School of Public Health and Community Medicine

The CBRNE Prehospital Major Incident Environment - Recent Advances and Persistent Gaps Impacting Casualty Treatment, Medical Operations, and Decontamination Operations

Associate Professor David Heslop

School of Public Health and Community Medicine
University of New South Wales

d.heslop@unsw.edu.au
Scope

• Introduction
• Prehospital CBRNE environments
• Prehospital CBRNE medical approaches
• Casualty treatment
• Medical operations
• Decontamination operations
• Conclusion
Introduction

CBRNE medicine is not simply toxicology in the field – unique features and considerations

Siloed within specialist organisations

Traditional focus of CBRNE Defence in reducing human impacts has been:

- Detect, warn and avoid
- Medical treatment and countermeasures
- PPE/Protection

Gradually increasing likelihood of population exposures to CBRNE agents

All-hazards approaches hold sway
CBRNE Environment - Chemical Threats

Nerve agents
- E.g. Tabun, Sarin, Soman, VX

Pulmonary Oedemagens
- E.g. Chlorine, Ammonia, Phosgene

Cyanides
- E.g. Hydrogen Cyanide, Cyanogen Chloride

Vesicant agents
- E.g. Mustard Agents, Lewisite
CBRNE Environment - Chemical Threats

Toxic Industrial Chemicals and Materials
- Wide range of possible compounds
- Most commonly Pulmonary Oedemagens or Vesicants

Incapacitating Agents
- E.g. Opiates, Anaesthetics, Pharmaceuticals, Irritants

Riot Control Agents
- E.g. Tear Gas, Pepper spray
CBRNE Environment – Biological Threats

Bacterial Agents
• E.g. Anthrax, Plague

Viral Agents
• E.g. Viral Haemorrhagic Fevers (Ebola), Smallpox

Fungal Agents
• T3 Mycotoxin

Toxins
• E.g. Botulinum neurotoxin, Clostridium toxin, Staph Enterotoxin B

Exotic/Novel/Chimeric
• Endocrine modulators, Neuropeptides, Transgenics, Nanoagents
CBRNE Environment – Radiological Agents

The University Seven:
• $^3$H, $^{14}$C, $^{32}$P, $^{60}$Co, $^{125}$I, $^{131}$I, $^{252}$Cf
• Isotope labelling/Research purposes (e.g. biochemistry)

The Industrial Three:
• $^{192}$Ir, $^{137}$Cs, $^{60}$Co
• Industrial scale X-Rays, Food Sterilisation

The Military Four:
• $^3$H, $^{235}$U, $^{239}$Pu, $^{241}$Am
• Nuclear Weapons Development and Manufacture
CBRNE Environment - Explosive Threats

- Improvised explosive devices
- Formed charges
- Certain forms of mines
- Area effects conventional weaponry
- Indirect fires
- Focussed energy devices
Individual vs Systems

CBRNE Medicine usually discussed at an individual casualty level, in isolated context

Factors relating to health system integration poorly considered:

• Resource requirements
• Personnel requirements
• Training requirements
• Multiple casualty situations
• Managing novel or unknown agents
• Decontamination contexts
• Outcome measures
• Test and evaluation
• Ethics and Law
The Prehospital environment

- Austere
- Remote
- Complex
- Exposed
- Variable
Emergency Response Risk Management

- Achieve risk reduction while completing the mission
- Minimising the modifiable risk
- Accepting the unmodifiable risk
- Avoiding exposure altogether if possible
- Appropriately using risk controls
- Minimising harms
Protection Factors

Pre event
- Physical training
- Medical training
- Point of injury countermeasures
- Vaccinations
  - Pathogens
  - Toxins
- Casualty Management System rehearsals
- Emergency treatments in place
- Knowledge updates

Peri/Post Event
- Rapid countermeasures
- Rapid diagnosis
- Rapid decontamination
- Rapid evacuation
- Rapid stabilisation
- Definitive Care
- Identify lessons learnt
- Adjust to improve:
  - Medications
  - Training
  - Doctrine
  - Command decision loop
  - Tactics and Techniques
The CBRN Hostile Threat Environment
- Chemical agents
- CWA
- TIC/TIMs
- Biological agents
- BWA
- Radiological agents
- Any other noxious environmental threat

Intrinsic Measures
- Natural immunity
- Natural physical protective measures
- Physiological mechanisms
- Protective behaviours, both automatic and otherwise

Deliverable Measures
- Pre-event:
  - Information Systems
  - Early Warning
  - Medical Force Protection
  - Training and Drills
  - Clinical Skills Training
  - Command Training
  - Logistics Planning
- Post-event:
  - IPE
  - Countermeasures
  - Casualty Regulation Systems
  - Emergency Treatment
  - Evacuation
  - Risk Analysis and Decision Support

Outcomes
- Effects & Capabilities
  - Emerg Response:
    - Force Projection
    - Sustainability
    - Mission options
    - Predictability
    - Readiness
    - Operational risk reduction
    - Survive and operate
  - Medical:
    - Improved survival
    - Early Return to Duty
    - Decreased health logistic burden
    - Improved long term rehab outcomes

UNACCEPTABLE RISK
SYSTEMATIC RISK REDUCTION
ACCEPTABLE RISK
The Prehospital Environment

Austere (i.e. resources):
- Needs will not match available resources:
  - Personnel
  - Equipment
  - Consumables
  - Transport Assets
  - Environmental conditions
  - Logistic support
  - Bystanders
- Plays for time may be unavailable – leading to forced decision making

Remote (i.e. time):
- Impacts on event occurrence times:
  - Time to self/buddy aid
  - Time to initial evaluation
  - Time to triage
  - Time to retrieval
  - Time to initial decontamination
  - Time to evacuation to higher care
  - Time to key treatment Decision Points
- Impacts on processes involving delay:
  - Duration of initial treatment
  - Duration of retrieval
  - Duration of decontamination
  - Duration of resuscitation/treatment
  - Duration of evacuation
Generic Concept of Prehospital Management

Per patient

- Applicable to a variety of CBRNE incident contexts:
  - HAZMAT
  - TIC/TIM
  - Biological
  - Chemical weapon
  - Other (combined, complex, novel)
  - Unknown exposure

- Applicable in a variety of contexts:
  - Humanitarian Assistance
  - Disaster Relief
  - Combat
  - Civilian
  - Mass gathering
Key Concepts for CBRNE Med Ops

PRE RELEASE/EVENT

**Know your enemy**
- Robust information gathering and analytical capability (surveillance)
- Broad and deep technical training continuum

**Build resilience and resistance**
- Selective vaccination
- Medical countermeasures
- Rigorous standardised survival training

**Install risk controls**
- Avoidance strategies
- Technology
- Better IPE
- Operational and Risk planning

POST-PERI RELEASE/EVENT

**Chain of Survival**
- From Point of Injury to Definitive Care

**Prevent Further Casualties**
- Do the most good for most casualties
- Avoid exposing other personnel
- Protect medical workforce

**Ensure risk controls work**
- Monitoring systems
- Accountability
- Feedback loops
Typical Prehospital CBRNE Medical Approaches

Personal (carried on person):
- Nerve agent antidotes
  - Oxime (various types) im
  - Atropine im
  - Diazepam im
- Cyanide antidote
  - Amyl nitrite
- Trauma pack
- Hasty decontamination options

With accompanying medical support:
- Forward medics and complex retrieval
- Resuscitation
- Critical care stabilisation and transportation
- Wound debridement and decontamination
- Various antidote options
- Monitoring and testing
- Follow on medications
- Evacuation
Key Concepts in Austere Environments

Logistics
- Canisters/Respirator supplies
- Individual Protective Ensemble
- Replacements

Personnel
- Fatigue
- Heat Stress
- Psychological Effects
- Task overload

Medical Resources
- Mass Casualty Environment
- Inadequate resources
- Contaminated equipment

Evacuation
- Implications of contaminated evac
- Decontamination standards
- Deteriorating or unstable casualties

Mortuary Affairs
- Repatriation
- Evidence preservation, Legalities
<table>
<thead>
<tr>
<th>Clinical Task or Event</th>
<th>Response System Prepared &amp; Tailored</th>
<th>Response System Prepared Generic</th>
<th>Response System Unprepared Tailored</th>
<th>Response System Unprepared Generic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Aid</td>
<td>Drilled Very rapid</td>
<td>Rapid</td>
<td>Standard</td>
<td>Minimal</td>
</tr>
<tr>
<td>Buddy Aid</td>
<td>Drilled Very rapid</td>
<td>Rapid</td>
<td>Standard</td>
<td>Minimal</td>
</tr>
<tr>
<td>Removal from further exposure</td>
<td>Standard</td>
<td>Standard</td>
<td>Standard</td>
<td>Delayed</td>
</tr>
<tr>
<td>Initial Medical Care</td>
<td>Targeted</td>
<td>Standard</td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td>Initial Decontamination</td>
<td>Standard</td>
<td>Limited</td>
<td>Standard</td>
<td>Minimal</td>
</tr>
<tr>
<td>Retrieval</td>
<td>Selective Rapid</td>
<td>Standard</td>
<td>Delayed</td>
<td>Very Delayed</td>
</tr>
<tr>
<td>Formal Decontamination</td>
<td>Rehearsed Rapid</td>
<td>Standard</td>
<td>Delayed</td>
<td>Very Delayed</td>
</tr>
<tr>
<td>Handover to further medical care</td>
<td>Rehearsed Rapid</td>
<td>Standard</td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td>System Flexibility to Novel Challenge</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>
Tropical Conditions

- Temperate water immersion is more effective in lowering core temperature than shade, crushed ice ingestion or use of a misting fan during rest periods.
- For protracted incidents requiring strenuous work, a rehabilitation centre with medical support, hydration and cooling inclusive of temperate water immersion is recommended.

Issues:
- Practicality
- Cost
- Mission impacts
- Resource requirement
- Personnel requirement
- Support requirement
- Unintended systems effects
Current Assumptions

- All hazards approaches to CBRNE incidents are sufficient to manage such incidents well
- Point of injury to formal decontamination care systems will function across the range of CBRNE exposures and agents
- The deterioration or death of casualties during prehospital care is manageable within existing frameworks
- Prehospital providers are adequately trained, resourced and prepared to manage the range of prehospital CBRNE casualty deterioration pathways possible
- Variation in CBRNE expertise in clinicians is insignificant, and can be addressed with just in time training
- Generic care prior to arrival of specialised CBRNE assets is sufficient to prevent mass casualties.
- Variation in standards of care from usual business during a CBRNE MCI incident will be minimal
- CBRNE MCI standards of care have been developed, and are widely understood, within jurisdictions at risk of major incident.
- Centralised decision making on major incident operational and medical policies applicable in CBRNE incidents is effective.
- Current clinical approaches to CBRNE casualties provide sufficient differentiation, across the range of casualty severity, to prioritise scarce medical resources in an MCI context
Decontamination Operations

Value:

• Medical necessity
• Reduces spread
• Returns personnel to service
• Returns equipment to service
• Psychological effects
• Scene control
• Investigation efforts
• Saves resources
Decontamination in policy

Population assumptions:
- “normality”
- Nil cultural variation, obedient and adherent
- Fit young adult population (male)
- Minimal medical comorbidities
- Once process started, not interrupted
Decontamination reality - Population

Civilian population norms:

- Multiple comorbid conditions
- High prevalence of mental illness
- Varied education levels
- Varied literacy levels
- Elderly
- Disabled
- Children
- Culturally diverse
- Obesity
- Culturally sensitive situations/issues
- Personality and mental illness

Plus management of:

- Prisoners
- Management of dead bodies
- Personal items
- Perpetrators
- Emergency Services/Key Staff

Decontamination reality - operators

- Preparedness and fitness
- Comorbid conditions
- Exposure/Environment
- Heat injury
- Psychological impact
- Worried well
- Special populations
- Rapid deterioration
- Large numbers of litter casualties
- Rotation of personnel
- Equipment and medical resource resupply
- Passage of essential medical information
Advances and Gaps

Recent Advances:
- Automation processes
- Self contained systems
- EMR
- Novel Antidotes
- Active Cooling
- Physiological Monitoring
- Decon evaluation techs
- Modelling and Simulation to answer operational questions
  - Agent Based/Hybrid
  - Combinations of real world and computational

Persistent Gaps:
- Decon line command and control
- Medical care during decon
- Medical device swap out
- Optimum operator numbers
- Logistics support options
- Waste water management
- Complex injury management
- Handling of in queue casualty decline or collapse
- Handover standards
Conclusions

- Prehospital CBRNE environments are unique
- Technical solutions have been research focus over many years
- Policy is based on assumptions – de-linked from reality of CBRNE environment
- Major gaps:
  - Exploring performance of prehospital CBRNE systems under real world conditions, or closer to real.
  - Developing new test and evaluation paradigms
  - Operations and technical research approaches
- New technologies are providing some solutions e.g. computational modelling
- A return to traditional methods are also required (but come with costs)
WADEM CBRNE Special Interest Group

• Join the WADEM CBRNE SIG
• Specialist CBRNE Medicine stream at the WADEM Biennial conference
• Launch to be confirmed in the coming months…
Associate Professor David Heslop

School of Public Health and Community Medicine
University of New South Wales

d.heslop@unsw.edu.au
References