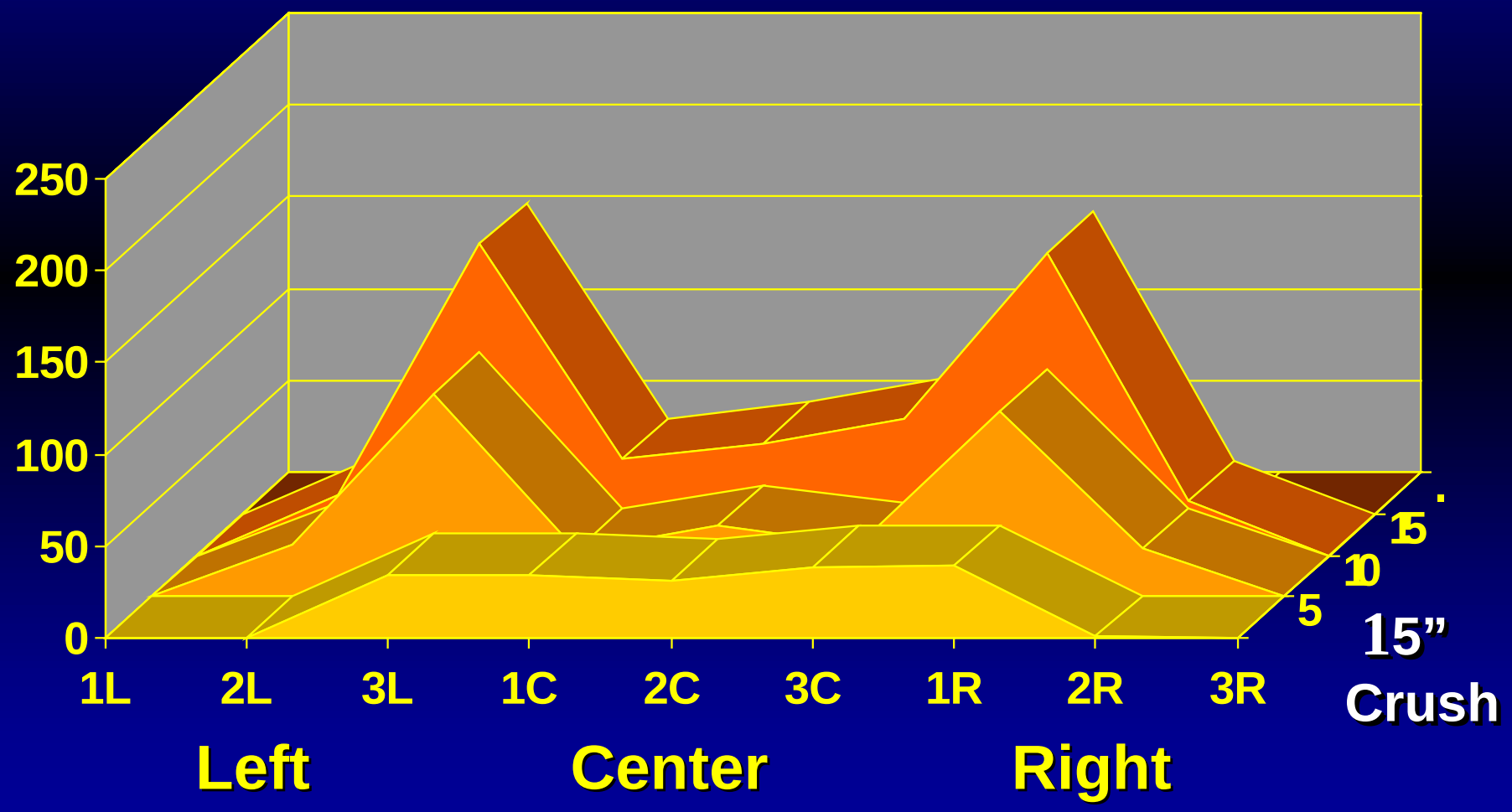

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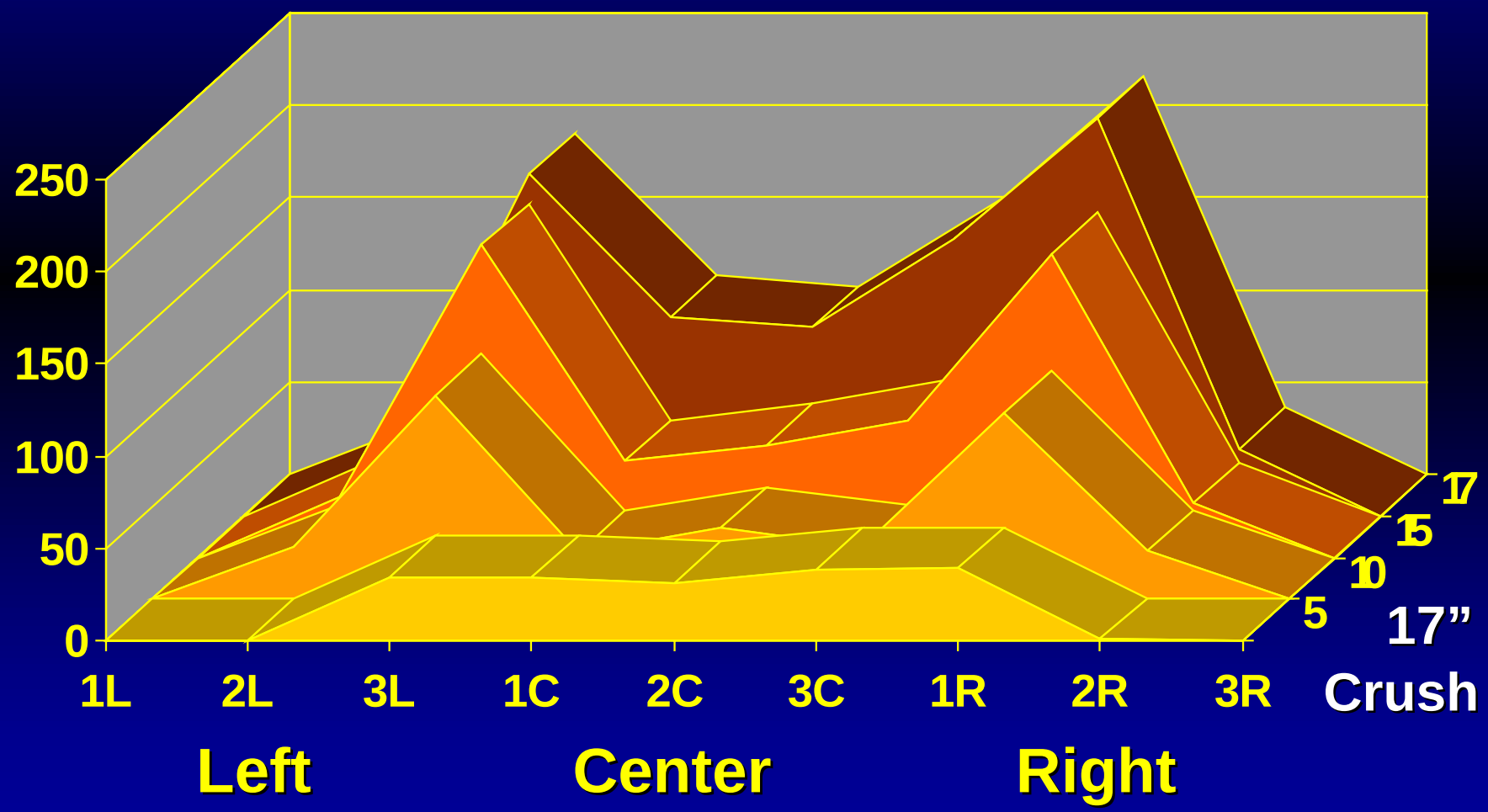
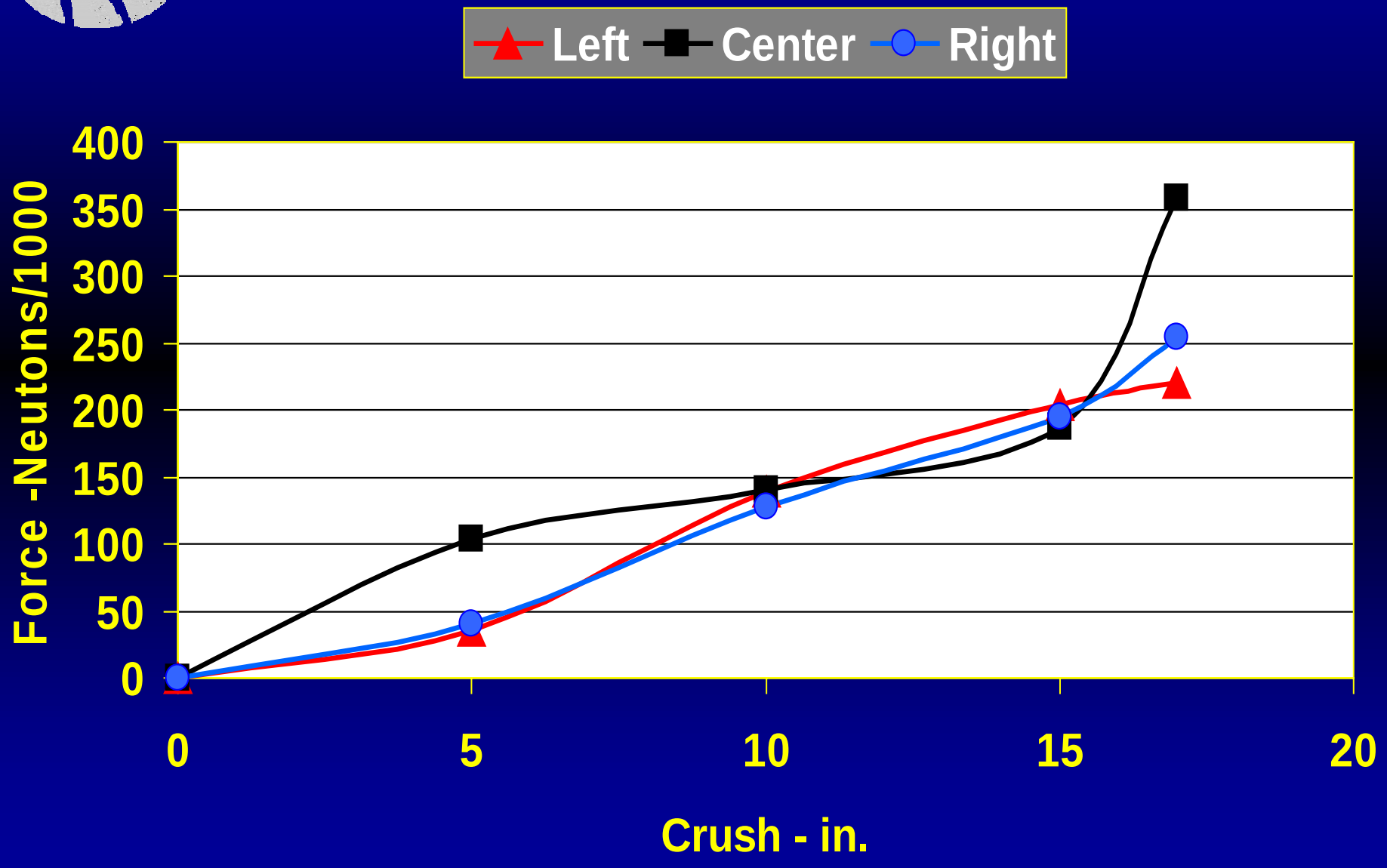
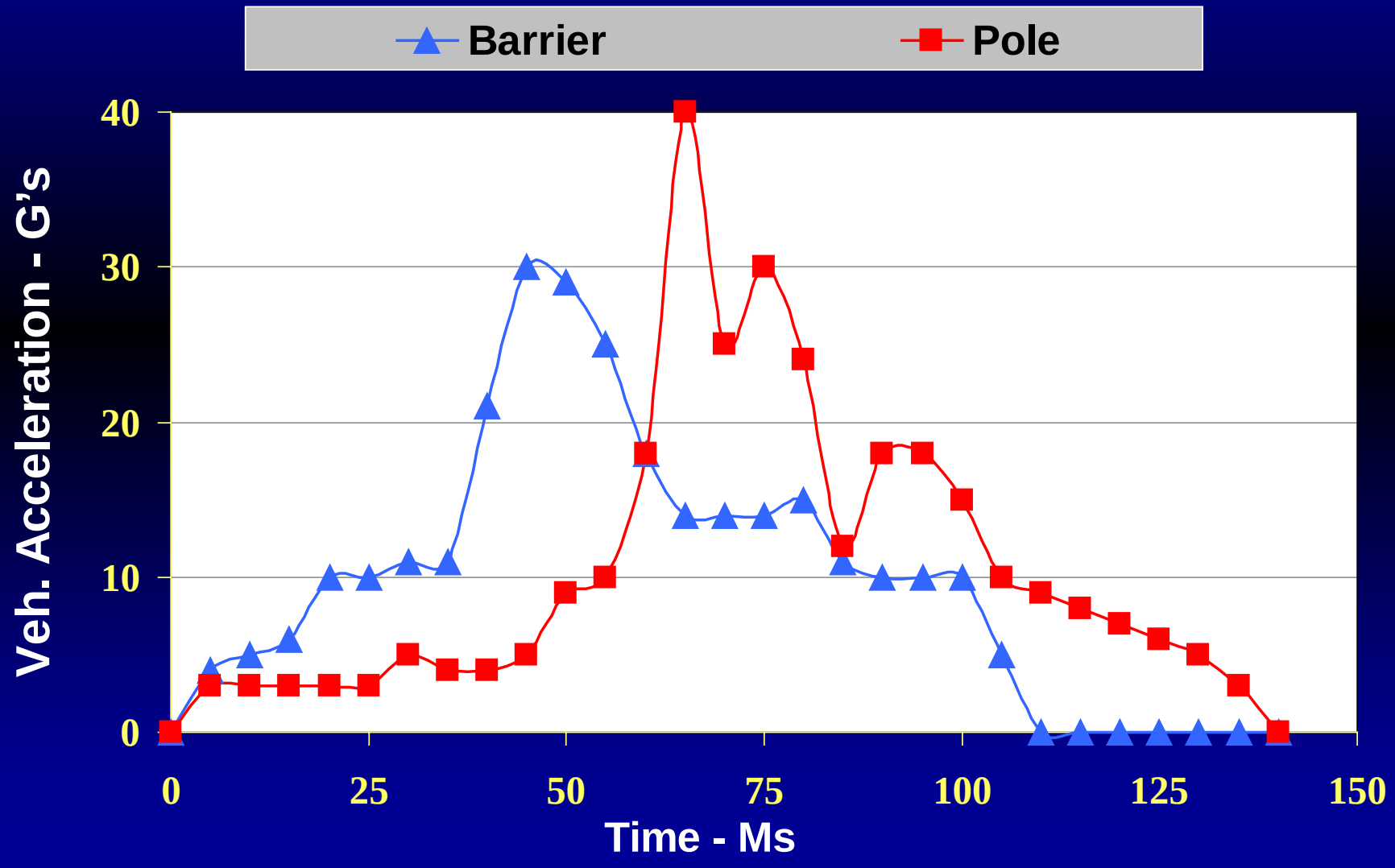


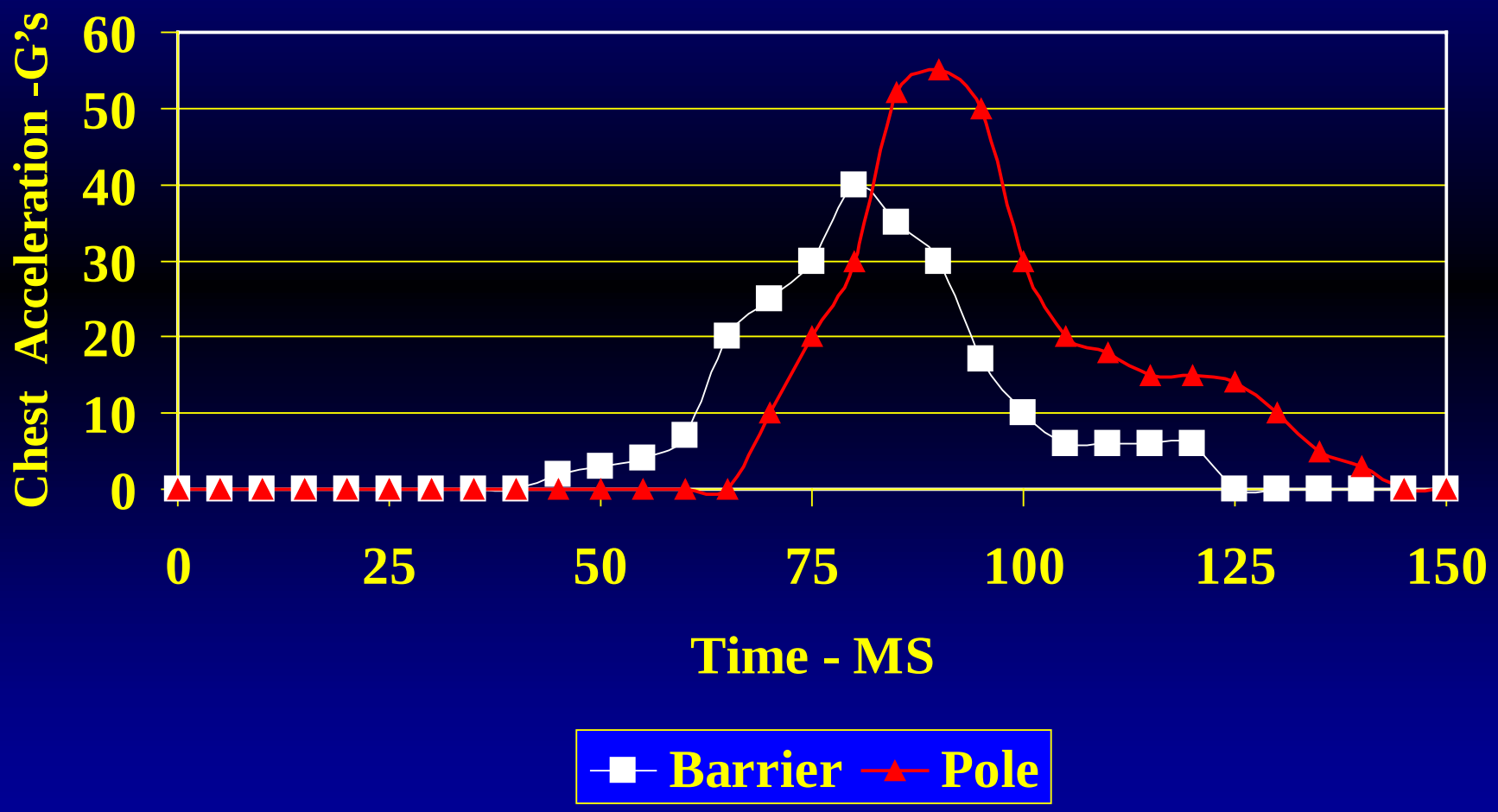
Force vs. Crush



Vehicle G's 30 MPH Crash Pulses Measured in Occupant Compartment



Chest G's in 30 mph Crash Pulses
Belted Driver Dummy



Characteristics of Centerline Crashes with Narrow Object

(25+ MPH Crash Severity)

- Large Extent of Crush - Intrusion
- Late Acceleration
- High Belt Loading
- Late Air Bag Deployment
- Higher Risk of Chest Injury

Case Presentations

Case #97-014

Automatic Shoulder Belt
Manual Lap Belt
Air Bag Deployment
Non-Fatal

Crash Description

‘94 Ford Escort

Tree Impact

30” Diameter

PDOF - 12 O’clock

Delta V - 30MPH

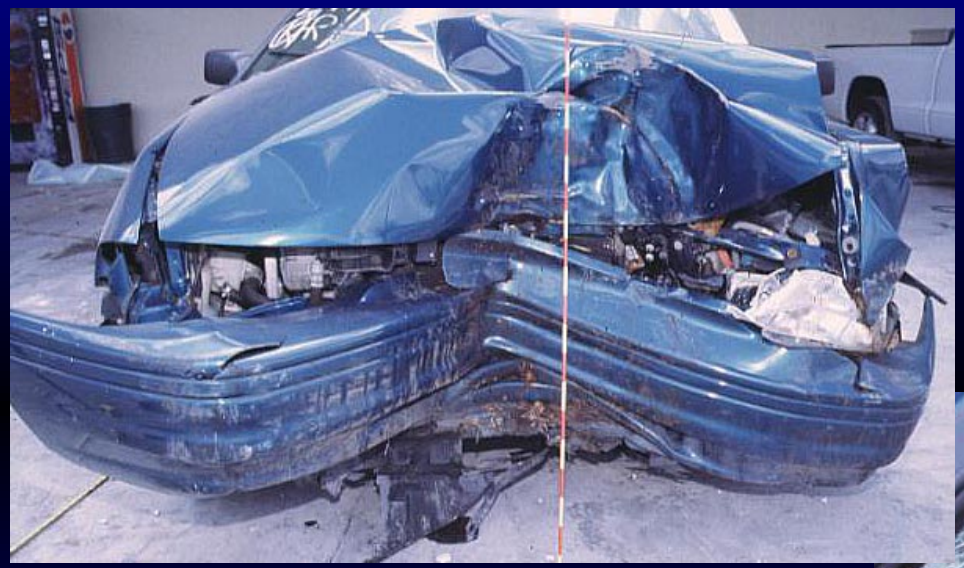
Case #97-014

Occupant Description

- 20 Y/O Male
- Driver
- 67“ Tall, 140 Lbs.
- Automatic Shoulder Belt
- Manual Lap Belt
- Air Bag Deployed

Case #97-014

Case Vehicle



Max. Crush - 24.8”

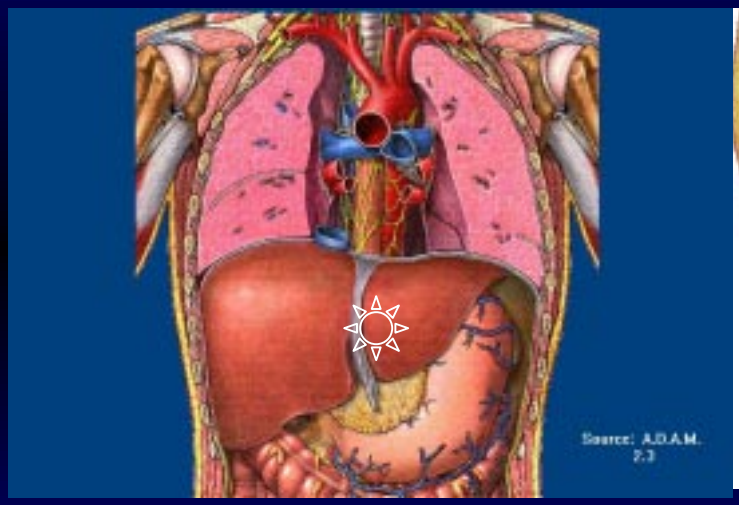
Intrusion:

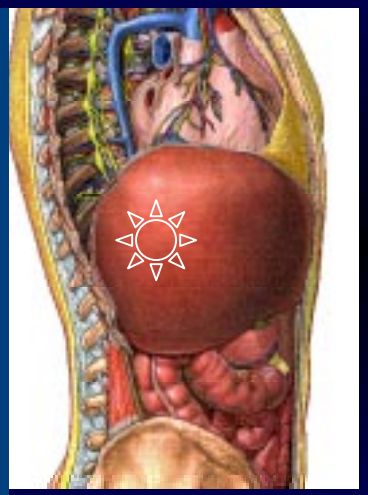
Inst. Panel:	2.5”
Toe Pan:	12.5”
SW Def.:	0”

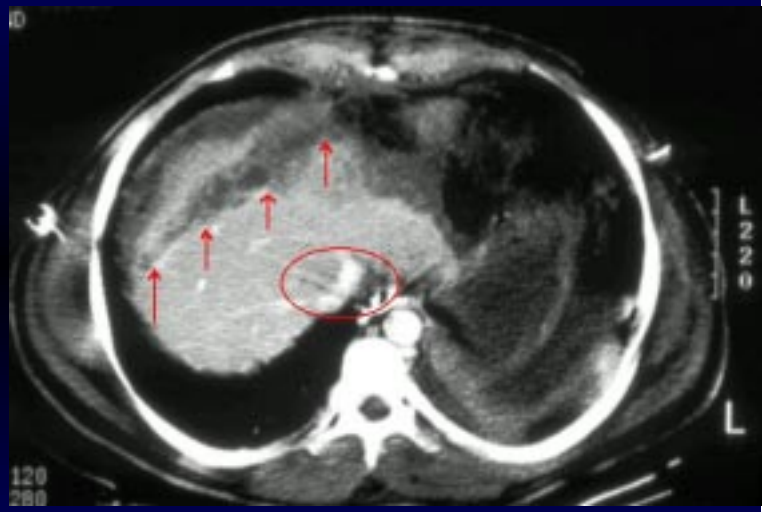
Case #97-014

Injury Summary

Multiple External AIS 1 Injuries







Liver Lacerations

Left Lobe - Anterior Medial- AIS 3

Right Lobe - Posterior - AIS 4

Case #97-014

‘94 Ford Escort NCAP Test

Driver: Air Bag + Automatic Belt

- **Driver HIC - 533**
- **Driver Chest - 47 G**

Passenger: Automatic Belt

- **Passenger HIC - 525**
- **Passenger Chest - 46G**

Significance

- Severe 30 MPH Crash - Narrow Rigid Object
- Vehicle Performed Well in NCAP
- Chest Loading > Than in Car-to-Car Crashes
- Air Bag Prevented Head Injuries
- Belt Related Liver Injuries
- Optimized Belt-Bag Chest Loading Needed

  Belt Geometry, Stiffness

Case #97-014

Case #95-029

2 Point Shoulder Belt Only
No Air Bag

Crash Description

‘94 Hyundai S Coup

Tree Impact

17” Diameter

PDOF - 12 O’clock

Delta V - 32 MPH

Case #95-029

Occupant Description

22 Y/O Male

Right Front Passenger

72“ Tall, 175 Lbs.

Shoulder Belted Only

No Air Bag

Case #95-029

Case Vehicle

Maximum Crush
30 Inches

Case #95-029

Vehicle Interior

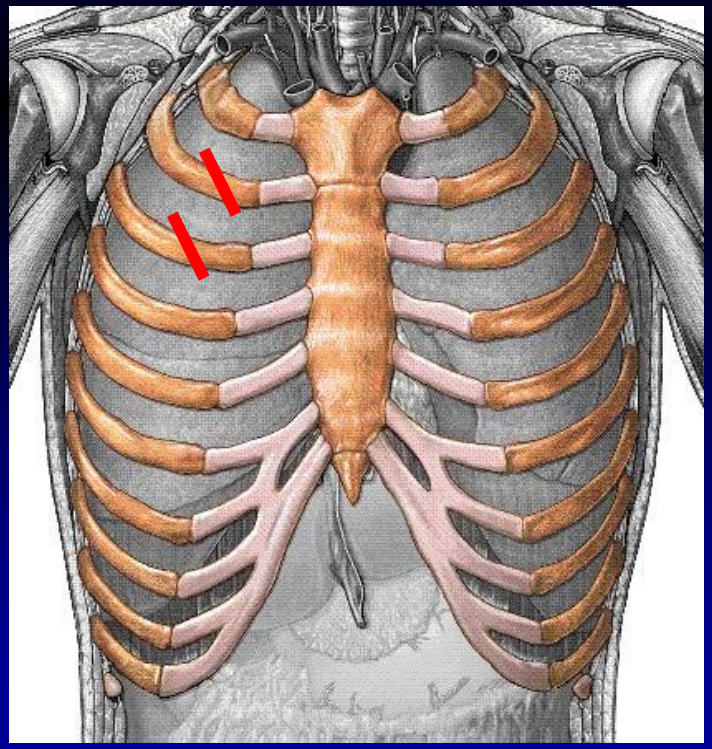
Right Toe Pan Intrusion - 10”

Case #95-029

Injury Summary

Multiple External AIS 1 Injuries:

- Chest
- Lower Extremities
- Head/Face



Rib Fractures
Left Ant. 2 & 3
(AIS 2)

Case #95-029

Significance

- Heart Injury With Only 2 Rib Fractures
- A.C.N. May Have Changed Outcome
- Center Pole Impacts Produce Severe Crashes

Case #95-029

Case #95-016

3-Pt. Manual Belt System
Air Bag Deployed

Crash Description

‘95 Toyota Tercel

Pole Impact

PDOF - 12 O’clock

Delta V - 29 MPH

Case #95-016

Occupant Description

- 39 Y/O Male
- Driver
- 70” Tall, 200 Lbs.
- Lap & Shoulder Belted
- Air Bag Deployed

Case #95-016

Case Vehicle

Maximum Crush - 26.0”

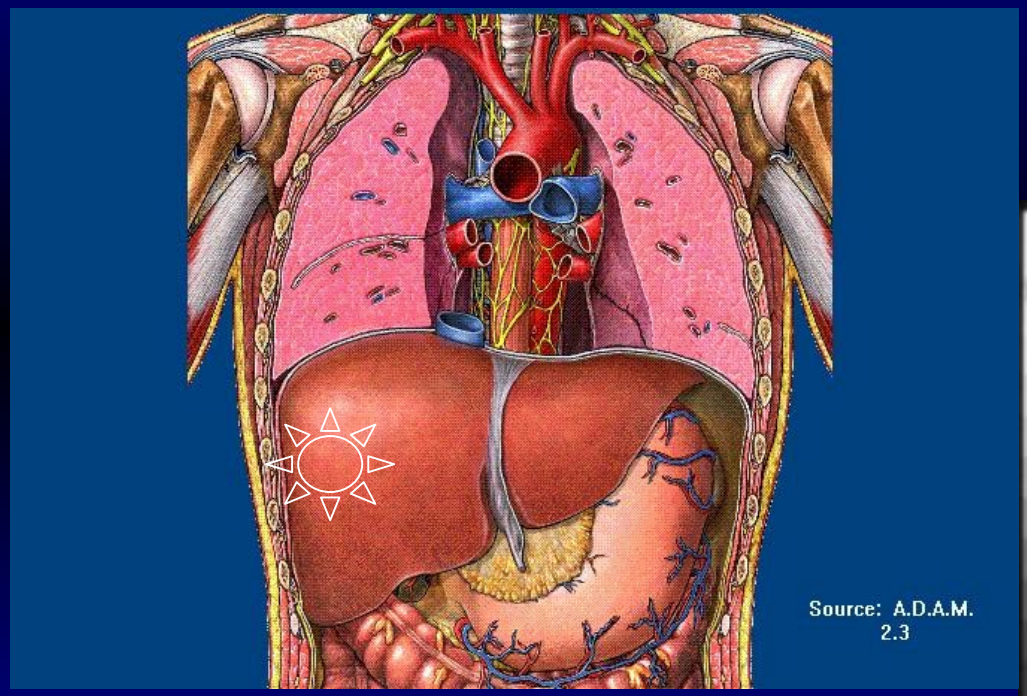
Toe Pan Intrusion - 4.0”
SW Deformity - 1.5”

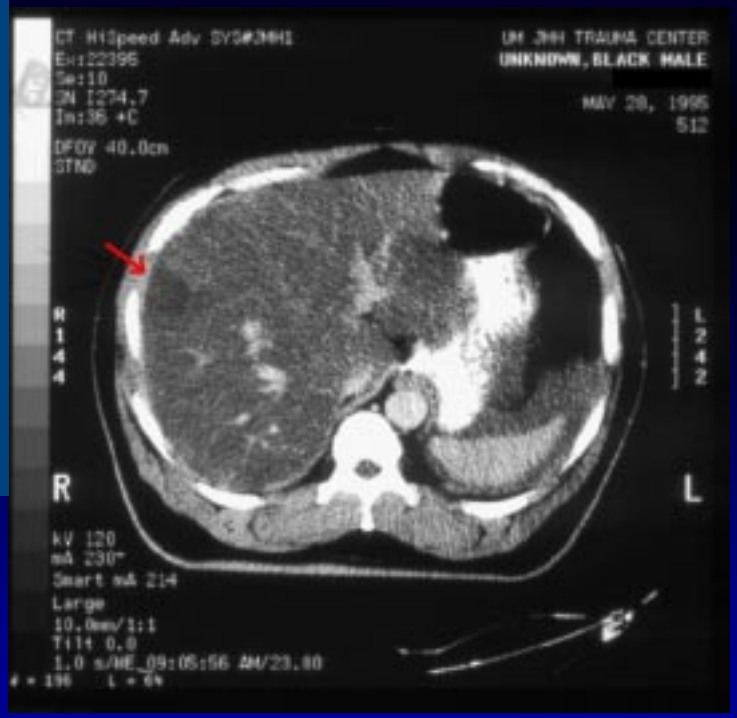
Case #95-016

Injury Summary

Liver Laceration

Right Posterior Lobe
AIS 2





Case #95-016

‘95 Tercel NCAP Test

Driver: Air Bag +3-Pt Belt

- HIC - 907
- Chest - 51 G

Passenger: Air Bag +3-Pt Belt

- HIC - 561
- Chest - 53 G

Significance

- Severe 30 MPH Crash - Narrow Rigid Object
- Air Bag Prevented Head Injuries
- Belt Related Liver Injuries
- Optimized Belt-Bag Chest Loading Needed

Case #95-016

Case #94-018

Manual 3-Pt. Belt System
No Air Bag
Fatal

Crash Description

‘84 Toyota Tercel

Pole Impact

- 30” Diameter

PDOF - 12 o’clock

Delta V - 19.5 MPH

Case #94-018

Case Occupant

54 Y/O Male

Driver

68” Tall, 185 Lbs.

Lap & Shoulder Belt

Case #94-018

Case Vehicle

Max. Crush - 16.3”

SW Deformity 0”
Toe Pan Intrusion 5.0”

Case #94-018

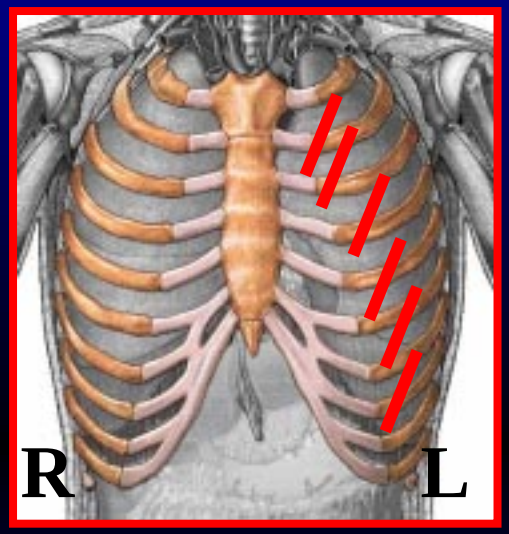
Injury Summary

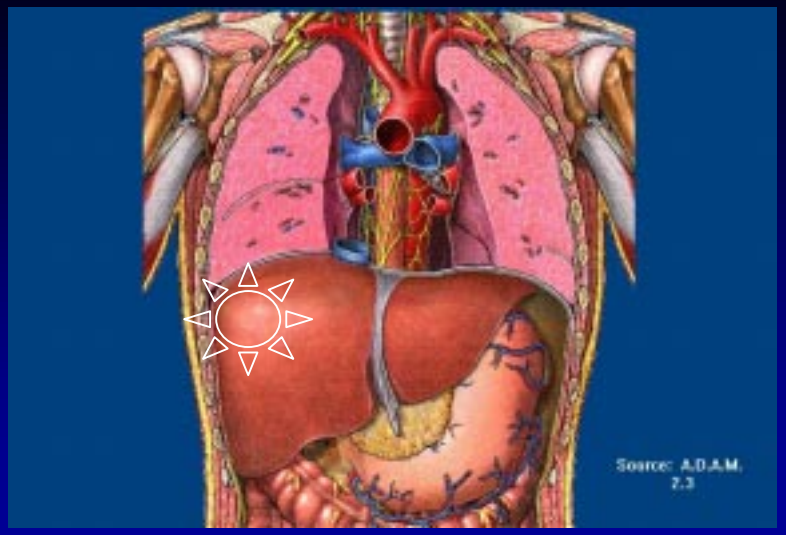
Multiple External AIS 1

Rib Fractures, L. Anterior 2-7 AIS 2

R. Renal Artery Transection AIS 4

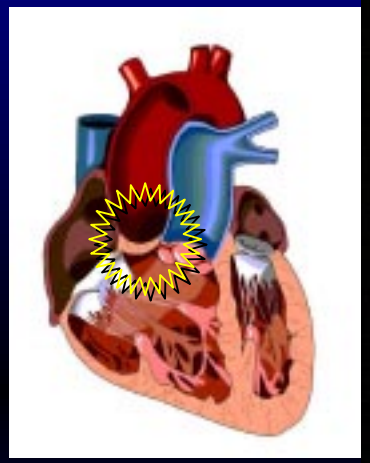
Liver Laceration,
Post. R. Lobe, Medial AIS 5

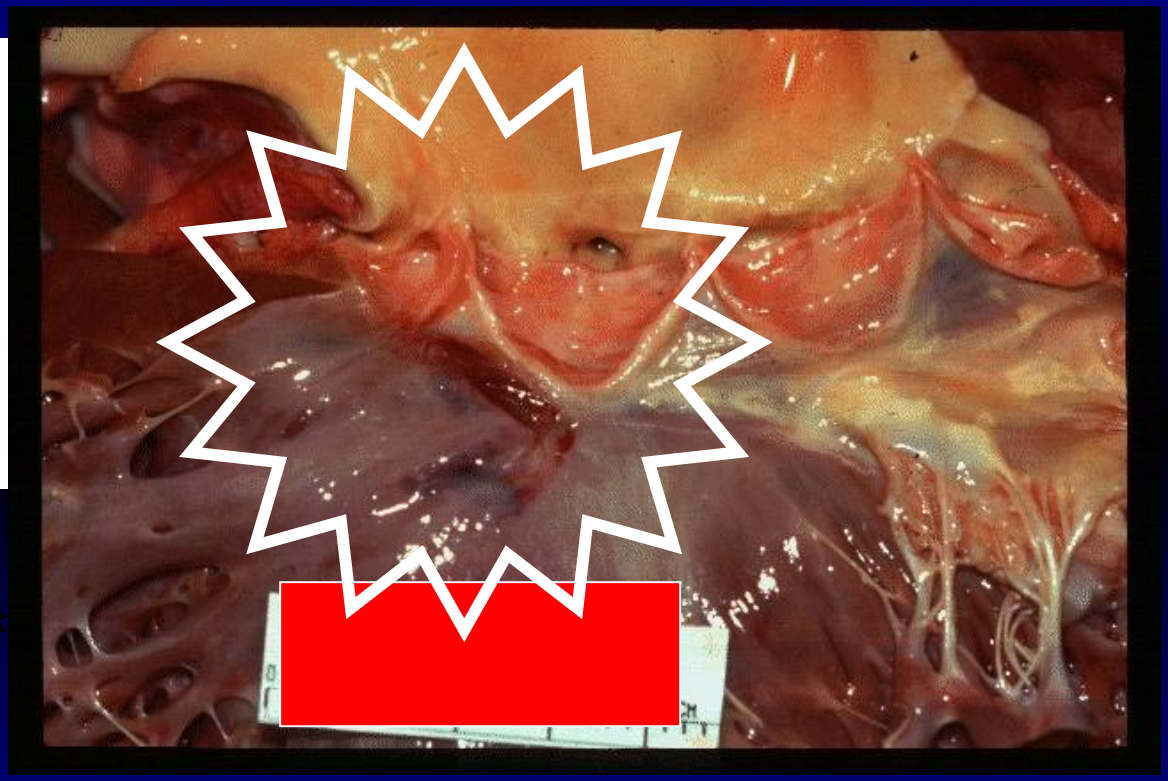




Case #94-018

Injury Summary





Endocardium Laceration AIS 5

Below Left and Right Coronary Artery Cusps at Aortic Valve

Case #94-018

Case Significance

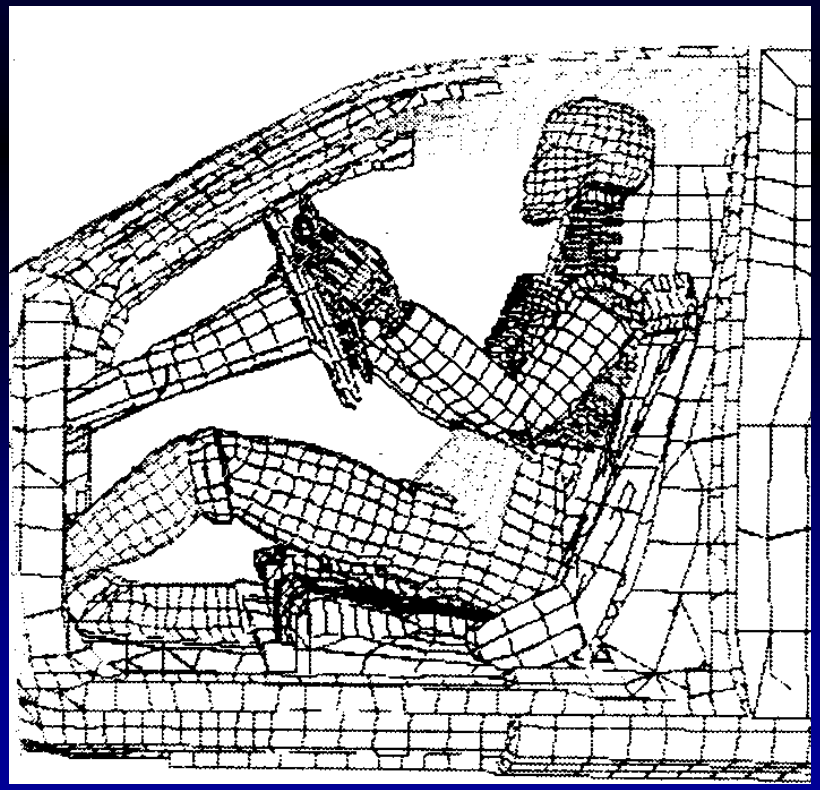
- Older Occupant -
  - Possibly Out of Position
- Older Vehicle
- Injuries Due to Belt Forces

Case #94-018

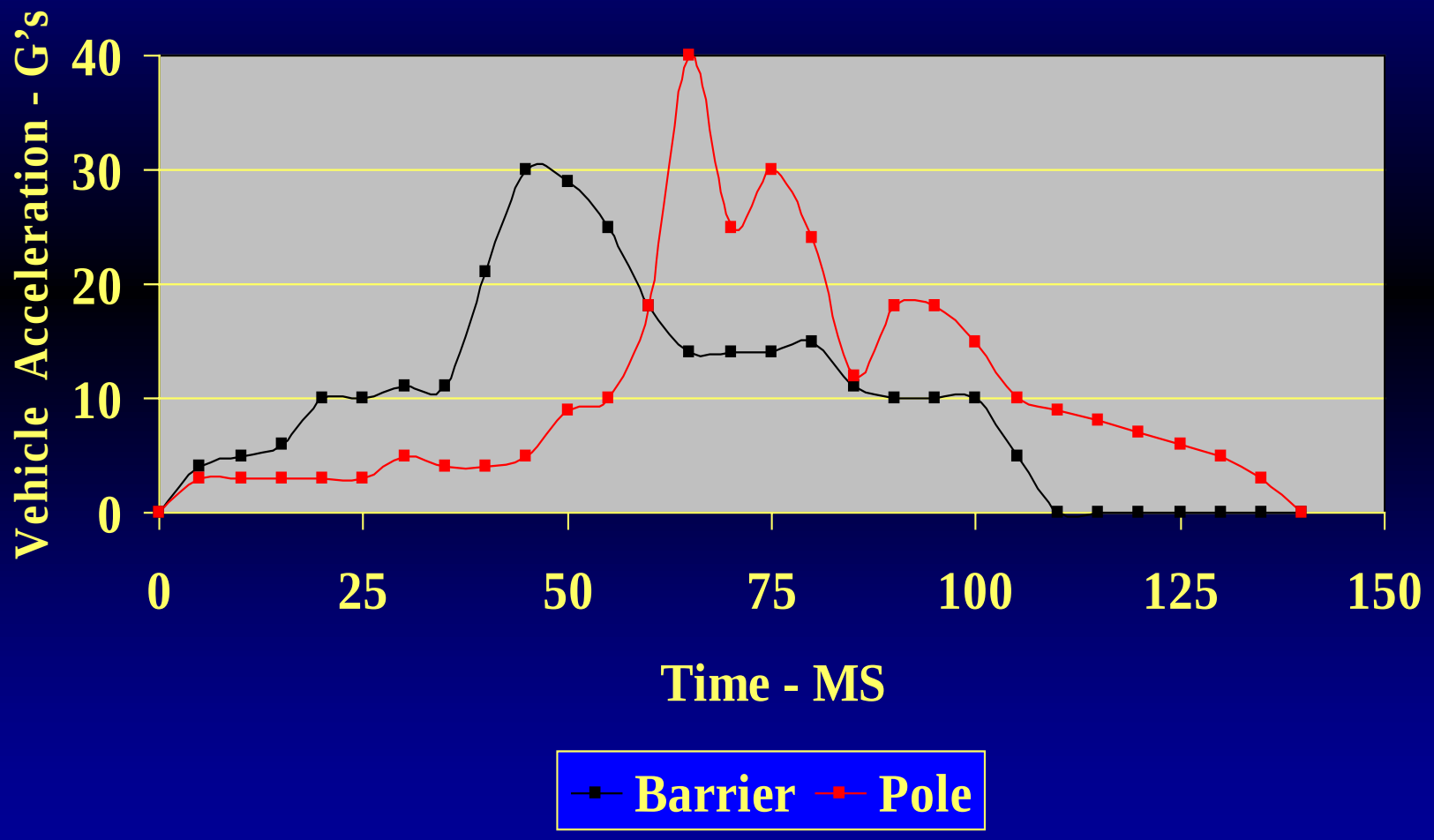
Crash Modeling by Computer

Finite Element
Dummy Model

15,000 Elements

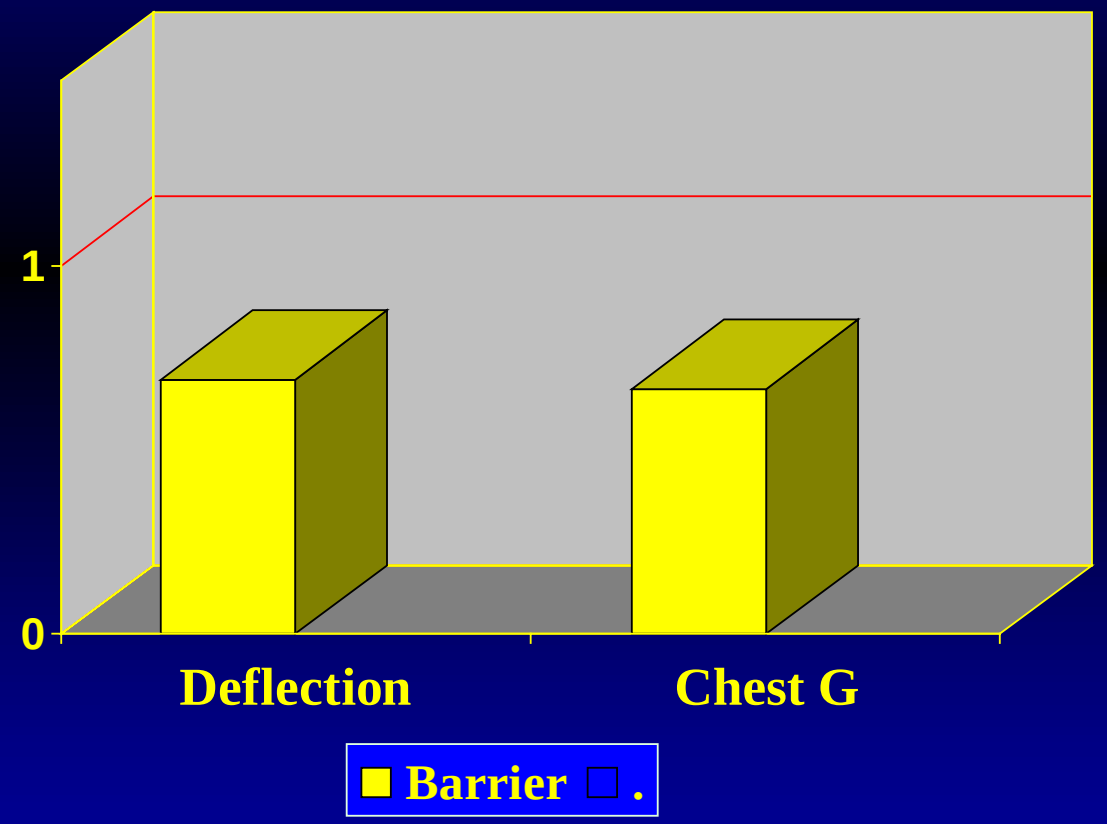


Vehicle G's 30 mph Crash Pulses Measured in Occupant Compartment

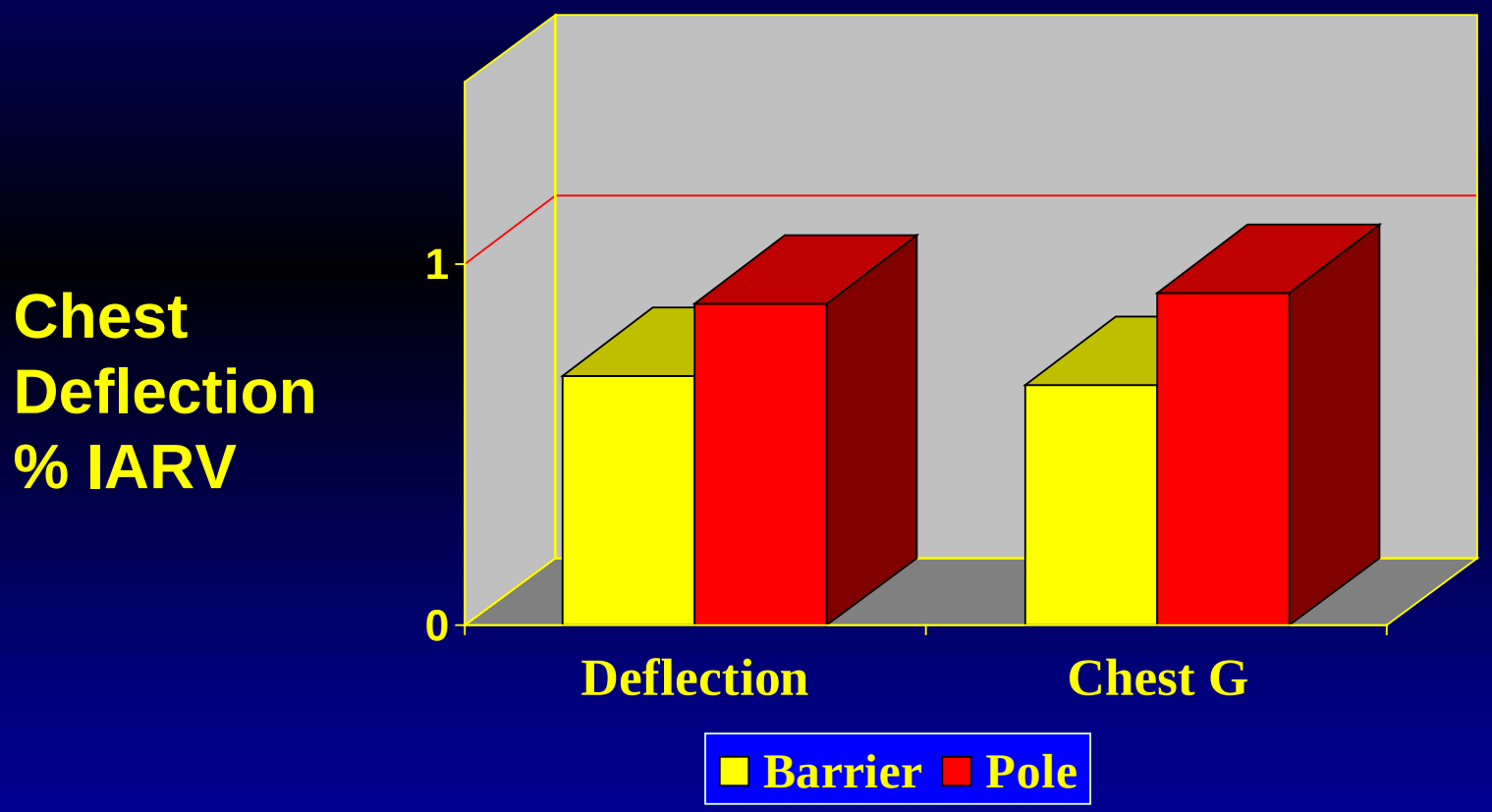


Chest Criteria (IARV) - 30 Mph Barrier Crash (Modeled)

Chest Deflection % IARV



Chest Criteria (IARV) - 30 Mph Pole Crash (Modeled)



Conclusions

- **Narrow Object Impacts**
  - 3.2% Of All Crashes
  - 16% Of All Fatalities
  - 10% Of All HARM
- **Testing Not Federally Mandated**
- **Centerline > 25 MPH Higher Injury Risks**
  - Possible New Trauma Triage Criteria
  - Applications for A.C.N.