Ambulance Transport Safety: Where is the State of the Art?

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New York, USA

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Science behind Policy

“For successful technology, reality must take precedence over public relations, for Nature cannot be fooled.”
Richard P. Feynman 1988

Outline

I. Review of data on ambulance crashes and safety standards and guidelines that exist for the ground EMS
II. Identification of ground EMS transport safety issues, hazards and areas of risk to patients, providers and public
III. Highlight unacceptable mythology and challenges to advancing EMS transport safety
IV. Profile innovation, new safety technologies and strategies and knowledge transfer to enhance safety and reduce risks of ground EMS and patient transport

Science behind Policy

A tragic emergency health care intervention outcome

It does happen.....

In a nutshell

Comprehensive perspective on:
• System wide data
• The challenges
• The cutting edge
• The gaps in knowledge and application of transportation systems safety in the big picture of Emergency Medical Services transportation

Interactive handout
http://www.objectivesafety.net

Emergency Medical Service Transport

What are the transport safety issues that pertain to this important public service and public safety industry?
What do we know of the risks and hazards and how can we measure these?
How can the safety of this transport system be optimized?

Recent adverse EMS transport outcomes

Some odd facts

• Ambulances are generally not built by the automotive industry
• Intelligent Transportation Systems (ITS), transportation safety engineering and transport systems engineering are 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

Recent adverse EMS transport outcomes
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......

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

The ‘accident’ scenario...

There were three personnel in the back of the ambulance plus the patient.
The patient being treated had a self inflicted laceration with an arterial bleed to an upper extremity.
The ambulance was traveling lights and sirens and moving slowly through an intersection when they were involved in a T-bone collision.
They were struck on the passenger side of the vehicle near the rear of the box.

At the time of the ‘accident’...

The paramedic with the serious head injury was seated and unrestrained on the bench seat over the rear wheel well on the impact side of the vehicle.
At the time of impact, the paramedic with the head injury had just finished starting an IV and he was discarding his needle in a wall mounted sharps container.
A second Paramedic was standing at the head of the patient involved in an unknown activity. An EMT was standing near the front of the bench seat, holding direct pressure and elevating the patients arm upright.

The tip of the iceberg of the ‘accident’ outcome...

The second paramedic and the EMT received minor soft tissue injuries only.
The paramedic with the head injury was intubated for a short time and then extubated later that same evening.
He is back to work after a couple of months off the job. He is not working as a paramedic yet, but he is back on the line as a chiefs aid until his doctor gives him permission to return to active duty status. He has been dealing with memory problems and the need to sleep for longer hours than normal.

What do ambulance crashes really cost?

Loss of life and injury
Negative impact on EMS system
Collisions are the largest liability cost and exceeds malpractice or negligence
Besides the direct financial costs of replacing a damaged ambulance and equipment, there are additional hidden costs incurred:
- investigating the ambulance collision
- malpractice/litigation/settlement/lawsuit
- medical/disability costs of injured EMTs
- hiring of new employees to replace injured personnel
- retraining and psychological counseling of personnel involved and others
- increased insurance rates

New York.....
Major deal...

This month....

Last month ....

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#### May 25th 2007?

**Fatalities and funerals**

Is it your services tragic year?

- ~ 50 fatalities a year
- 15,000 EMS services
- Each year one in 300 services experiences a fatality

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#### Last month....

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#### What needs to happen NOW?

- Implement a Fleet Safety Program
- Correct the basic policies and procedures regarding:
  - Intersections
  - Use of occupant restraints
  - Securing equipment
  - Driver performance
- Data
- Epidemiology
- Ergonomic
- Safety oversight
EMS Transport Safety IS Complex AND Multidisciplinary

- Epidemiological Data Collection
- Ergonomic Research
- Environmental Automotive Safety
- Biomechanical Research
- Communications Technology
- EMS Policy
- EMS Safety
- EMS Testing
- EMS Regulations
- EMS Standards
- Fleet Safety Program


August 16th…

Deadly Ambulance Accident

August 22, 2005…

Daily American Republic

Firstly!

An accident?

or a predictable and preventable event

The EMS transport process

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

An ambulance is not an ED /ICU on wheels
Balance of concerns and risk during transport

- Response and transport time
- Clinical care provision
- Occupant safety/protection
- Public Safety

Transport oversight?

- In contrast to the bus and truck industries, which have -
  - comprehensive safety oversight
  - transportation safety interventions
  - transportation safety data capture via the Federal Motor Carrier Safety Administration (FMCSA)
- EMS has been focused more as an acute health care delivery and emergency medical service and largely outside of much of the other transportation oversight infrastructure that exists

Knowledge Transfer?

Active Projects

- Commercial Motor Vehicle Driver Training Curricula and Delivery Methods and Their Effectiveness
- Commercial Motor Vehicle Carrier Safety Management Certification
- The Role of Safety Culture in Preventing Commercial Vehicle Crashes
- The Impact of Behavior-Based Safety Techniques on Commercial Motor Vehicle Drivers
- Health and Wellness Programs for Commercial Motor Vehicle Drivers

What are the solutions?

- Practice Policy?
- Training?
- Transportation Systems Engineering?
- Automotive Engineering?
- Education of other road users???

Unique workplace

- In vehicles
- At roadside and other emergency scenes

USA EMS

- EMS Systems - >15,000
- Personnel - ~1 million
  (~30% F/T professional & 70% volunteer)
- Vehicles - ~50,000
  (Type I, Type II, Type III, Freightliners, ?motorcycles)
- Transports - ~50 million
  (to Emergency Depots ~ 50% < 1/3 emergent)
- Cost - ~$8 Billion annually
- Safety Oversight - ? Disparate

Safety oversight of what and .... by whom

- Vehicle Safety
- Vehicle Design
- Transportation systems safety
- Safety Equipment Design
- Vehicle and Safety Equipment Testing and Standard development
- Safety policies

This is about you and your safety

- What safety practices do you use??
  - Seat belts ?
  - EVOC training ?
  - Equipment lock down ?
  - Helmets ?
  - “Black Box” technology ?
  - Tiered dispatch ?

The National Transportation Safety Board (NTSB)
**A Simple Question….**

*Wings, Wheels & Rotors*

A Simple Question

A passenger vehicle - sure

A ‘laundry or mail truck’ - ?

*The first and only published scientific text on ambulance crashes (1995)*

… and by an optometrist

*1960 to 2007*

A passenger vehicle ...

We've known for 10 years that red fire trucks are twice as likely as lime yellow trucks to crash at an intersection

*The first and only technical symposium 2001*

**Key Issues**

- Mythology
- Injury Hazards
  - Biomechanical
  - 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
- 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 workplace – ‘exempt’ from automotive research and regulation

**What’s missing**

1. What data is collected nationally?
   - We have no denominator data
   - We have incomplete numerator data
2. Absent population based national injury data or injury mechanics data
3. Absent structured transportation safety engineering input
4. 2 + 2 = resultant inability to design and evaluate efficacy of injury interventions
5. What oversight is there?
6. Which organizations would determine policy?

**Challenges to Optimizing EMS Transport Safety**

- Disparate and fragmented safety infrastructure
- Lack of a centralized EMS Safety oversight or data
- A large number of small groups of end users, with a mix of volunteers and professionals
- Ambulances are hybrid non-standard vehicles, a truck chassis and an after market box or a modified van
- EMS vehicle safety is not integrated as a part of the transport safety industry

**Challenges to Optimizing EMS Transport Safety**

- Rear compartment exempt from FMVSS
- Complex automotive safety area bridging acute clinical care, public health, public safety and automotive safety
- Very recent history as a research issue
- Limited fiscal support for cross disciplinary EMS transport safety research
But what about head protection?

Role of a head protective device
- A simple, immediate and inexpensive adjunct – a protective device –
  - To protect occupants from hazardous interiors
  - As vehicle crashworthiness design advances
  - As driver training advances
  - For when equipment becomes unsecured
  - As EMS Safety Standards are developed, for both EMS vehicles and EMS occupational safety

New EMS helmet prototypes for 2006-2007

Hmm...

So why is it...
- That the EMS providers -
  - Were wearing navy blue – one of the most difficult colors to see at night
  - Had no head protection, when all other emergency personnel at the scene did
  - Had no protective clothing, when other emergency personnel at the scene did???
**Goals**

- Standards for safety
- Policy based on Science
- Databases to demonstrate outcome

**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

*FARS/BTS 2005-6

**USA EMS and Fire Vehicles**

Minimum Annual Fatalities 1995 - 2005

**Ambulance Safety Research: A New Field**

- engineering
- ergonomic
- epidemiology

<table>
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<th>Year</th>
<th>EMS</th>
<th>Fire</th>
<th>Ambulance</th>
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<tr>
<td>2005</td>
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**EMS Provider Fatalities**

- 12.7 fatalities/100,000 EMS workers
- Greater than 2 x the national average (5.0 fatalities/100,000)
- Similar to Police (14.2/100,000) and Fire Fighters (16.5/100,000)


**and what is killing EMS ?**

EMS personnel fatalities*

- 74% transportation related
  - 1/5 of ground transport fatalities were struck by moving vehicles
  - 11% were cardiovascular
  - 9% were homicide
  - 4% needle sticks, electrocution, drowning and other


**So does it make sense ?**

- Gloves and universal precautions?...
  - good biohazard protection BUT aren't going to give much protection in a ambulance crash

**Occupational Health and Safety.....?**

- This IS an Automotive Safety issue
**Occupational transportation fatalities.**

<table>
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<th>Year</th>
<th>Fatalities/100,000 workers</th>
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<tbody>
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</table>

**Predictable risks**

- Fatal crashes more often at intersections, & with another vehicle (p < 0.001)
- 70% of fatal crashes EMS crashes during Emergency Use
- Most serious & fatal injuries occurred in rear (OR 3.7 vs front) & to improperly restrained occupants (OR 2.5 vs restrained)
- 82% of fatally injured EMS rear occupants unrestrained
- 74% of EMS occupational fatalities are MVC related
- Serious head injury in >65% of fatal occupant injuries
- More likely to crash at an intersection with traffic light (p < 0.05 vs 0.001) & more people & injuries/crash than similar sized vehicles

**And very Predictable…**

- Intersections are lethal environments

**So… The real world for an EMS vehicle approaching a red light**

- You think they heard you…
- You know they must have seen you...
- And maybe they did
- ….. But...
- There is NO way humanly possible that they could stop…..

**The real world**

**Intersection passenger car stopping distance**

- at 40 mph dry and wet

<table>
<thead>
<tr>
<th>Condition</th>
<th>Stopping Distance</th>
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<tbody>
<tr>
<td>Dry</td>
<td>176 feet</td>
</tr>
<tr>
<td>Wet</td>
<td>220 feet</td>
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**Stopping distance**

Perception time + Reaction time + Vehicle braking time

**Global EMS Standards**

- Australia & New Zealand ASA 4535
- Common European Community EN1789
- USA KKK & NTEA – AMD
- [Aviation – FAA/CAA/JAA]
- CAMTS
- CAAS
- International Joint Commission on Medical Transport
- ANSI/ASSE Z15

**USA ambulance purchase specifications**

**GSA:KKK-A-1822E, 2002**

- Static Pull test
  - 2200 lbs. (8G’s) in Longitudinal and Lateral
- No dynamic test
- No definition to manikin mass
- No restraint for equipment
- Voluntary

**Some KKK spec info**

- Text detail:
  - lighting systems
    - 150 lines of text, 2 tables and a diagram, over 5 pages
  - preparation of painting, color and markings
    - 107 lines of text, 1 table, over 3 pages
  - protection of patients and crew
    - 2½ lines of text

**USA Ambulances: FMVSS Exempt**

- 49 CFR Parts 571, 572, and 589
- [FMVSS 490] (USA)
FMVSS exempt.....

ASTM F 1086 - 94
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

Z15 Incident Rates
- Incident rate based on number of vehicles operated:
  Incident rate = Number of incidents / Number of vehicles
- Incident rate based on vehicle miles:
  Incident rate = Number of incidents / Vehicle miles
- Injury incident rate based on vehicle miles:
  Injury incident rate = Number of injuries / Vehicle miles
- Incident rates based on service activity:
  Incidents per 10,000 transports = Number of incidents / Number of transports
- Vehicle injury rates based on work hours:
  Vehicle incidents per 200,000 hours = Number of incidents / Number of hours

Legal Perspectives on Z.15
- ‘patient safety’
- ‘provider’ and ‘public safety’

EMS Transport Safety
**What’s new**
- New automotive safety technologies
  - Crashworthiness
  - EVS
  - TS
  - Monitoring and feedback enhancements
- New expertise
  - TRB
  - ASSE
  - SAE
  - UTRC
  - Ergonomics
  - Industrial Design

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

**Why do we do this?**

**Patients must be in the over the shoulder harness, medics restrained in seat belts, equipment secured**

**Full Vehicle Crash Tests**

- **Test 1 – Right side impact**
- **Test 2 – Frontal**
High speed crash, rolled and the occupants (patient and medics) had only minor scratches.

Major events for innovation sharing — but regional and often language isolation.

Vehicle Occupant Safety design

2007 European design

Safety technology is a key focus.

Ergonomic design

Ergonomic layout and equipment

Driver behavior monitoring and feedback device

Demonstrated Effectiveness

A key to safe ambulance transport

Levick NR, Swanson J, Proceedings — 49th Annual Conf. of the Assoc. for the Advancement of Automotive Med, September 2005

AMBEX-999 Research Forum 2006 — Research most likely to change practice award

MEMS ABC Miles Per Month

MEMS MONTHLY OVER SPEED VIOLATION TREND 2003/2004

216,922

550,353

2,074 1,609

285 547

4,046

207 407 710 780

3,069

1,004 1657 2709

179,721

0

100,000

200,000

300,000

400,000

500,000

600,000

Mar

March April

May June July

Aug August

Septembe September

Oct October

Novembe November

December

Jan

January

February

Mar March April May June

MONTH Series1

II I III

I — blind data, no growth

II — growls & tones ON

unidentified data capture

III — identified data

0.044

0.017

0.018

3.886 5.244

15.843 12.059 9.94


7.24 9.41 6.9 8.39 9.61

2.27 7.57

4.289 9.27

17.43 15.25 16.61

17.49 15.76

19.32 13.11

0 5

10 15

20 25
Automotive Injury Triangle and Safety Development

Host Vehicle Environment Field Data Scholarly Research Technology, invention & development Voluntary initiatives Regulatory initiatives Countermeasure deployment

Protective devices/concepts
To prevent a crash
- Driver feedback
- Driver monitoring
- Driver training
- Vehicle Intelligent Transportation System (ITS) technologies
- Tiered dispatch
- Appropriate policies

In the event of a crash
- Vehicle crashworthiness
- Seat/seat belt systems
- Equipment lock downs
- Padding
- Head protection

Vehicle visibility and conspicuity

Protective Equipment

Integration and Collaboration

Tips for Emergency Vehicle Operations

Transportation Research Board is an excellent resource… we should be using it!!
No need to reinvent the wheel...

USFA Emergency Vehicle Safety Initiative

March 2007 - FHWA

'Safety' approaches being driven by manufacturers' claims and sales rather than by science and data

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..."

The squad bench??


and those rock climbing harnesses??

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

Safety Management
- A Safety Culture
- Protective Policies
- Protective Devices
  - In the event of a crash
  - To prevent a crash
- Continuous Education and Evaluation

Creating a Safety Culture
- within a company must start with upper management's commitment to safety
  - Awareness
  - Training
  - Incentive
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.

Future

- Meaningful Goals
- New policies
- New practices
- New standards
- New vehicles
- New technologies

Conclusion

- EMS transport has serious hazards and safety issues
- Major advances in EMS safety research, infrastructure, and practice over the past 5 years
- Development of substantive EMS safety standards is a necessity and a reality
- Multidisciplinary safety issue that EMS cannot solve internally
- 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, transportation and occupational safety

And...

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

small changes can make a BIG DIFFERENCE

- PREPARE – TEACH – REACH – RESPOND
  - Look at your own safety record
  - Teach safety and hazard awareness
  - Reach out with safety information to all your EMS providers
  - Respond with the best safety practices

An excellent model