Ambulance Transport Safety
An automotive occupant protection and system transportation safety issue
Phoenix, Arizona, January 5-6, 2009
Nadine Levick MD, MPH

Emergency Medical Services (EMS)
An important and unique transport system
- Public safety, public health and emergency service
- Is there to save lives

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

Now, who have we here??
- Do you transport patients?
- Are you responsible for vehicle purchases?
- Do you manage the oversight of your vehicle performance and safety?
- Do you design, 'spec out' your vehicles?
- Do you have automotive safety and crashworthiness, occupant protection and fleet safety scientific and technical data background and support?
- Do you rely on health care colleagues and aftermarket retrofitters for technical vehicle and fleet performance safety advice?

Disclosure
- I am an Emergency Physician
- I am NOT an engineer
- Am apparently now speaking as a designated "engineering expert", at an "ambulance safety seminar" in a "vehicle section"

Asked to speak on
- EMS crash reporting and data systems
- Crash testing of EMS vehicles
- Restraints
- Standards
- Future research directions
- All in 30 minutes

Your Interactive Handout awaits you online at...
- www.objectivesafety.net

This WILL be FAST!!
No need to take any notes – all today's text slides will be awaiting you gratis and online – as is an electronic record of the TRB EMS Summit events

Here.... No need to write it down – it is on the card handed out

A serious problem...
In the USA there are more safety standards for moving cattle than for moving patients

October 22, 2009
Provider and Patient Killed

April 30, 2009 - Tennessee

Negative impact on system performance...
• 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 those involved AND wipe out a rural EMS system AND negatively impact a regions response capacity......

How are we counting these events?
WhatWhere are the relevant data bases?
– FARS
– NASS/CDS
– GES
– State Traffic Records
– FMCSA
– BLS
– NEMSIS
– Other

FARS – A National Data Set?
Small numbers – but NO data captured from 20% of the nation in 10 years

and what is an EMS crash?
• Definition of an EMS crash
• Definition of Emergency Response Mode
USA EMS transport safety
data estimates

- ~50,000 vehicles
- ~9,000 crashes a year
- One fatality each week
- ~23 pedestrians or occupants of other car
- ~10 serious injuries each day
- Cost estimates > $500 million annually

Ambulance transport a serious
USA transport safety problem...

- the most lethal vehicle on the road both per mile travelled and per vehicle
- is exempt from federal commercial fleet safety oversight (FMCSA)
- 2/3 fatalities not in the ambulance
- Exempt from most FMVSS standards

Balance of concerns and
risk during transport

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

Haddon/Baker/Runyan Phase-Factor Matrix
as applied to EMS Safety

Data...

- What is your transport safety record in your service?
- How can you improve if you don’t have a meaningful measure of safety performance?
- Transport safety is not guesswork, it is a science

The laws of physics prevail...

- and they don’t care what your job title is or if you are a patient, a provider or a member of the public

Science behind Policy

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

The Future??

- Seems that we are actually stuck in the past and are ignoring the present....

Safety is a tool to save

- Lives
- Time
- Money
- must be evidenced based
Firstly, the DANGER...

- The state of EMS transport safety research is an EMBARRASSMENT
- Lags at least 30 years behind general automotive and transportation safety research
- EMS Safety research is NOT EVEN ON THE PLAYING FIELD of state of the art automotive safety research
- ‘Reinventing the wheel’ – should be avoided at all costs

Then, The OPPORTUNITY

- This is vehicles, and this is transportation safety
- Vehicle and transportation safety technology and research infrastructure exists
- Ditto drivers, and driver/fleet safety technology
- Collaboration, and the multidisciplinary model is key
- Optimal use of very scarce resource

A challenge we know now...

- …is that there is a major problem with the present approach and what is being done currently
- and many practices are in conflict with, or not supported by, existing technical engineering science

What is known

- Ambulance transport is part of a system of integrated elements, as is an ambulance vehicle a microcosm safety system of interrelated occupant and safety issues
- The laws of physics prevail -

Ground Ambulance Transport Safety IS Complex AND Multidisciplinary
The independent technically expert occupant protection and automotive safety engineers say about our current ambulances and ‘safety’ approaches:

- “The rear compartment Death Vault”
- “The Kitchen Design must go”
- “The Kill, Kill, Kill (KKK) spec”
- “The organ donor harness system”

Independent Technical Expertise

- The “kitchen design” is completely unacceptable and a failure in health care delivery, occupant protection and ergonomics.
- Independent technical expertise must be here and involved.

The realm of burden and benefit

- measuring the safety of the system
- determining the economic, ethical and risk benefit challenges
- Transport System Management
  - fleet safety and oversight technologies and policies
  - operations management – dispatch, congestion routing, deployment of resources, benchmarking
- Vehicle safety
  - occupant protection design and testing
  - vehicle performance safety
  - vehicle and personnel human factors issues
- Dissemination and Policy
  - Knowledge transfer
  - Standards, specifications and policy

Transport System Management

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What could you learn from the National Academies – right NOW and gratis

- The realm of burden and benefit
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Take a look at last year’s three posters – three pages to steer you toward some key issues
- Concept safety vehicles
- Wading thru the MUCC
- Commercial Comparisons

NB. You can download them gratis too from www.objectivesafety.net

How did we justify this $2 million+ debacle taking place outside of technical expertise???

Ambulance design is a vehicle and automotive safety engineering issue and is a technical field of expertise outside of EMS practice.

Based on peer reviewed and established automotive safety principles and data there are major deficiencies in the safety of the design of these ambulances.

Would the NIH tolerate research funds being spent like this in any other area of health care ‘research’ and in conflict with valid science???

An ~$2 million + expenditure on alleged ‘safety concept’ vehicle development by EMS providers and aftermarket manufacturers, outside of - and in conflict with - accepted automotive safety technical data and expertise is completely unacceptable and should not be tolerated.

Sadly stated at NAEMSP 2009/08/07/06/05/04/03/02/01/00/99... And yet where are these essential experts today...??

Automotive safety, crashworthiness and transportation safety expertise, technical data and oversight must be centrally integrated into ambulance vehicle safety concepts, assessment and development.

Just what is an ambulance?? and how is a crash defined??

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Definition

Emergency Response mode

Data pitfalls and failures

- Current data capture system for traffic records data collection creates unidirectional bias towards identifying ambulance vehicles, resulting in inaccurate and underreporting of ambulance crash events.
- Designation of 'emergency response' is almost arbitrary.
- It is the responsibility of the leadership in the EMS community to ensure that there is proper EMS input to the ongoing development of these transport data bases.

Ambulance transport is hazardous when compared to other commercial vehicles

- both per ambulance vehicle and per estimated ambulance mile travelled
- FMCSA provides extensive detail, denominator data and oversight of commercial carrier safety data and performance for which EMS is exempt.
- Thus monitoring the safety of any interventions in EMS transport is severely hampered

Technical information available

- EMS Safety and Performance Standards
  - Australia & New Zealand 4536
  - Common European Community (CEN) EN1789
- Non EMS Specific USA Standards
  - Aviation - FAA/CAUAA
  - [Fleet vehicles - ASSE/ANSI Z15 ]
  - USA Other
  - Purchase Specification: KKK
- “Standards” - NTEA – AMD, ASTM F 26
  - Guidelines: EMSC Dos and Don'ts, and (ASTNA, CAAS and CAMTS)

Ambulance Vehicle Standards??

- KKK?
- AMD?
- FMVSS?
- NFPA?
- SAE…?
- International
  - ASA
  - CEN

Global EMS Vehicle Safety Standards v Specifications and Guidelines

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30 years later and still the same problem

What KKK-A-1822F, AMD and FMVSS state and don’t state...
USA Ambulances: FMVSS Exempt

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

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

USA KKK ambulance purchase specifications

Occupant protection......??

July 2007

KKK/AMD – 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.

KKK Specification and AMD Standards both default to the FMVSS for safety – however:
- 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

Ridiculous current 2009 USA ambulance ‘safety testing’ !?!? – IS NOT consistent with accepted automotive safety practice...

No ‘a’... then NO ‘F’ !!!!!
- F = ma

where F – force
m – mass
a – acceleration

Yes a “nationally recognized testing lab” – BUT - NOT an automotive/occupant safety crash test lab!!
FMVSS exempt……

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

- "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.

CEN testing - 2007

Standards Development Update
- NFPA – Meetings June and December 2009
- SAE – x2 standards underdevelopment
  - General vehicle crashworthiness and occupant safety standard
  - Specific equipment and occupant restraint standard
- ISO - ISO/AWI 39001 - Road-traffic Safety management systems
  - Recent update meeting in Canada

The Future…??
- Lets just look at 10 years ago …
- And even information presented previously here

1995- Deceleration Sled test (upon impact) 24 G, 30mph

What is actually happening during an actual ambulance crash

2000 Full Vehicle Crash Testing
- Pre-impact CTD positioning

And this all takes place in 60 milliseconds – the blink of an eye.

Impact residue

CTD dynamics

During impact

AMD 2007 - 025 ‘static occupant safety testing’

- Compared with -

Accepted automotive safety dynamic occupant testing

USA 2004, NIOSH Head strike zone hazards

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 over both shoulders for side-facing occupants are potentially lethal – and in NO WAY SUPPORTED BY ANY DATA OR INDEPENDENT AUTOMOTIVE SAFETY EXPERTISE

2004 NIOSH Canadian Testing

SAE J833 or SAE J1522 ??

- Are these meaningful terms to you?
- The pitfalls of health care providers and non-automotive folks trying to glean info from technical journals

Misleading use of ergonomic design dimensions to suggest occupant crash survivability envelopes

- Inappropriate standards are being used in this instance to assess the crashworthiness of the crash tested ambulance.
- Neither SAE J833 nor J1522 are occupant protection or crashworthiness standards. These standards are essentially ergonomics standards.
- SAE J833 is an ergonomics standard involving human physical dimensions to be used in vehicles such as construction, trucks and agricultural tractors, and forestry and specialized mining machinery categories.
- SAE J1522 is the recommended practice for describing the two-dimensional 95th percentile truck driver side view, and anthropometric contours for randomly selected human populations.
- To assess risk to occupants of vehicles, it is essential that crash test dummies and generally accepted injury criteria such as those provided by Eppinger et al [36] are used.
- Any crashworthiness assessment must be injury performance based.”
‘Safety’ approaches being driven by manufacturers marketing claims and sales rather than by science and data.

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

NO automotive safety crashworthiness and occupant protection engineer
NO ergonomist
NO reference to ANY existing or relevant automotive safety or crashworthiness technical publications... yet multiple occupant fatalities and injuries annually....

Systems safety failure AND dangerous
Overwhelming existing evidence these practices are HIGHLY dangerous
NO evidence whatsoever that these practices are NOT dangerous, let alone safe

PPE from the stationary environment can be highly hazardous in the automotive setting

NOT new technical data...

Yet another potentially lethal example marketed as a ‘safety innovation’ YET outside of automotive safety practice

Airbags in the back....??
Absent safety testing standards, any meaningful crash or injury mechanism data or effective occupant positioning – rear compartment airbags are likely to be hazardous.
We should be embarrassed…

- Mast pants – a design that was largely a mistake – that we were able to see didn’t work as we were measuring outcomes –
- We are not measuring outcomes with ambulance design – we don’t even have a denominator let alone a numerator.
- How many ambulances are there really, what is the distribution of the type of vehicle, how many patients are transported annually in which vehicles – by whom -where?

Garbage in Garbage Out

- Without the involvement of the appropriate technical experts in the field we are at risk of far more egregious hazards than mast pants
- Why is it that we won’t listen to the experts on this one – it would save lives, time and money

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 by the automotive safety industry

Technical Collaboration is key

- We are NOT the experts in this science
- We cannot afford to play the silo game here, it is costing lives, time and money
- We MUST have a meaningful evidenced based approach to operations and policy
- We must be outcomes driven
- We MUST cease to be a fiefdom in a discipline we have no technical background or expertise in

Vehicle Safety Design 101

- What makes a vehicle design safe, with both active and passive safety approaches?
- Basically three things
  - Vehicle handling and stability control
  - Crashworthiness - Occupant protection design
  - Vehicle visibility and conspicuity

Crashworthiness

- Crashworthiness – a technical automotive science driven by laws of physics and real world crash mechanics and injury biomechanics – NCAP
- Absent real world crash injury and fatality data it is not possible to develop meaningful safety interventions.
- Standards exist for automotive passenger vehicles, but ambulances are exempt (AMD propaganda)

Crash Dummies aren’t smart

- Crash dummies are not smart – absent meaningful standards there is risk of garbage in and garbage out
- There are side impact dummies for side impact crashes, tests for intrusion
- No dummies to meaningfully model standing up in a moving vehicle –

So…

- Crash dummies are not smart – absent meaningful standards there is risk of garbage in and garbage out
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Automotive engineers addressing EMS Safety Foundation Workshop
VEHICLE DESIGN and SAFETY

Extensive Passenger Car and Light Truck Vehicle Safety Standards apply to vehicles below 10,000 Gross Vehicle Weight (GVW)

VEHICLES over 10,000 GVW have a reduced set of Federal Safety Standards

VEHICLE SELECTION IS CRITICAL

ACTIVE Vehicle SAFETY

PASSIVE Vehicle SAFETY

PASSIVE SAFETY: Crashworthiness
- Vehicle Structural Design
  - Front and Rear Compartment Design
  - Seating and Restraint Systems
  - Occupant Containment
  - Impact Friendly Surfaces

Passive Safety-Seat Structure

Structural Enhancement

Fold-in ridges on subframe

Passive Safety- Vehicle design

A main feature in a front-end crash is the "disconnectable" front axle, which releases additional deformation zones in the longitudinal frame member when a particular force level is reached.

EMS Ergonomics 2005, 2006

December 2007 Prof Issachar Gilad
Vehicle type/selection also has bearing on hazards to loading and unloading

- Lowering the loading height to 27 inches or below, can result in a major reduction to injury causing forces during loading and unloading.

Emergency Vehicles – Viewer Awareness

For a timely, appropriate and safe response

- Location
- Size
- Shape
- Speed
- Intended path

Policy and practice ignorant of existing technical safety data

- Having access to that technical knowledge supports changes to improve safety practice
Muskoka EMS - Canada

Old design

New design

Old design

New design

But whatever color …. If you run a red light someone will be killed

Invehicle technologies to enhance vehicle safety

• Aftermarket in vehicle electronic e-safety devices with monitoring and feedback

Transportation safety invehicle e-monitoring and feedback device
MEMS March 2003 – July 2006

Goals

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

Collaboration and Outcomes

• Interdisciplinary Collaboration is what is key – not orthopedic folks talking to cardiologists – BUT collaboration between the health care folks appropriate automotive and occupant protection engineers and transportation system design and industry standards that make sense – and
• Meaningful measures of outcome and performance

The EMS Safety Foundation: A practical and functional model

Interdisciplinary and Operational
• Innovation
• Collaboration
• Knowledge transfer
Awkward tasks? Develop solutions! Collaboratively with appropriate technical experts.

Texas’ Careflite’s new vehicles.
Manitoba’s new fleet

Why...?
- We don’t ask engineers to write cardiac arrest protocols...
- ...then why are we specking out and designing the layout of vehicles – ??
  occupant protection environments – it is happening on a daily basis.

Which of these two vehicles would you want?
Sprinter v Ford Transit crash test
http://www.youtube.com/watch?v=C3kN6WF5vAA&feature=related

this vehicle is safety crash tested by automotive experts

Unlike this vehicle

Is this acceptable...?
- There are ambulances rolling out of the show room on a daily basis – as we speak – being designed by health care providers and built by after market retrofitters, who are not at all governed as are other passenger vehicle manufacturers by existing occupant protection standards

So what do we need to do ??
- Reach out to the appropriate experts – they sure do want to help us
- STOP being philistines and be the scientists we are trained to be and at least seek a scientific approach
- Get your heads out of the sand – there is plenty of valid technical information – FMCSA, TRB, SAE
- Make policy and purchase decisions on technically sound data, not a marketing brochure
- HAVE MEANINGFUL AND TRANSLATABLE OUTCOME MEASURES FOR YOUR SERVICES SAFETY PERFORMANCE
What is the EMS Transport Safety Research Agenda?

- Shouldn’t it be driven by data, and appropriate technical expertise

And what is the EMS Transport Safety Research budget??

- What has been spent by whom, on what and how, and with what oversight??

What now?

- We need to stop and take a serious look at what we are doing
- Reach out to the automotive and transportation technical experts for interdisciplinary collaboration
- Mainstream sessions on transport safety at NAEMSP??
- To wrap up – here is the exact closing slide from 2006 – It is still the future, as we are still trapped in the past and ignoring the present

Future Directions

- Rational use of limited resource
- Avoid reinventing the wheel
- Formal safety research agenda
- Framework bridging key research and infrastructure
  - Society of Automotive Engineers
  - Involvement with ESV activities
  - EMS safety research funding
  - Foster evidence based initiatives

GOALS...

- To cut mortality by half ?....
- How?
- Interdisciplinary Collaboration
- Use the RBHPSA
  (Runge Big Hairy Problem Strategic Approach)

Thank you!

Any Questions??

Electronic handout available online
http://www.objectivesafety.net

National Academies TRB Ambulance Transport Safety Summit
October 29, 2009 -

http://www.objectivesafety.net/TRBSummit2009.htm