A tragic emergency health care intervention outcome

It does happen....

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......

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

In a rural Virginia county, an ambulance transporting an injured child careened off a road and crashed into a tractor-trailer truck Saturday, killing five people and leaving the hospital of children's injuries.

The crash is the worst in the history of the United States, and the drivers were not in control of the ambulance.

http://www.objectivesafety.net

Outline

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

New paradigm - Integration of EMS

- 'patient safety'
- 'provider' and 'public safety'

EMS Transport Safety
Unique workplace

- In vehicles
- At roadside and other emergency scenes

The ‘workplace’ IS a vehicle

- EMT’s often in vulnerable positions during transport.
  - Bench seat
  - Captain’s chair
  - Standing or kneeling

The ‘workplace’ is also a crash scene

“Ripoff and Duplicate”

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

Knowledge transfer

Active Projects (all due 2007)

- 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

The truck and bus industry is on the right track.... Where is EMS??

Major crash investigation

NTSB has expertise to do this comprehensively

BHP - Key learnings for the organization were:

- Fatalities often have similar underlying causes
- High near miss reporting often correlates with declining injuries or fatalities
- Leadership visibility in the field is vital
- Hazard identification and risk awareness are fundamental to success.

Safety Improvement Roadmap
Its not magic……

Valuable information from the transportation industry

These folks know what we need to know……

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

Ambulance Safety Research: A New Field

Transport Canada, Ministry of Health

 DOT Funding for Reptiles and Road Kill

National Academies- TRB EMS Safety Subcommittee

What’s new

- New expertise and collaborations
- New automotive and transportation safety technologies
- New Information
- New events

July 2007 Report
And what's really not new...

"Ambulance transport has a death toll...."

Carl Craigle EMT-P, Chief Platte Valley Ambulance
Colorado Springs, April 2007

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
- the vehicle
- the driving/skill
- other road users
- the road

An ambulance is not an ED/ICU on wheels

EMS Transport Safety IS Complex
AND Multidisciplinary

- Epidemiological Data Collection
- EMS Safety
- Risk Management
- Public Safety
- EMS Policy
- EMS
- EMS Research
- EMS Practice
- Regulations and Standards
- EMS Safety Program

EMS Transport Safety IS Complex
AND Multidisciplinary

Occupational Health and Safety.....?

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

And keep focus on 'All hazards' in addition to crashworthiness

- Driver age?
- Driving history?
- Patient condition?
- Dispatch?
- Vehicle stability?
- Driver feedback technologies?

News we don't want to see

- Caught On Video: EMT Struck By Car

[Image of an ambulance and text discussing EMS transport safety.]
This looks cool AND SAFE!

Not rocket science...

Occupational transportation fatalities...

A problem

2007 Insurance data –

27 fold more likely to have a claim based on transport than related to medical care

Is it your services tragic year?

~ 50 fatalities a year

15,000 EMS services

Each year one in 300 services experiences a fatality
Key Elements to Safety
- Data Capture
- Vehicle Biomechanics and Crashworthiness
- Ergonomics and Biohazards
- Transportation Environment
- Safety Management – evaluation and analysis

An excellent model

What are the solutions?
- Training?
- Practice Policy?
- Transportation Systems Engineering?
- Automotive Engineering?
- Education of other road users???

New expertise and collaborations
- TRB
- ASSE
- OSHA
- SAE
- UTRC
- Ergonomics
- Industrial Design

New Technical Publications
- Ambex 2006
- IEA 2006
- NAEMSP 2006 & 2007
- ASSE 2006 & 2007
- ESV 2007 x 3
- APHA 2007 (to be November)

New Information
- ESV
- ASSE
- OSHA best practices
- KKK-F Public Comments
- Worker visibility Act
- SAFETEA-LU
  - (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users)
- State Strategic Highway Safety Plans
- State EMS Council Policies

EMS Today... ‘expert panel’ ambulance manufacturer funded and NO automotive safety engineering or other technical expertise

Role of the NTSB

NTSB 1979 Accident Report

Recommendations
- EVOC
- LICENSE RECORDS
The NTSB said this in 1979...

The NTSB: 1979 Recommendations never implemented

- To NHTSA – Class II & III Priority Action
  - Extend Federal Motor Vehicle Safety Standards (220, 221, 301) to include ambulances and other emergency vehicles
  - Extending FMVSS re: padding and restraints
- To GSA – Class II Priority Action
  - Maintainance of handling
  - Loading instructions
  - Body structural integrity
  - Anchorage for all equipment
  - Occupant protection
- To National Committee on Uniform Traffic Laws
  - Modify criteria

A Simple Question....

Engineering

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

Some recent adverse outcomes

This is not acceptable

In the USA*

- ~5,000 crashes a year
- ~One fatality each week
- ~20 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

New automotive and safety technologies

- crashworthiness
- EVS
- ITS
- Monitoring and feedback enhancements

The NTSB

History and Mission

The National Transportation Safety Board is an independent Federal agency charged to investigate accidents and determine the causes of aircraft, highway, marine, and railroad crashes and safety issues.
Thursday July 5th 2007……

and who’s life was he racing to save?

NASCAR, Car of tomorrow ready to go
USA Today – March 23rd, 2007

What happened??
Why is it that Emergency Medical Services have developed outside the umbrella of transportation safety infrastructure??

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 rate estimates are – 7.66 - 41.93 fatalities per 100 million ambulance-miles

What type of passenger carrier do you need ?

An AMBULANCE!!!
What about FMCSA’s Mission

- Office of Research and Analysis is committed to reducing the large truck-related fatality rate from 2.8 per 100 million truck-miles in 1996 to 1.65 by 2008.

Mission

The mission of FMCSA’s Office of Research and Analysis is to reduce the number and severity of commercial motor vehicle (CMV) crashes and enhance the efficiency of CMV operations by:

- Conducting systematic studies directed toward fuller scientific discovery, knowledge, or understanding
- Adopting, testing, and deploying innovative driver, carrier, vehicle, and roadside best practices and technologies
- By expanding the knowledge and portfolio of deployable technology, the research and technology program will help FMCSA achieve [goal].

Transport related aspects of EMS

- dispatch of EMS vehicles
- transport policies and protocols
- vehicle fleets and vehicle design
- vehicle purchase standards
- Intelligent Transportation Systems technology
- driver training
- training simulation
- driver performance monitoring
- roadside and road design
- integrated traffic, safety technologies
- scene safety and visibility
- safety data capture
- safety oversight

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>Perceived time</th>
<th>Reaction time</th>
<th>Vehicle braking time (dry)</th>
<th>Stopped at</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>40 mph</td>
<td></td>
<td></td>
<td>176 feet</td>
</tr>
<tr>
<td>Wet</td>
<td>44 feet</td>
<td></td>
<td></td>
<td>220 feet</td>
</tr>
</tbody>
</table>

* Stopping distance: Perception time + Reaction time + Vehicle braking time (varies with age, skill, agility, alertness + vehicle type, tire pressure, road etc)

A peer reviewed tragedy

- Persistent disconnect between automotive safety science and EMS transport safety approach
- Pre-hospital and Emergency Care 2004
  - "EMS vehicle drivers are advised to approach the intersection, slowing to ensure that traffic has stopped and making eye contact with other drivers before entering the intersection."

In the modern era of road safety to suggest that a strategy of “eye contact” to be made at an intersection with a driver traveling at ~ 40mph in the hope that this would result in a safety intervention, is at best frightening

Ambulance Driver Safety - Australia

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Pre-hospital and Emergency Care 2004

"EMS vehicle drivers are advised to approach the intersection, slowing to ensure that traffic has stopped and making eye contact with other drivers before entering the intersection."

In the modern era of road safety to suggest that a strategy of “eye contact” to be made at an intersection with a driver traveling at ~ 40mph in the hope that this would result in a safety intervention, is at best frightening.
Fleet Driver Training.

Dynamics of Fleet Safety - NSC

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
  - litigation/attorney/lawsuit
  - medicolegality costs of injured EMTs
  - hiring of new employees to replace injured personnel
  - retraining and psychological counseling of personnel involved and others
  - increased insurance rates

June 2007

A few weeks ago....

Key Issues

- Mythology
  - That Emergency Medical Service personnel are safe
- Injury Hazards
  - Biohazard
  - 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
   - 1 + 2 + 3 = resultant inability to design and evaluate efficacy of injury interventions
4. What oversight is there?
5. Which organizations would determine policy?

Balance of concerns and risk during transport

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

Firstly!

An accident?

- or
- a predictable and preventable event
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

USA Ambulances: FMVSS Exempt

- Ambulances must comply with some of the most stringent safety and performance standards applicable to vehicles in the United States, all motor vehicles generally on public roads and highways must conform to Federal Motor Vehicle Safety Standards (FMVSS) contained in the Act of the Code of Federal Regulations (49 CFR). Ambulances, although considered commercial vehicles, are categorized with public safety vehicles in these regulations. This includes certain vehicles provided by governmental agencies, such as those used by law enforcement agencies. The design, engineering, and production of such vehicles, whether for government purchase or not, are governed by these regulations.
- There is no definition to manikin mass
- No restraint for equipment
- Voluntary

USA ambulance purchase specifications


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

KKK – static ‘safety testing’

- Ignorant of automotive safety principles – and specifies -
  - 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.

Unacceptable, and ridiculous current 2007 USA ambulance ‘safety testing’ practices!!!

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

- Voluntary
No ‘a’... then NO ‘F’ !!!!!!

- **F = ma**
  
  where
  
  - **F** – force
  - **m** – mass
  - **a** – acceleration

**Bottom line**

- The AMD should consider revising the standard comprehensively to reflect current accepted automotive safety practice, given the current vehicle crashworthiness and occupant protection knowledge and published literature.

30 years later and still the same problem

- 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.

A closer look

- ‘Safety’ approaches being driven by manufacturers claims and sales rather than by science and data

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..."
The first and only published scientific text on ambulance crashes (1995) … and by an optometrist

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

Science not, next best guess

With many aspects in addition to crashworthiness
- Human factors and ITS
- Crash avoidance technologies
- Predictors of crash risk
- Policy

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

What does crash testing mean?
- Vehicle to vehicle crash test
- Vehicle to wall crash test – (barrier)
- Sled test – need to configure the ‘pulse’
- Crash test modeling -
- Crash test dummies
  - Frontal
  - Side facing
  - Adult / child

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

Intrusion

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

Full Vehicle Crash Tests
Test 1 – Right side impact
Test 2 – Frontal

Systems safety failure AND dangerous

Design Principles for Injury Mitigation upon Impact
i. Reduce the exchange of energy
ii. Provide energy absorption (maximize the stopping distance)
iii. Ensure compatible interfaces
iv. Manage the exchange of energy
v. Provide a survival space

And in the absence of standards....

NOT new technical data...

At even slow speeds 4-point harnesses have been demonstrated to be lethal

NASCAR inspired ????.... How ridiculous
In both the military and the automotive industry being ambulant in a moving ground vehicle or crash, in any device, is a dangerous practice and is not supported.

Use of current ‘seated’ crash dummies to demonstrate that such ambulatory devices may be safe is a fallacy, and misleading.

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.

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.

concept vehicles I & II ??

Most recent - Attention to vehicle visibility... but failures of occupant protection and systems engineering.

The squad bench...? This does worse than double the vehicle risk!!!

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

- We NEED meaningful injury data to better understand the mechanism of injury and fatality
- A crash test program without 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

Occupant protection......??
July 2007

Bigger is not necessarily better......

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?
Intelligent Transport Safety Systems

Back up Camera... Shouldn't all vehicles have one of these?

NAEMT July 2006 Position statement

Policy makes a difference...

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

Z15 Incident Rates

- Incident rate based on number of vehicles operated: Incident rate = Number of incidents / Number of vehicles
- Incident rate based on vehicle mileage: Incident rate = Number of incidents / Vehicle mileage
- Injury incident rate based on vehicle mileage: Injury incident rates are useful for tracking events that have the potential to affect financial or operational performance of the operating unit.
  - Injury incident rate = Number of incidents with injury / Vehicle mileage
- Incident rates based on service activity:
  - Motor vehicle operations that pose injury risks other than those associated with driving should also use the service activity as the basis of a safety performance rate. The number of deliveries, stops, or loads should be considered as appropriate indicators of performance.
  - 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 worked

Legal Perspectives on Z.15

EMS Specific Z.15....

http://www.objectivesafety.net/TransActions%20Z15.pdf
Safety leadership... from the IAFC and USFA

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

Automotive Injury Triangle and Safety Development

Protective devices/concepts
- To prevent a crash
  - Driver feedback
  - Driver monitoring
  - Driver training
  - Vehicle Intelligent Transportation System (ITS) technologies
  - Countermeasure deployment
- In the event of a crash
  - Vehicle crashworthiness
  - Seatbelt systems
  - Equipment lock downs
  - Padding
  - Head protection

The “Black Box”
Driver behavior monitoring and feedback device

The “Black Box” - A transportation safety monitoring and feedback device
This technology is conceptually like a vehicle safety “pulse oximeter” - that with auditory feedback, can save your life, your coworkers life, your patients life, and others on the road

Purpose of ‘Black box’ Program
- Enhance Safety
- Improve Driver Performance
- Save Maintenance Dollars
- Aid Accident / Incident Investigation
**Demonstrated Effectiveness**

1. Blind data, no growls
2. Growls & tones ON, unidentified data capture
3. Identified data

**A key to safe ambulance transport**

**Other monitoring devices**
- Primarily to record events during and immediately preceding a crash
- Give no driver crash prevention feedback
- Administratively burdensome
- Intrusive
- Not demonstrated to be as effective in improving vehicle maintenance costs or as effective in modifying driver behavior long term

**The jury is out on**
- Opticon
- Simulators

**The difference having data makes?**

**International approaches**
- The state of the art non-USA vehicles have NO squad bench nor the after market structural vehicle modifications that can potentially decrease crashworthiness integrity that were seen in study vehicles.

**Major events for innovation sharing**
- But regional and often language isolation
High speed crash, rolled and the occupants (patient and medics) had only minor scratches.

Vehicle Occupant Safety design

2007 European design. Safety technology is a key focus.

Ergonomic design

Secure equipment

Secure occupants

Don't drive through red lights

Use properly implemented “Black Boxes”

Monitor crash events with common denominators (i.e. per 100,000 miles and per trip)

Have a written and implemented ‘safety program’

Securing equipment

Ergonomic layout and equipment

Basically...

The failure to address the design of these vehicles based on accepted published and peer reviewed automotive safety literature, and in isolation of the extensive global expertise in automotive safety, human factors and ergonomics, remains a serious concern for this aspect of the EMS system.

Were we safer in the Cadillac???
There is need for vehicle safety researchers, ambulance industry and vehicle designers to recognize and apply these existing principles to reduce current system failures in an important and essential service that has a poor safety record well below that of passenger vehicles and other commercial vehicles.

What do we know works...
- Policy
- Lap seat belts
- Over the shoulder harnesses
- Securing equipment
- Forward and rear facing seating
- Some electronic technical devices
- Safety awareness
- Cultural change

Small changes can make a big difference
- Injury data
- Coordinated initiatives to promote safety (with strings attached)
- Input from science and technical data
- Knowledge transfer

Be ready for...
- New Infrastructure
- New information
- New collaborations
- New events
- Innovation in safety technologies, strategies and policy
- Knowledge transfer
- Unacceptable mythology
- Challenges to advancing EMS transport safety

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