Ambulance Safety -
What You Can’t Afford Not To Know
A Crash Course in Ambulance Vehicle Safety Design Issues and Crashworthiness

Nadine Levick, MD MPH
Research Director, EMS Safety Foundation
CEO, Objective Safety
New York, NY

What we shall cover…
- Multimedia overview of safety statistics, demonstration of crash testing, and a review of what is on the horizon in ambulance safety development.
- An outline of strategies and new safety technologies to enhance occupant safety, highlight of important predictable and preventable occupant risks, and expose mythologies regarding safety practices and devices.

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Highlight some of the areas of ambulance transport system safety and risk management-
- Safety for the patient, the provider and the public
- System safety data
- Interdisciplinary aspects
- Innovations to optimize system safety performance

Real world answers to real world questions -
- What features will enhance safety of my new vehicle purchase?
- What color scheme do I want on my vehicle to make it safest?
- What do KKK and AMD really mean from an occupant safety perspective?
- What policies offer the safest system?
- How do I get my team to address safety issues?
- What data should I collect when something goes wrong, and how to analyze it?

In a nutshell
- Am here to try to save you Lives, Time and Money

Firstly!
- An accident?
- or a predictable and preventable event
"...I'd like to know what can be done so this never happens again...."

Friday July 20th 2007
The worst ambulance crash in USA history

Five Killed in Crash of Ambulance and Semi
July 21, 2007 06:20 AM EDT

Emergency personnel throughout the region are still shocked and mourning their own.
"This is one of the worst scenarios when it's our own," said Car Shoemaker of the Prairie Fire Department.
"Everyone is in shock," said Shoemaker. "Everyone is in shock after every event.
"We've lost four very important people in our county."

An ETT down the wrong hole may kill your patient and be a terrible burden for the pts family and for the medic involved

A devastating tragedy...

An ETT down the wrong hole may kill your patient and be a terrible burden for the pts family and for the medic involved

But an EMS crash can kill all involved AND wipe out an EMS systems response capacity......
Charged with Vehicular Homicide

June 17th 2008

a paramedic and a patient killed

In this vehicle…

October 31, 2008, Kentucky

Florida - January 12, 2009

Fire truck vs ambulance…

Are we designing vehicles that are difficult to see…?

Crash occupant hazards

Fatalities and funerals

October 31, 2008, Kentucky

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Fire truck vs ambulance…

Are we designing vehicles that are difficult to see…?

Crash occupant hazards

Fatalities and funerals
An interhospital transport? “Do no harm…”?

Key Issues

- Mythology
  - The Emergency Medical Service personnel are safe
- Injury Hazards
  - Chemical/Radiation
  - Physical/Mechanical Trauma – THE BIG PROBLEM
- Motor Vehicle Crashes are the highest cause of death at work – EMS has > 2X the mean national rate in USA
- An R & D and Regulatory Gap
  - Occupational Health and Safety
    - the workplace is in a vehicle – exposure data are scant
  - Automotive Safety
    - a vehicle is the work place – “exempt” from automotive research and regulation

New Information 2006-2009

- Enhanced Safety of Vehicles (ESV), June 2007
- American Society Safety Engineers (ASSE), June 2006 & June 2007
- International Ergonomists Association (IEA), June 2006
- Transportation Research Board – EMS Safety address, Jan 2007
- AMR Engineering Public Comments, July 2007
- SAE J211, Aug 2007
- SAE J223, Nov 2007
- SAE J223, 2007 Federal Register
- SAE J224, 2007 Federal Register
- SAFETY GLU, 2006
- Safe Systems Approach to Medical Transport: Efficient Transportation Safety Act: A Legacy for whom?
- State Strategic Highway Safety Plans, October 2007
- State EMS Council Policies 2007-2008
- APHA, Nov 2007
- OSIA EMS best practices late 2008
- Transportation Research Board – Shredded EMS Safety
- Worker visibility Act, Implemented, Nov 2008
- TRB Inaugural Ambulance Transport Safety Summit, Nov 2008
- TRB Summit for October 2009

Safe Systems Approach

Source: Road Safety Branch, Infrastructure and Surface Transport Policy, Department of Infrastructure, Transport, Regional Development and Local Government, Australia.

Key Elements to Safety

- Data Capture
- Vehicle Biomechanics and Crashworthiness
- Ergonomics and Biohazards
- Transportation Environment
- Safety Management – evaluation and analysis

Benefit of Safety

- Any cost of addressing these issues is dwarfed in contrast to the huge burden of not doing so – in financial costs let alone the personal, societal, ethical and litigation costs

Federal Motor Carrier Safety Administration….

A very serious gap in data, performance and oversight

- FMCSA Truck safety goals – to decrease the fatality rate of 2.8 per 100 million truck-miles in 1996 to 1.65 by 2008
- EMS crash fatality estimates are - 7.66 - 41.93 fatalities per 100 million ambulance-miles
Some odd facts

- Ambulances are generally not built by the automotive industry.
- Intelligent Transportation Systems (ITS), transportation safety engineering is not generally integrated into EMS systems.
- Although all EMS systems have medical direction and oversight, it is rare for there to be transportation expertise oversight.

UPS and Laundry trucks have very similar design and even more stringent safety requirements to EMS vehicles. BUT very different cargo......

People are passengers and NOT packages or parcels.

Testing the real world

So....

- Which vehicle do you want to be in?
- Which vehicle is the best for efficient and effective patient care?
- Which vehicle provides optimal risk management?
- What is the optimal fleet mix?

So

- What’s important
- What’s not important

- What’s going to save your life
- What might take your life
- What’s going to hurt you
- What’s going to protect you
- What is factual
- What is garbage
What is new

What is not new

Unique workplace

- In vehicles
- At roadside and other emergency scenes

Absence of standards and oversight

- Challenges in identifying best practice
- Myriad of unregulated commercial products
- No safety performance standards
- Absent national safety oversight

What we need to consider, where is the ‘bang for buck’ in ambulance transport safety:

Canada - Corporate Manslaughter Corporate Homicide Act: 8th April, 2008

October 2008 JEMS Article “Rig Safety – 911”

2008 - Air EMS on the NTSB’s “Most Wanted List”, where is ground EMS??

National Academies TRB EMS/Medical Transport Safety Summit - November 7, 2008
Safety - Why now?

- Operating optimally in a transportation environment that is largely devoid of specific safety standards for the hazards and risks present
- Bridge the gap between what technical information exists and what is accessible and applied to EMS

1960 to 2009

- Bridge the gap between what technical information exists and what is accessible and applied to EMS

1960 to 2009

- A passenger vehicle
- A laundry or mail truck

"Ambulance transport has a death toll...."
Carl Craigle EMT-P, Chief Platte Valley Ambulance

There are more safety standards for moving cattle than for moving patients in the USA

The EMS transport process

- communications/dispatch
- the patient
- restraining device/sheet
- transporting device/gurney
- paramedics/transport nurses, doctors & family
- patient monitoring equipment
- clinical care & interventions
- protective equipment
- the vehicle
- the driver/driving skill
- other road users
- the road

The Emergency Department (ED)
An ambulance is not an ED / ICU on wheels

Ground Transport Safety is Complex AND Multidisciplinary

- Epidemiological Data Collection
- Risk Management
- Public Safety
- Transport Policy
- PPE
- Driver Training
- Safety Technologies and Standards
- Fleet Safety Program

Transport Safety

- Ergonomic Research
- Biomechanical Automotive Safety
- Communicating Technology
- Safety Technology

Occupational Health and Safety…..?

- This IS a Transportation and Automotive Safety issue
- This is a Systems safety issue

What is a survivable impact?

\[ E = \frac{1}{2} m v^2 \]

- 37 mph (60 km/h) - survivable

- 62 mph (100 km/h) – not survivable

A survivable impact??
It does happen....

But what about head protection?

EMS Transport Safety

- 'patient safety'
- AND also
- 'provider' and 'public safety'

Is there an acceptable rate of morbidity and mortality for pre-hospital transport systems??

This is not acceptable

In the USA*

- ~ 5,000 crashes a year
- ~ One fatality each week
- ~ 23 pedestrians or occupants of other car
- Approximately 4 child fatalities per year
- ~10 serious injuries each day
- Cost estimates > $500 million annually
- USA crash fatality rate/capita 35x higher than in Australia


Standards and Policy

- Operations and fleet management
  - Vehicle design safety and crashworthiness
  - Australia: ASA (AS/NZS 4535:1999)
  - USA: KKK-F 2007, AMD 2007 (not by national standardizing bodies)
- Worker and vehicle visibility
  - Some apparel, minimal vehicle visibility standards limited evidence base

Ambulance Standards??

- Australasia
- Europe
- USA
  - KKK?
  - AMD?
  - FMVSS?
  - NFPA?
Australia & New Zealand
Ambulance restraint
standard AS/NZS 4535:1999

- "Restraint systems shall apply to all
equipment and people carried in an
ambulance…"
- Dynamic Testing - 50th & 95th
percentile manikins
- 24G in Forward and Rearward
- 10G in Transverse

Common European Community
(CEN) EN 1789:1999/A1:2003,
European Committee for Standardization
Medical vehicles and their equipment - Road Ambulances

- "Without exception, all persons,
medical devices, equipment,
and objects normally carried
on the road ambulance shall
be maintained to prevent them
from becoming a projectile when
subject to a force…"
- 50th percentile manikins - 10 G in Forward,
Rearward, Transverse, & Vertical directions
- Certified by Notified Body and Ambulance Mfg.

What KKK-A-1822F, AMD and
FMVSS
state and don’t state…

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USA KKK ambulance purchase
specifications

- Specifications for the purchase of a Star of Life
Ambulance
- Static Pull test
- 2200 Lbs. static stretcher test in
longitudinal, lateral & vertical
- No dynamic test for vehicle, occupants or equipment
- No automotive test manikin
- Voluntary

USA Ambulance Manufacturing
Division (AMD)
Ambulance Standards – August 2007

- No dynamic or impact test
- No automotive test manikin
- Mandates NO ‘crumple zone’
- No impact tested anchorages for
occupant restraint or equipment
- Internal, not independent

KKK/AMD

- Appear ignorant of basic automotive safety
principles -
- Makes no reference to dynamic testing and
YET makes reference to this standard
YET makes reference to this
standard providing protection in the setting of vehicle
crash forces
- The complete ABSENCE of any real world
injury data applied to the determination of
these test protocols

AMD 2007 - 025 'occupant
safety testing' - Compared with -
Accepted automotive safety
occupant testing

AMD – static ‘safety testing’

- Inconsistent with automotive safety
principles – and specifies that a ‘successful
test’ is -
- No structural damage to any load bearing or
supporting members, i.e., torn or broken
material, broken welds, popped or sheared body
rivets, bolts, and/or fasteners, shall be evident
during the application of the force and after the
release of the force.

Occupant protection……??

July 2007

Medic Survivors

Medic Fatality
No ‘a’… then NO ‘F’ !!!!!

$\mathbf{F = ma}$

where $\mathbf{F}$ – force
$\mathbf{m}$ – mass
$\mathbf{a}$ – acceleration

Unacceptable, and non-automotive AMD/KKK-F ‘safety testing’ practices and standards !?!

FMVSS has a specific exemption for ambulance vehicles once you are 600mm or 2 feet positioned rearward of the driver

KKK require a ‘national test lab’ to conduct AMD ‘tests’ BUT NOT an automotive test lab!

No dynamic impact tests AT ALL

No crashworthiness tests

USA Ambulances: FMVSS Exemption

FMVSS exempt......

NFPA Ambulance Standard Development

Balanced of concerns and risk during transport

Benefit of Safety

Safety Management

- A Safety Culture
- Protective Policies
- Protective Devices
  - To prevent a crash
  - In the event of a crash
- Continuous Education and Evaluation
The Crash Event - Crash Testing

- An introduction
- What one needs to know
- What do the tests really mean
- And, what tests are meaningful

Intrusion vs Deceleration

- Intrusion
  - vehicle to vehicle or vehicle to fixed narrow object
- Deceleration
  - sudden stop – ie. sled test

Intrusion

Dynamic Safety Testing

- requires sophisticated, expensive equipment
- measurably demonstrates forces generated during collision
- accepted international standard for vehicle restraint systems

If we know this – and its published....

Why do we do this?

And this all takes place in 60 millisecs – the blink of an eye
USA 2004, NIOSH Head strike zone hazards

A few key words about restraint systems…

Side facing shoulder harnesses demonstrated to be lethal, even at slow ground vehicle speeds.

NOT new technical data…

Side facing shoulder harnesses demonstrated to be lethal, even at slow ground vehicle speeds.

Being seated IN an automotive seat is what will protect you

- Anything that allows or encourages you to get up out of your seat will also encourage you to be injured or killed – it is potentially lethal to be out of your seat in any fashion.
- 4 or 5 point harnesses for side-facing occupants are potentially lethal – and is in NO WAY SUPPORTED BY ANY DATA OR AUTOMOTIVE SAFETY EXPERTISE.

And very Predictable…

- Intersections are lethal environments.

The real world

Intersection passenger car stopping distance* at 40 mph dry and wet

* Stopping distance: Perception Time + Reaction Time + Vehicle Braking Time (varies with age, skill, agility, distance, vehicle type, tire pressure, road etc.)
Increasing awareness …

What do we know now??
- Intersection crashes are the most lethal
- There are documented hazards, some which can be avoided
- Occupant and equipment restraint with standard belts is effective. (Over the shoulder harnesses for patients should be used, with the gurney in the upright position where medically feasible)
- Some vehicle design features are beneficial - automotive grade padding in head strike areas, seats that can slide toward the patient
- Electronic Driver monitoring/feedback systems appear to be highly effective
- Head protection??

Vehicle design and safety
- The principles of automotive safety involve a complex science, engineering technical skill, expertise, training and knowledge
- “Give the engineers a working list of our needs and let them tell us how it should be built to accomplish those tasks…..”

Rash of “Safety Concept” vehicles…..
- Devoid of substantive automotive safety engineering input or testing

Wyoming Ambulance Manufacturer, August 17, 2007..
- “… the current crop of “Safety Concept Vehicles” being built by some manufacturers are a sham and they do not address the problem but are merely used as a sales gimmick.”

An admirable goal – BUT…
- implementing interventions that have not in anyway been demonstrated to be effective let alone safe is a very serious problem
- There is NO vehicle safety without real world injury data and automotive safety expertise
- With what authority has ground EMS squandered $3,000,000 on these concept vehicle shams??
- We NEED meaningful injury data to better understand the mechanism of injury and fatality
- A crash test program without automotive safety expertise and real world representative injury data is irresponsible
- Without real world injury data it is not possible to effectively measure the burden of the hazard NOR the effectiveness of any interventions
- Yet another potentially hazardous example marketed as a ‘safety innovation’, YET outside of automotive safety practice
Yes, the ride of your life….

Sure… these vehicles all parade around the EMS and Fire shows BUT…

NOT ONE of these vehicles has been to the automotive safety shows or scrutinized independently by the automotive safety industry

JEMS and EMS Responder ARE NOT automotive safety journals

And the reviews in them are completely inappropriate, misleading and outside of what is known in automotive safety

We should NOT TOLERATE this as it is both completely irresponsible and very dangerous ……

Innovation

What's new

- New automotive safety technologies
  - Crash worthiness
  - EVS
  - ITS
  - Monitoring and feedback enhancements
- New expertise
  - TRB
  - ASSE
  - SAE
  - UTRC
  - Ergonomics
  - Industrial Design

Safety concepts out there now

- Driver feedback technologies
- Tiered dispatch
- Enhanced ambulance vehicle design
- Intelligent Transport Technologies - ITS
- New Safety Standards

Important…

- Ergonomics and automotive safety issues are interrelated
- Crashworthiness priorities override the ergonomic issues

RETTmobil – ’Mobile Rescue’ European EMS vehicle innovation

http://www.rettmobil.com/

Vehicle Occupant Safety design

2007 European design

Safety technology is a key focus
Ergonomic layout and equipment

NSW Australian vehicles

Flexibility to manage two patients

Awkward tasks? Develop solutions!

Visibility and lighting issues

Worker visibility Act:
Help is on the way!! November 24th 2008

Policy and practice ignorant of existing technical safety data
Night visibility

Here’s the real world at 6 ft...

This addresses some very real risks, very creatively – and currently ONLY available in London Ontario!

Summit County EMS - Colorado

Old vehicle

New yellow vehicle markings

Staff use lime-green vests & jackets

Increasing safety with a 30% cost saving

Queensland Ambulance Australia

Emergency Vehicles – Viewer Awareness

For a timely, appropriate and safe response

Location

Size

Shape

Speed

Intended path

Under Way...

Emergency Vehicle Visibility and Conspicuity Study

Funded by the USFA conducted by IFSTA

Looking at the effectiveness of reflective markings used on emergency vehicles

Doing best practice research and working with manufacturers

So...

Which vehicle do you want to be in?

Which vehicle is the best for efficient, and effective patient care?

Which vehicle provides optimal risk management?

What is the optimal fleet mix?
Were we safer in the Cadillac???

Technical information available

R & D

“Ripoff and Duplicate”

- Avoid reinventing the wheel at all costs
- Where are the best practices that we need to transfer knowledge from

American National Standard
ANSI/ASSE Z15.1-2006
Safe Practices for Fleet Motor Vehicle Operations

What Z15 encompasses

- Safety Program
- Safety Policy
- Responsibilities and Accountabilities
- Driver Recruitment, Selection and Assessment
- Organizational Safety Rules
- Orientation and Training
- Reporting Rates and Major Incidents to Executives
- Oversight

Best Practices?

EMS Best Practice, Sept 2006

September 2007, Its not magic.....

Valuable information from the transportation industry
These folks know what we need to know...

IAFC June 2007

Transportation Research Board is an excellent resource… we should be using it!!

Tips for Emergency Vehicle Operations

An excellent model

http://www.EveryoneGoesHome.com

USFA Emergency Vehicle Safety Initiative

Traffic Incident Management Systems (TIMS)

Risk/Hazards

- Predictable risks
- Predictable fatal injuries
- Serious occupational hazard
- Public safety hazards
What do we know works...
- Vehicle Operations Safety Policies
- Squad bench lap seat belts
- Patient over the shoulder harnesses
- Securing equipment
- Forward and rear facing seating
- Some electronic technical devices
- Safety awareness
- Cultural change

What you can do now
- Have a written and implemented “safety program”
- Secure all equipment
- Secure occupants with standard belts
- Don’t drive through red lights/stop signs
- Use properly implemented “Feedback Boxes”
- Monitor crash events with common denominators (ie. per 100,000 miles and per trip)

Important Principles!
1. A culture of safety
2. Drive cautiously
3. Wear your belts & restrain all occupants
4. Secure all equipment
5. Integrate scientific data into your policies and procedures

- Unrestrained occupants and equipment are a potential injury risk to all occupants

Very Important Principle
Ambulance transport safety is part of a SYSTEM, the overall balance of risk involves the safety of all occupants and the public

PREDICTABLE PREVENTABLE and NO ACCIDENT

Conclusion
- EMS transport has serious hazards and safety issues
- Major advances in EMS safety research, infrastructure and practice over the past 5 years
- New technologies for vehicle design, occupant PPE and equipment restraint and driver performance are now available
- Development of substantive EMS safety standards is a necessity and a reality
- Failure to transfer knowledge from transportation and automotive safety is unacceptable and dangerous
- EMS is still way behind the state of the art in vehicle safety and occupant protection

And...
- It is no longer acceptable for EMS to be functioning outside of automotive safety and PPE safety standards for prevention of and protection of EMS providers and the public from injury and death

Thank you!
Any Questions??
Electronic handout available online
http://www.objectivesafety.net