Provision of pre-hospital medical care for terrorist attacks

Claire L. Park1,2,3,4,* and Gareth R. Grier1,3,5

1Barts Health NHS Trust, London, UK, 2King’s College Hospital NHS Trust, London, UK, 3Institute of Pre-Hospital Care at London’s Air Ambulance, London, UK, 4Specialist Firearms Department of the Metropolitan Police Service, London, UK and 5Queen Mary University London, London, UK

*Corresponding author. E-mail: claire.park7@nhs.net

Summary

The delivery of medical care to the severely injured during major incidents and mass casualty events has been a recurring challenge for decades across the world. From events in resource-poor developing countries, through richly funded military conflicts, to the most equipped of developed nations, the provision of rapid medical care to the severely injured during major incidents and mass casualty events has been a priority for healthcare providers. This is often under the most difficult of circumstances.1,2 Whilst mass casualty events are a persistent global challenge, it is clear in developed countries that patients and their families demand and expect a high standard of care from their rescuers, that this care should be delivered rapidly, and this should be of the highest quality possible.3 Whilst there is respect afforded to those who ‘run towards danger’ during a high-threat situation, first responders are subjected to a high degree of scrutiny for their actions, even when the circumstances they are presented with are considered to be extraordinary.4 Likewise, even for those who are catastrophically injured beyond salvage, society expects the response to be dignified, calculated, and thorough.3

Keywords: analgesia; major incident; mass casualty incident; pre-hospital medical care; preventable death; terrorist attack

Major incidents and terrorist events

The terms ‘major incident’, ‘mass casualty event’, ‘terrorist attack’, and others are often used interchangeably, with the former largely defined by the availability of ‘normal’ resources to meet the demands on the day of the event. The definition of a terrorist attack varies, with one of the broadest examples given by the global terrorism database as ‘the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation’.5 The motives of
Opportunities for improving outcomes

It has been recognised for several decades that there are opportunities to improve outcomes for the severely injured through the delivery of better care in the pre-hospital phase of the patient journey. Supporting the work of statutory emergency services, the specialties of anaesthesia and emergency medicine have been instrumental in the provision of the majority of physician-based care to severely injured patients in this very early phase after injury. This specialty of pre-hospital medicine is now a standard of care within UK trauma systems, with the delivery of medical interventions by ‘enhanced’ teams of clinicians often following a physician-paramedic model. These teams are often delivered by helicopter or fast-response car, and have specific skills that can be offered to the relatively niche group of severely injured patients. These include (not exhaustively) the provision of pre-hospital anaesthesia, resuscitative thoracotomy, endovascular interventions, procedural sedation, and delivery of potent analgesia. The importance of senior medical decision makers at the ‘front door’ is well recognised within hospital mass casualty plans, and the presence of senior doctors and paramedics at the major incident scene is one that has been integrated into the response for many years.

There are no agreed patient outcome measures for those involved in terrorist or other major events in the UK. Similarly, given the supposed heterogeneity of the circumstances surrounding such incidents, data collection and standardised criteria for reporting of such events could be assumed to be highly complex. However, with an increasing volume of similar events, the opportunity for data capture, analysis, and then research is enhanced. The Hartford Consensus in the USA was developed after the active shooter disaster at Sandy Hook Elementary School. This recognised the patterns of morbidity and mortality over multiple events, producing a national strategy for the prevention of unnecessary deaths from extremity haemorrhage during an increasingly predictable epidemic of homogeneous incidents.

Peer reviewed publications that interrogate preventability of deaths from civilian ‘terrorist’ attacks are relatively rare, but they provide interesting insights into the opportunities for improved medical care; for example, 34 (16%) of all fatalities from 19 civilian public mass shootings were found to have potentially survivable injuries, with the most common injury being a gunshot to the chest without haemothorax or major vascular injury (n=24; 71%). Although caution is needed in drawing parallels with lessons from military conflict, evidence from Iraq and Afghanistan shows 25% of pre-hospital deaths were found to be potentially preventable, with 8% of these being attributed to airway compromise and 91% to catastrophic haemorrhage. The challenge is that 80% of the patients who died from exsanguinating haemorrhage had non-compressible bleeds that would have required temporising endovascular resuscitation or a surgical procedure to control the haemorrhage.

Strategies for decreasing preventable deaths

Measures for ensuring preventability of death from injury during a marauding terrorist event have their foundations in the strategies used in the mitigation and elimination of any disease. The ‘pre-event’, ‘event’, and ‘post-event’ method for prevention of mortality from injury has useful application. Much energy is committed to the prevention of terrorism in the ‘pre-event’ phase. Once an event has begun to occur, the primary focus for the emergency services (usually the police) is to neutralise the threat, aiming to prevent an increase in number of patients. The terms ‘hot’, ‘warm’, and ‘cold’ zones have been used to delineate geographical areas with differing levels of threat, although there is an ongoing debate about the usefulness of this terminology in real-life events. For the emergency services, the primary challenge during terrorist events is how patients are afforded a level of pre-hospital care that is rapid and effective despite realities of the situation. This triad of reality being the potential of ongoing threat, the ‘fog of war’ around safety, and the real risk of potential harm to those professionals who are involved in the response. In preventing unnecessary deaths with adequate medical intervention, the ‘golden hour’ begins immediately after the point of wounding. Any subsequent time without medical intervention has been termed a ‘therapeutic vacuum’. Once the pre-hospital component of an event is complete, the ‘post-event’ phase often involves significant periods of time for patients cared for in operating theatres, in the ICU, and in rehabilitation, inclusive of the psychological support that may be required. These are all vital components of the wider trauma system in reducing preventable deaths.

Categories of on-scene interventions

There are opportunities to reduce the duration of the therapeutic vacuum, and therefore morbidity and mortality. Three categories of interventions are relevant: first responder interventions (FRIs), enhanced care interventions (ECIs), and bridging interventions. First responder interventions are vital, and whilst it was historically deemed that FRIs were the remit of the statutory or volunteer responders, it has become clear that bystanders have a vital role in delivering aid to their fellow civilians. Useful FRIs include the application of tourniquets and direct pressure over bleeding wounds, simple airway opening manoeuvres, and the rapid removal of companions to a safer area using whatever means necessary. First responder interventions are usually only effective if performed rapidly, often even before the arrival of the emergency services.

Evidence from recent military conflicts shows that external catastrophic haemorrhage can be controlled with a well-placed tourniquet. When tourniquets were introduced as a standard of care by deployed coalition military troops in the 2000s, an 85% reduction in potentially preventable deaths was
seen from extremity haemorrhage. Bystanders have demonstrated the effective placements of tourniquets under pressure, for example at the Boston marathon bombing, with improvisation of devices reported to have been highly effective. Tourniquets applied late are likely to be less effective, and not all terrorist events require a focus of tourniquet application.

Where ambulance services and other formally trained medical professionals are delayed in attending a scene because of an active threat, FRIs must be carried out by bystanders who are themselves often entrapped within the scene, or by adequately protected emergency personnel. In the case of a firearms incident, it is likely that these individuals will be armed police officers who have the unenviable task of primarily locating, confronting, and neutralising the threat, and then also delivering life-saving interventions. The adoption of these early battlefield-type casualty care concepts known as ‘care under fire’ or ‘direct threat care’ has been clearly described for civilian events, and is an approach that has been discussed in some detail during recent inquests into UK terrorist incidents.

Bridging interventions are those interventions that do not deliver a therapy, but that enable ECIs to be delivered. Examples include the insertion of i.v. cannulae. There is little evidence to support additional interventions to those provided by first responders, when these are carried out effectively.

Enhanced care interventions are those carried out by enhanced care practitioners or teams, and include

(i) Anaesthesia for ventilatory failure in severe chest injury and ongoing airway compromise
(ii) Thoracostomy to treat severe chest injuries in patients who are not in cardiac arrest
(iii) Blood transfusion in specifically defined circumstances
(iv) Open-chest surgery in specific cases of penetrating trauma
(v) Intravenous sedation for patients with multiple limb fractures
(vi) Delivery of potent analgesia
(vii) Endovascular control of torso haemorrhage

As with day-to-day practice, the utility of these interventions is weighed against the advantage of a rapid removal to hospital. There are additional competing considerations during the context of an ongoing terrorist event related to hospital surge capacity, local geography, and the stage of readiness of the receiving hospital teams. Even with the speediest of pre-hospital responses, it is likely that ECIs will not be delivered until a significant proportion of the ‘golden hour’ has been consumed by the therapeutic vacuum. This raises an even greater sense of urgency in delivering the appropriate teams to the incident scene. Meanwhile, even outside of the context of terrorist events, significant data are accumulating to suggest that the opportunities for intervention sit firmly within the pre-hospital phase of care, as follows.

A crucial contemporary paper by Holcomb identified that the peak time of death after severe truncal injury is within 30 min, with an average 2.1 h to achieve haemorrhage control in hospital. Blunt head injury remains an important entity at a terrorist incident scene, especially one where vehicles have been used as a weapon. Whilst the traditional approach to head injured patients has been to rapidly transfer for neurosurgical care, there is an increasing appreciation that the hypoxaemia with or without hypercapnia associated with head injury can be remedied early, halting the development of hypoxic axonal injury. Resuscitative thoracotomy has been delivered on scene during terrorist events in the UK, as it is in multiple cases of assaults with bladed weapons each year. Survival of a late-stage exsanguinating haemorrhage patient after tourniquet placement, pre-hospital blood transfusion, and cautious anaesthesia has been described following the Fishmongers’ Hall terrorist incident in London.

**Importance of early analgesia**

The importance of early analgesia cannot be over emphasised. Whilst the provision of adequate analgesia is associated with many proven benefits, the extraction of a patient from the scene to a place of safety or to hospital is fraught with difficulty, where adequate analgesia cannot be provided. Painful blunt injuries, such as those suffered when vehicles are used by terrorists as weapons, provide a real-world challenge for analgesia provision. Traditional methods for delivery of analgesia available to ambulance personnel, such as inhaled nitrous oxide, i.v. paracetamol, or opioids (such as morphine), may not provide the conditions for the rapid extraction of an injured patient from a high-threat scene. Administration of sedative doses of ketamine, widely described by enhanced pre-hospital medical teams, is not without difficulty, where there are multiple patients requiring attention over a large geographical area. Recent work on the delivery of oral transmucosal fentanyl citrate by the military shows promise in this area for civilian first responders. Additionally, a number of police forces in the UK now carry analgesic doses of inhaled methoxyflurane for administration in high-threat areas before ambulance arrival on scene. The introduction of a safe yet potent analgesic strategy into the very early stages of a terrorist event is essential if patients are to undergo adequate haemorrhage control and splinting, and be moved rapidly towards definitive care in time to prevent deterioration.

**Options for delivering enhanced care interventions**

There is, therefore, a persuasive case for the early delivery of ECIs at the scene of a terrorist attack, following rapidly on from FRIs delivered by bystanders and appropriately armed police resources. The presence of a suspected or ongoing live threat has often precluded the rapid deployment of ambulance personnel into this initial response. Multiple recommendations have been made for further work in this area. Solutions include a French model, where doctors are ‘embedded’ with police units. This delivered results during the Bataclan attack in 2015, where two doctors triaged all 100 of the live casualties, also identifying 89 dead, whilst the tactical situation was managed by police providing cover around them. This approach requires extensive investment in training, protective equipment, and a model that exists in perpetuum, awaiting the trigger of a terrorist attack.

Other models focus on the urgent creation of protected ‘corridors’ and ‘islands’ through which senior clinicians can move whilst protected by armed police. Alternatively, they may be used for the injured to reach senior clinicians who are deployed to ‘less hot’ areas of the scene, where they are protected to undertake their roles. All models require training to ensure such clinicians are cognisant of the potential threats associated with
modern terrorist attacks, and of how to move safely in and around such threats and within a corridor or ‘bubble’ of armed police officers.\textsuperscript{9,20} Such tactical training for pre-hospital clinicians currently exists within differing models internationally, occasionally but not routinely, including enhanced care teams. The discussion of potential educational programmes would build on these. The potential delivery of a model where clinicians work with, but are not embedded within the police response, requires exemplary communication between services so that the shared mental model is understood and delivered successfully. The challenge of accurate communication, especially between differing agencies during major events, has been described extensively in reports and inquiries.\textsuperscript{2,7,26,29}

Conclusions

Many recommendations suggest the need for a paradigm shift in the inclusion of senior clinical leaders in the organisation of the response.\textsuperscript{3,19,26} Medical decisions at the scene are the domain of the clinician, and it has long been recognised that the presence of senior clinicians impacts positively on clinical care, under a host of circumstances. Tactical decisions by ambulance and police officers in charge can only be accurately taken where the clinical opportunities for intervention are understood. Terrorist attacks are dynamic, constantly changing phenomena that require flexible strategic medical leaders. These should be medical leaders who can intimately identify with the role of the senior tactical clinicians on the ground who will be delivering interventions to orchestrate a malleable, precise response, tailored to the circumstances of the event. The opportunities for appropriately trained acute specialty clinicians to influence patient outcomes during terrorist events are significant. Whilst the future scale and impact of such attacks are difficult to predict, it is important that we continue to learn the lessons of events of the past and to invest in the survivors of the future.

Declarations of interest

The authors declare that they have no conflicts of interest.

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Higher pre-hospital anaesthesia case volumes result in lower mortality rates: implications for mass casualty care

Peter Paal1,*, Ken Zafren2,3 and Mathieu Pasquier4

1Department of Anaesthesiology and Intensive Care Medicine, St. John of God Hospital, Paracelsus Medical University, Salzburg, Austria, 2Department of Emergency Medicine, Alaska Native Medical Center, Anchorage, AK, USA, 3Department of Emergency Medicine, Stanford University Medical Center, Stanford, CA, USA and 4Emergency Department, Lausanne University Hospital, University of Lausanne, Lausanne, Switzerland

*Corresponding author. E-mail: peter.paal@icloud.com


Summary

Senior physicians with a higher pre-hospital anaesthesia case volume have higher first-pass tracheal intubation success rates, shorter on-site times, and lower patient mortality rates than physicians with lower case volumes. A senior physician’s skill set includes the basics of management of airway and breathing (ventilating and oxygenating the patient), circulation, disability (anaesthesia), and environment (especially maintaining core temperature). Technical rescue skills may be required to care for patients requiring pre-hospital airway management especially in hazardous environments, such as road traffic accidents, chemical incidents, terror attacks or warfare, and natural disasters. Additional important tactical skills in mass casualty situations include patient triage, prioritising, allocating resources, and making transport decisions.

Keywords: airway management; anaesthesia; anaesthesiologist; emergency medical services; mass casualty incidents; tracheal intubation; videolaryngoscopy

In this issue of the British Journal of Anaesthesia, Saviluoto and colleagues1 present a retrospective registry-based cohort study of the association between the pre-hospital anaesthesia case volume of helicopter emergency medical services (HEMS) physicians and mortality. Physicians were divided into three groups according to the case volume of pre-hospital anaesthesia in the year preceding the airway management of a given patient. Twelve physicians treated more than 36 cases in the preceding year (511 patients), 56 physicians treated 13–36 cases in the preceding year (2033 patients), and 88 physicians treated 12 cases or fewer in the preceding year (2274 patients).

On-scene time was significantly shorter for the physicians with higher case volumes (median time: 28 min for physicians with >36 cases, 32 min for physicians with 13–36 cases, and 32 min for physicians with <12 cases). First-pass success rate was significantly higher for physicians with higher case volumes (98%, 93%, and 90%, respectively) and mortality was lower (25%, 29%, and 36%, respectively). Overall, 30-day mortality was 32% (n=1469). In the multivariate logistic regression analysis, the pre-hospital anaesthesia case volume of the preceding year was inversely correlated with 30-day mortality. The authors suggest that physicians with higher pre-hospital