EMS Transport Safety – Trends and New Technologies?

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‘Kelen’ Doctrine
- Less is more
- If you want to do important work, work on something important
- Finish one thing before you move onto the next

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

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

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?

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

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......
A tragic emergency health care intervention outcome

It does happen....

EMS Transport Safety IS Complex AND Multidisciplinary

Epidemiological Data Collection
Risk Management
Public Safety
EMS Safety
EMS Policy
PPE
Driver Safety
EMS Safety

Ergonomic Research
Biomechanical Research
Vehicle/Chassis Research
Communications Technology
EMS Policies
Regulations and Standards
Fleet Safety Program

EMS Safety

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

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

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

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

Transport related aspects of EMS
- dispatch of EMS vehicles
- transport policies and protocols
- vehicle fleets and vehicle design
- vehicle and fleet standards
- Intelligent Transportation Systems technology
- driver selection/training
- shift length and wellness
- driver performance monitoring and feedback
- roadside and road design
- integrated traffic safety technologies
- scene safety and visibility
- safety data capture
- safety oversight

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, Freighliners, motorcycles)
- Transports - ~50 million
  (to Emergency Depts ~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

The National Transportation Safety Board (NTSB)

A Simple Question....
1960 to 2007
- A passenger vehicle - sure
- A 'laundry or mail truck' - ?
- A passenger vehicle – yes!
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

Key Issues
- Mythology - that Emergency Medical Service personnel are safe
- Injury Hazards
  - Radiation
  - Chemical/Radiation
  - Physical/Mechanical issues – 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
  - Occupancy Health and Safety
    - we work in a vehicle – research data are scant
  - EMS regulatory gap – a vehicle in the workplace – “except” from automotive research regulations

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. 1+2+3 = 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

Ambulance design & transport safety initiatives
- 1960’s National Academies of Medicine - the Cadillac to the chassis and box truck, not for application conversion or actual EMS (then very few EMS ambulances)
- 1979 - NTSB report on ambulance crashes – reality or myth?
- 1980 – First published text on Ambulance Collisions - reality or myth?
- 1983 – National Ambulances Transport Safety Institute (NATSI) – reality or myth?
- 1987 – Swedish Barrier Crash Tests – reality or myth?
- 1987 – JAMA paper - Paul Auerbach – reality or myth?
- 1995 – First published text on Ambulance collisions - reality or myth?
- 1995 – First ambulance rear compartment sled tests with instrumented dummies – reality or myth?
- 1998 – EMSC Pediatric Ambulance Transport Safety Grant – reality or myth?
- 1999 – ASA and CEN ambulance safety standards in Australia and Europe – reality or myth?
- 2000 – First peer reviewed engineering publication on ambulance crashworthiness – reality or myth?
- 2000 – First full vehicle ambulance crash tests – reality or myth?
- 2001 – First SAE Emergency Vehicle Safety Symposium – reality or myth?
- 2003 – Mobile Medical Transport Safety Task Force (MMTS) established – reality or myth?
- 2004 – NIOSH program – reality or myth?
- 2005 – First ambulance ergonomics paper – reality or myth?
- 2006 – First NAEMSP ambulance safety keynote – reality or myth?
- 2006 – First EMS Chiefs of Canada ambulance safety Keynote – reality or myth?
- 2006 – AMBEX - research most likely to change practice – reality or myth?
- 2007 – Inaugural TRB Ambulance Transport Safety Seminar – reality or myth?
- 2007 – First NHTSA Ambulance Safety Seminar – to be July 2007 – reality or myth?
- 2008 – Second TRB Ambulance Transport Safety Seminar – to be January 2008 – reality or myth?
- 2008 – First Ground EMS Transport Safety Summit – to be March 2008 – reality or myth?

Recommendations
- EVOC
- LICENSE RECORDS

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

The first and only technical symposium 2001

NTSB 1979 Accident Report

The NTSB 1979 Accident Report:
- Highway Account Number
- Highway Accident Number
- First published text on ambulance crashes - reality or myth?
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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

The inevitable bottom line...

Safety saves time, lives AND money Canada, Nova Scotia

- Since 2000 working towards a goal of zero loss ratio with insurance provider
- 10 million kilometers per year
- 150 emergency response ambulance units
- Collision claim history measured in dollars per 100,000 kilometers traveled:
  - 2000/2001 $1725.00
  - 2001/2002 $1049.00
  - 2002/2003 $751.00
  - 2003/2004 $416.00
  - 2004/2005 $229.00

Very Scary insurance data

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Workers Compensation Rate increased by 26.5 %
Was $5.86/$100 payroll in 2005-2006
Now it is $7.41 for 2006-2007

EMS CANNOT Afford to keep paying out like this....

"Workplace' Hazards
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

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

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???
An ambulance is not an ED / ICU on wheels

This is not acceptable
In the USA*

- ~ 5,000 crashes a year
- ~ One fatality each week
- ~ 2/3 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

Occupational Health and Safety.....?
- This IS an Automotive Safety issue

Ambulance Safety Research: A New Field

We should use the best safety practices demonstrated in engineering
and in ergonomics

Research papers in the past 30 years

- EMS Safety
  - 40 papers - on ambulance safety
  - 1 paper - on ambulance ergonomics
  - 1 paper - on stretcher ergonomics
- Computer Workstations
  - 30,000 papers – on ergonomics of computer work stations
- Erectile Dysfunction
  - 100,000 papers – on Erectile Dysfunction

Comprehensive data here too...

 EMS personnel fatalities*
- 74% transportation related
- 15% of ground transport fatalities were struck by moving vehicles
- 11% were cardiovascular
- 9% were homicide
- 4% needle sticks, electrocution, drowning and other

and what is killing EMS?

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

So does it make sense?

- DOT Funding for Reptiles and Road Kill

Occupational transportation fatalities..

Predictable risks

- Fatal crashes more often at intersections, & with another vehicle (p < 0.001)
- 70% of fatal crashes EMS crashes during Emergency Use*
- Most severe & fatal injuries occurred in rear (OR 2.7 vs front) & to improperly restrained occupants (OR 2.5 vs restrained)**
- 82% of fatally injured EMS rear occupants unrestrained**
- > 74% of EMT occupational fatalities are MVC related***
- Serious head injury in >65% of fatal occupant injuries#
- More likely to crash at an intersection with traffic, ign (37% vs 18% p<0.001) & more people & injuries/crash than similar sized vehicles

And very Predictable...

- Intersections are lethal environments

** Becker, Zaloshnja, Levick, Li, Miller. Acc Anal Prev 2003
# NIOSH, 2003
## Ray AM, Kupas DF, Prehosp Emerg Care 2005 Dec; 9:412-415
### Kahn CA, Pirrallo RG, Kuhn EM, Prehosp Emerg Care 2001 Jul-Sep;5(3):261-9
#### Be

* WE HAVE A BIG PROBLEM HERE
The real world
Intersection passenger car stopping distance* at 40 mph dry and wet

Perception + Reaction time + Vehicle Braking time
stopped at

- 44 feet wet
- 176 feet dry

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

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
- 2G 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.


- 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:
- 151 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

- Ambulances must comply with some of the recent safety and performance standards applicable to vehicles or the blind, elderly, and non-ambulatory persons. Each vehicle must also comply with federal, state, and local requirements for ambulances. Additional Federal, state, and local requirements must be met for vehicles used for public transportation.

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First Joint Commission International Accreditation Standards for Medical Transport Organizations – Jan 2003

New accreditation program for medical transport organizations, including:
- Emergency medical transport
- Non-emergency transport
- Ambulance services
- Land, air, and water medical transport
- Fire brigade emergency services

Commission on Accreditation of Medical Transport Systems - CAMTS Accreditation Standards

2006 Edition

Commission on Accreditation of Ambulance Services - CAAS

ASTM F 1086 - 94


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:
  \[ \text{Incident rate} = \frac{\text{Number of incidents}}{\text{Number of vehicles}} \]

- Incident rate based on vehicle mileage:
  \[ \text{Incident rate} = \frac{\text{Number of incidents} \times 100}{\text{Vehicle mileage}} \]

- Injuries incident rate on vehicle mileage:
  \[ \text{Injury incident rate} = \frac{\text{Number of incidents with injury} \times 1,000,000}{\text{Vehicle mileage}} \]

- Incidents per 10,000 transports:
  \[ \text{Incidents per 10,000 transports} = \frac{\text{Number of incidents}}{10,000} \]

- Vehicle injury rates based on work hours:
  \[ \text{Vehicle incidents per 200,000 hours} = \frac{\text{Number of incidents}}{200,000} \]

Legal Perspectives on Z.15

- \( Z.15 \) standards: A tool for Preventing Medical Vehicle injuries and Improving Patient Care

- By Mark L. Reiter, PhD, CAAS

What a novel idea…
EMS Transport Safety

- ‘patient safety’
- AND also
- ‘provider’ and ‘public safety’

Section 21 Paramedic Health and Safety Control


NAEMT July 2006 Position Statement

What’s new

- New automotive safety technologies
  - crashworthiness
  - EVS
  - ITS
  - Monitoring and feedback enhancements
- New expertise
  - TRB
  - ASSE
  - 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

Vehicle Crashworthiness testing

Europe - USA in best CEN
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

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
- Tiered dispatch
- Appropriate policies

In the event of a crash
- Vehicle crashworthiness
- External aid systems
- Equipment lock downs
- Padding
- Head protection
Intelligent Transport Safety Systems

Back up Camera… Shouldn’t all vehicles have one of these?

Vehicle visibility and conspicuity

Prevent IP, 2005

Intelligent Transport Safety Systems


EMS RESPONDER CRASH PREVENTION

- Undertake a systematic review of other state actions and protocols for prevention of EMS responder crashes
- Increase education and involvement of EMS providers in principles of emergency vehicle safe driving
- Develop and implement emergency vehicle traffic safety protocols at state, regional and service level
- Identify factors and protocols to identify those that may contribute to injuries resulting from the impact of emergency vehicles
- Develop methods for providing incentives for adoption by EMS providers of protocols that enhance traffic safety
- Establish partnerships with NHTSA and education companies to improve driver awareness of driver responsibility and appropriate response to approaching emergency vehicles

Tips for Emergency Vehicle Operations

Transportation Research Board is an excellent resource… we should be using it!!
USFA Emergency Vehicle Safety Initiative

March 2007 - FHWA

This IS a transportation safety issue
- Systems engineering
  - Where do ambulance crashes occur?
  - What transportation safety engineering interventions
  - ITS
  - Does opticom work effectively in this environment given the traffic density and emergency vehicle density?
  - Merit of emergency vehicles being fitted with early warning technologies
  - Proper design of emergency vehicle traffic flow
  - Fleet mix to match anticipated transport environmental challenges (ie police models – bicycle, motorcycles, horse, three wheeled, cruiser, van, truck)?

The squad bench??

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 sidefacing 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…”

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

http://www.EveryoneGoesHome.com

An excellent model
**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