SPECIAL REPORT

# Triage in Complex, Coordinated Terrorist Attacks

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**Abbreviations:**
CCP: casualty collection point
CCS: casualty clearing station
CCTA: complex, coordinated terrorist attack
EMS: Emergency Medical Service
FTS: Field Triage Score
GCS: Glasgow Coma Score
HEMS: helicopter Emergency Medical Services
IRC: Inland Regional Centre (San Bernardino)
LSI: life-saving intervention
MIMMS: Major Incident Medical Management and Support
RAMP: Rapid Assessment of Mentation and Pulse
SALT: Sort, Assess, Life-saving interventions, Treatment/Transport
SAMU: Service d'Aide Médicale d'Urgence
SBP: systolic blood pressure
SINUS: Système d'Information Numérique Standardisé
START: Simple Triage and Rapid Treatment

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## Abstract

**Introduction:** Terror attacks have increased in frequency, and tactics utilized have evolved. This creates significant challenges for first responders providing life-saving medical care in their immediate aftermath. The use of coordinated and multi-site attack modalities exacerbates these challenges. The use of triage is not well-validated in mass-casualty settings, and in the setting of intentional mass violence, new and innovative approaches are needed.

**Methods:** Literature sourced from gray and peer-reviewed sources was used to perform a comparative analysis on the application of triage during the 2011 Oslo/Utoya Island (Norway), 2015 Paris (France), and 2015 San Bernardino (California USA) terrorist attacks. A thematic narrative identifies strengths and weaknesses of current triage systems in the setting of complex, coordinated terrorist attacks (CCTAs).

**Discussion:** Triage systems were either not utilized, not available, or adapted and improvised to the tactical setting. The complexity of working with large numbers of patients, sensory deprived environments, high physiological stress, and dynamic threat profiles created significant barriers to the implementation of triage systems designed around flow charts, physiological variables, and the use of tags. Issues were identified around patient movement and "tactical triage."

**Conclusion:** Current triage tools are inadequate for use in insecure environments, such as the response to CCTAs. Further research and validation are required for novel approaches that simplify tactical triage and support its effective application. Simple solutions exist in tactical triage, patient movement, and tag use, and should be considered as part of an overall triage system.

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## Introduction

Complex, coordinated terrorist attacks (CCTAs) present a unique challenge to prehospital medical responders. Overwhelming numbers of patients presenting almost simultaneously, multiple sites and modes of attack, varying mechanisms of injury, and secondary threats all combine to create a confusing and complex operating environment for responders.

All CCTAs are intentional, mass-violence incidents that involve coordinated tactics, various weapon types, and potentially, multiple sites of attack. Incidents such as the 2017 London Bridge/Borough Market terror attack (London, England) involved the attackers conducting a hostile vehicle attack, then dismounting to attack civilians with knives, while wearing fake suicide vests.[1] Responding to an incident such as this creates an uncertain environment with a high-index of suspicion for secondary attacks.

In the confusing and dangerous response to CCTAs, triage of victims is more difficult than in other disasters or mass-casualty incidents. This paper will compare and analyze three recent CCTAs to determine the applicability of triage systems in high-threat tactical settings and will identify successful elements that could guide development of an appropriate "tactical triage" system.

## Methods

Literature identified as being descriptive of prehospital response to terrorism through a literature search was utilized to conduct a comparative analysis of the CCTAs in Norway (2011), Paris (France; 2015), and San Bernardino (California USA; 2015).

The search strategy interrogated the MEDLINE (US National Library of Medicine, National Institutes of Health; Bethesda, Maryland USA), MEDLINE In-process, Cochrane (*The Cochrane Collaboration; Oxford, United Kingdom)*, EMBASE (Elsevier; Amsterdam, Netherlands), CINAHL (EBSCO Information Services; Ipswich, Massachusetts USA), and Google Scholar (Google Inc.; Mountain View, California USA) databases for the following Medical Subject Headings (MeSH) and keywords:

(terror* OR attack OR bombing OR mass casualty incident OR explosion OR shooting OR aggressive deadly behavior OR hybrid targeted violence OR complex attack OR multi modal attack) AND (Emergency Medical Services [EMS] OR ambulance OR prehospital OR medical response OR health response).

For the three identified CCTAs, the following search string was used on the Google Scholar and Google databases:

('event' and terror*) and (Emergency Medical Services or prehospital or medical or health or response).

All papers that were able to be located in full-text and identified as relevant to the theme were included, and a meta-aggregational narrative framework was utilized to identify themes in the application of triage in complex settings.[2]

## Report

### *Triage*

Triage is the process of categorizing patients according to their urgency for clinical interventions, including treatment, transport, and destination. The history of triage is well-described, and extends back for many hundreds of years to its first documented use by Napoleonic armies.[3] Despite a rich history, triage is still poorly applied and not well-validated.[4,5]

In the setting of prehospital response to intentional mass violence, triage is used firstly to distinguish patients that most urgently require life-saving interventions (LSIs), and therefore rapid extrication to further echelons of care. Tactical triage, the triage process conducted in the "warm zone" when threat may still be active and responder stress will be high, requires rapid application and simplicity of use.

Currently, few tactical triage tools exist, and improvisation of primary triage systems are commonly used.

Once the security situation has become more controlled, primary triage is applied using traditional "sieve" systems. These systems are most often used by EMS as the initial step in prehospital response to mass-casualty incidents. The majority of these systems rely on the use of algorithms, tags, and physiological variables, such as Simple Triage and Rapid Treatment (START) and Sort, Assess, Life-saving interventions, Treatment/Transport (SALT).

After patients have been moved from the warm zone into a casualty collection point (CCP) or casualty clearing station (CCS), more sensitive and specific tools can be implemented in the process of secondary triage. These tools identify patients with the greatest need for treatment and allocate them to the most efficient transport modality and highest level of definitive care (field or transport triage).

### *Triage and Complexity*

Triage is a linear system that aims to provide an objective rating of a patient's likelihood of requiring emergent medical intervention, the comparative urgency for transport to hospital, or the requirement for transport to a specific level of definitive care. The intent behind this is to remove the ambiguity and subjectivity that a human responder will bring to the process. It can be considered prescriptive. A consequence of this process is that an ordered, inflexible, process-driven algorithm is overlaid onto dynamic, complex, uncontrolled situations. The resulting juxtaposition of complexity and simplicity can result in the inability to recall or effectively utilize algorithms, as well as the incorporation of emotion and subjectivity into what should be an objective process.

Law enforcement and EMS responders to the San Bernardino attack reported extremely high levels of physiological stress, exacerbated by the noise and water from fire alarms and sprinklers, the smell of cordite and blood, and the screams of injured victims.[6] The 2008 Mumbai CCTA (India) shocked the world in its destructiveness and the difficulty in response from a law enforcement and medical perspective. Persistent threat to life, combined with sensory overload, complicated individual response and erected barriers to effective systematic implementation of emergency medical treatment. No triage was implemented in the prehospital setting, with triage systems only being applied once patients had been transported to hospital emergency departments.[7,8]

Low levels of stress are associated with increased performance in medical professionals; however, high stress is correlated with a significant deterioration in ability to make effective decisions and to perform clinical and technical skills, especially when an individual has a low perception of ability to cope with a given situation.[9–12] While fine motor skills can increase with moderate physiological and psychosocial stress, a systematic review of surgeons' ability to conduct procedures shows degradation of performance of technical and non-technical skills with increasing stress, particularly in stress "crises."[13,14] Likewise, under settings of high anxiety and pressure, police officers' performance in work-related tasks is shown to decrease significantly.[15–17] Terrorist events and incidents with tactical violence are self-reported by paramedics as types of responses they are least comfortable with, feel least prepared for, and impart the highest levels of stress.[18]

The overwhelming nature of CCTAs for prehospital responders emphasizes the need for triage systems that are able to be recalled and implemented effectively under situations of high stress with reduced fine motor skills.

### *Overview of Incidents*

A number of themes were highlighted in the comparative analysis of the three CCTAs, with a significant amount of commonality, suggesting these findings could be extrapolated to many CCTAs and other intentional mass-violence incidents.

*Oslo/Utoya: July 22, 2011*—The bombing in the Government District of Oslo (Norway) saw a rapid reaction from EMS, with adequate availability of resources.[19] Triage was conducted on a business-as-usual model, with good reported success of field triage, aside from some over-triage, which had little to no impact due to the ready availability of in-hospital resources.[20]

The second attack occurred shortly afterwards when Anders Breivik began shooting members of a political youth camp on Utoya Island, eventually killing 69 and injuring 65 that required hospitalisation.[19] Two CCSs were established on the mainland, and a forward, warm zone CCP established after two hours on the island itself.[21] Triage was conducted through these established positions, with the first mainland CCS requiring to be shifted due to security concerns.

*Paris: November 13, 2015*—Paris emergency services faced a grim task when gunmen fired upon cafes, suicide bombers attempted to enter the Stade de France during an international football match, and scores of hostages were taken inside the Bataclan Theatre. In total, 495 wounded were treated and 130 were killed, as well as the seven terrorists.[22]

Due to the number of Service d'Aide Médicale d'Urgence (SAMU; Paris, France) staff recalled to work, the control center



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was able to mobilize an appropriate number of Mobile Intensive Care Unit Physician teams who were sent to the various sites to assist with the triage and patient distribution process.[23]

Tactical physicians attached to the special forces police joined the assault into the Bataclan and triaged and treated over 50 invalid patients and 89 fatalities in a highly dynamic warm zone.[24]

*San Bernardino: December 2, 2015*—A husband and wife who had self-radicalized and sympathized with Islamic State (IS; Syria/Iraq) entered the San Bernardino Inland Regional Centre (IRC) and shot 36 people attending a meeting, killing 14 of them. They left a secondary improvised explosive device (IED), presumed to be intended to kill and injure first responders.[25,26] An hour later, the terrorists were killed in a gun fight on a suburban street that left two police officers injured.[6]

Patients were initially triaged inside the conference room of the IRC by a tactical paramedic attached to the Special Weapons and Tactics (SWAT) Team. Police extricated all casualties to a CCP in the carpark outside the IRC, where vehicles of opportunity were commandeered to transport all patients to "Triage A," where 15 patients were triaged and transported. Another five patients were triaged by fire department medics and transported from "Triage B," located on the golf course across the road from the IRC.[25]

*Themes in Triage*

*Use of Established Triage Systems*—Prior to the 2011 Oslo and Utoya Island CCTA, there was no national standard in Norway for prehospital triage.[21] Some local trusts had begun to implement triage tools, however, during the attacks none were utilized.[19] The disaster/major incident system in Norway designates a Medical Commander who oversees triage, treatment, and transport.[27] The presence of experienced clinicians was credited with the success of triage and transport decisions during the attacks, from the oversight of Medical Commanders as well as helicopter EMS (HEMS) anesthesiologists who conducted primary and field triage on-scene.

In contrast to the lack of a universal triage system in Norway, responders at San Bernardino had trained many times on the use of START adult and JumpSTART pediatric algorithms. No responder utilized this system during the incident. Post-incident analysis reveals that responders universally relied on clinical judgement and did not use physiological numbers or number ranges for triage decisions.[25] The metrics of activity, pallor, gasping or rapid breathing, presence of large amounts of blood, and the anatomic location of gunshot wounds were utilized instead to aid decision making.

France utilizes a national standard for triage.[28] While this was applied at CCSs across Paris, improvised and simplified tactical triage systems were also reported to be used at various sites, including the Bataclan.[29]

*Use of Triage Tags*—The use of triage tags is not recorded in any of the available literature from Oslo/Utoya Island. In the absence of a national or local standard system, the Norwegian Directorate of Health (Oslo, Norway) stated that no color-coded tags were available or used.

Triage tags were used at various times throughout the San Bernardino incident, in the form of tape and paper tags. The tactical paramedic that first encountered patients inside the IRC had minimal gear due to his role, and used colored tape to designate triage categories.[30] Fire department medics that arrived in response to reports of up to 20 more patients entered the IRC and conducted a secondary search for survivors and completed further verification of death, using paper triage tags to mark victims. The amount of water coming from the fire sprinklers and a ruptured pipe made this process problematic.[25] Once patients had been extricated to Triage A, they were initially assessed by fire department EMS and had a triage tag placed. Halfway through the total number of patients, a decision was made to discontinue this process as it was "interfering" with assessment and treatment of patients.[25]

The Système d'Information Numérique Standardisé (SINUS) is a national system used by Paris emergency services to track patients from initial triage, utilizing a bracelet and barcode. Paris fire brigades use SINUS regularly in day-to-day operations; however, other services such as SAMU are not particularly familiar with its use. During the Paris CCTA, there was decreased compliance in use of the system, which was exacerbated by a lack of available SINUS kits, and the system was not used across the board.[22]

*Casualty Collection Points and Casualty Clearing Stations*—The Oslo bombing saw a rapid and immense response from EMS, with 41 ambulance units available within 26 minutes of the explosion, and the first on-scene in three minutes.[19] To organize this response, incident command was quickly established and two CCSs sited due to the lack of a single evacuation corridor; however, only one CCS was used for the majority of the patients transported.[21]

With the close proximity of a primary care clinic, fire and police vehicles were used to move patients, as well as a commandeered bus and a number of patients moving by foot. The familiarity of the responding crews with the capabilities of the primary care clinic for low-acuity patients is credited with the successful field triage of patients, with only two requiring secondary transport to a trauma center.[19,20] A Kamedo report described that "...staff did not therefore need to use any special triage algorithm..." as they worked on their usual prehospital model in deciding transport disposition for trauma patients.[20]

The appropriate triage and transport of 64 patients to the primary care clinic was achieved in less than two hours through the established CCS.[21] A degree of over-triage was reported with three of the 10 patients transported to a designated trauma hospital, later deemed to be appropriate for a lesser level of care.[19]

With many patients initially arriving by civilian boats from Utoya island, a CCS was established at Utvika Quay, near the shortest distance from the island to the mainland of approximately 630m. Shortly after the marshalling area was established at the Quay, police elected to move it further back to the main road as bullets from the terrorist on the island were striking the water nearby.[19]

At this first CCS, EMS nurses, paramedics, and physicians conducted minimal interventions, with assignment of triage priority as a method of deciding on order of casualty evacuation. Many of these initial patients were swimmers with minor or no injuries, as well as patients with gunshot wounds brought to the mainland by boat.[21]

Due to geographical restrictions at the Utvika Quay CCS, as well as the discovery of the shooters' car in close proximity, a second CCS was established further away from the island at the bridgehead to Storoya Island.[21] During the time period that the primary CCS was being closed and the secondary established, seven severe trauma patients were transferred to a non-trauma hospital that required secondary transfers, and a few uninjured patients were also transported.[19] This apparent failure in field triage, with an overall under-triage rate of 43%, could be explained



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by the uncertainties surrounding the shift from one CCS to the other.

The secondary CCS had a number of paired physicians with a nurse or paramedic assistant to conduct minimal treatment and designate field triage categories as patients arrived by boat, as well as by ambulance, from the primary CCS.[21,31] Field triage was conducted utilizing the following improvised tool:[20]

- Unstable patient: transport by helicopter;
- Stable patient: transport by land ambulance; and
- Walking wounded: transport by bus.

*Triage in the "Warm Zone"*—An advanced CCP was established on Utoya Island prior to it being declared secure by police. Four victims were treated for gunshot wounds prior to evacuation off the island, and all others that came through this CCP were uninjured.[21] Police special forces provided security for the CCP, however, none of the medical personnel who moved to the island had any training or equipment for working in the "warm zone." No information is available on the application of triage for patients moving through this CCP.

All CCPs and triage/treatment had a security element during the San Bernardino incident, with the exception of Triage A for a period of time when the shoot-out began with the terrorists nearby. The security element responded to the incident, leaving the EMS exposed for that time.[25] Tactical Paramedics and Rescue Task Force personnel had previous training, as well as specific equipment to operate in unsecured "warm zone" environments.

As the tactical situation evolved in Paris, the presence of non-permissive and semi-permissive environments and the overwhelming numbers of "absolute emergencies" (Immediate) with penetrating trauma required the implementation of tactical triage. A simplified triage system was reportedly used by some doctors with an Immediate designation for patients wounded centrally, in the abdomen or torso, as well as those in hemorrhagic shock. "Relative emergencies" (Delayed) were patients wounded in extremities, even if a tourniquet had been placed to control haemorrhage.[28]

Inside the Bataclan Theatre, physicians attached to the police special forces were situated at the rear of the assault as the intervention columns pushed in. In the main area of the theatre, they were confronted with approximately 100 patients and 400 other hostages.[29] Due to overwhelming numbers and the unstable security situation, the physicians elected to perform tactical triage by having all those who were not "invalid" (immobile due to injuries) move themselves immediately from the theatre. They then began the process of moving through the tangle of dead and approximately 50 invalid patients performing remote damage control resuscitation interventions, such as hemostatic wound compression, tourniquet application, chest decompression, and tranexamic acid administration.[32]

*Patient Movement*—Over 50 Light Emergency Stretcher Systems (LESS) stretchers, specifically designed for use in mass-casualty incidents, were delivered to and used for patient movement at the Oslo bombing site and the Utoya second CCS.[20,33]

No similar lightweight stretchers were available in San Bernardino, and the extrication of casualties out of the IRC involved improvisation. The presence of blood and water made patients slippery and difficult to carry, and blankets, chairs, and manual techniques were utilized. To move patients to Triage A, police commandeered multiple vehicles of opportunity.[6]

The large number of patients discovered inside the Bataclan, once the police assault had pushed through, needed to be moved to the initial CCP at the theatre entrance and then a longer distance to the "cold zone" CCS. Due to a lack of stretchers, many were carried on police officers' backs and on crowd barriers sourced from the street outside.[29]

*Determination of Death/Black Tags*—According to San Bernardino Fire Department (SBFD) protocol, none of the 14 victims that were designated as black tags inside the IRC met "obvious death criteria."[25] According to the START triage algorithm, an apneic patient should have their airway opened, and if they still do not breathe spontaneously, then they are a "black" or "Expectant" category. A recent after-action report details that medics did not use either of these, but instead assessed presence of carotid pulse, absence of vital signs, and then assessed the futility of care in consideration to the potential danger and resources on-scene.[25]

On Utoya Island, at approximately 6:30PM on July 22, 2011, police had arrested the perpetrator. They could not declare the Island secure at this stage, as they were not positive that they were no accomplices involved. At around midnight, five medical teams, escorted by armed police teams, combed the Island to locate remaining victims and provide declarations of death. This was done in the dark due to the need for light discipline, and initially provided an inaccurate count of 72 dead. This was corrected to 69 the next day.[20]

## Discussion

The challenges of responders managing their own physiological stress, as well as an austere environment and a dynamic threat profile, create a barrier to application of accurate triage in CCTAs.

Operations on Utoya Island after the perpetrator was arrested demonstrate the complexities of working in areas that may be clear but are not yet deemed secure. The search for victims and declarations of death had to be conducted in the dark, with armed escort, creating difficult conditions for the medical teams.

The decision making in the Utoya Island attack on triage priority, especially in terms of transport triage, was associated with success in the literature due to the presence of experienced, senior physicians. This technique has been shown by an Israeli study to correlate to an accurate rate of identification of patients requiring an "Immediate" classification of only 50%.[34] A study of United Kingdom firearms officers found that with a short training course and the use of triage decision-making support tools, there was a significant increase in the effective and accurate triage of patients.[35] This finding has been replicated in a number of studies with various triage systems.[36–39]

In analysis of the July 22, 2011 attacks in Norway, the lack of a standard triage system was identified and later rectified, with a standard created and implemented across Norwegian EMS.[40] A tactical triage category was included in this standard, which suggests the use of verbal commands to distinguish patients who can respond and move to those who can't, splitting potentially large numbers of victims into those who require immediate assistance and those who can care for themselves for the short-term while the non-permissive environment persists.

Although it is clear that there is a need for a standard in prehospital triage, and that accuracy is improved with the use of training and decision-making tools, the complexities of response to incidents such as terror attacks can interfere with their practical



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application. In analysis of the triage conducted by medical responders to the 2005 London bombings, it was recommended that prehospital providers investigate more simplified triage systems, with only two prehospital triage categories rather than the traditional four.[41]

The majority of triage algorithms require the use of number ranges from assessed physiological parameters such as respiratory rate, pulse rate, and capillary refill. As the use of anatomic cues, such as injury location and mechanism of injury, tend to create higher rates of over-triage and assess for the potential to deteriorate rather than the current patient status, physiological ranges are used to provide a current snapshot in the triage process.[42]

A report created from debriefs of the Westminster, Manchester and London Bridge/Borough Market terror attacks stated that the distinction between P1 and P2 triage categories was less relevant than the ability to walk.[43] Another paper written by an attending paramedic to the London Bridge/Borough terror attack, where eight were killed and 48 injured, describes the difficulty of using physiological ranges in the setting of mass penetrating trauma.[1] Many patients at this incident were mobile, however, had serious wounds, and were physiologically compensating at the time of initial triage. By the time these patients show a significant change in their physiological parameters, they can be irreversibly decompensated.

A tool that has been designed to avoid the need for gathering these parameters is the Careflight triage tool, which has no qualitative parameters. This tool performed identically to START and Manchester Sieve when applied retrospectively to patient data from the 2005 London bombings.[44] The use of qualitative parameters only is well-suited to use in tactical settings, and with further simplification from Careflight's three steps and four categories, would be easily recalled and applied.

A technique formulated through experience with multiple mass-casualty events in Baghdad to differentiate patients between Immediate and Expectant was the assessment of the presence of a radial pulse and conscious state.[45]

This method has been validated in the prehospital combat environment through a retrospective analysis of the Joint Theatre Trauma Registry.[46] This study used the surrogate marker of 100mmHg systolic blood pressure (SBP) to replicate a weak or absent radial pulse, as well as a Glasgow Coma Score (GCS) Motor (GCS-M) component of six or less than six.

Named the "Field Triage Score" (FTS), these two parameters were applied to 4,988 combat casualties from Iraq and Afghanistan between 2002-2008. Having both parameters present in a given patient, an FTS of two was assigned; only one or the other parameter, an FTS of one; and neither parameter, an FTS of zero was assigned. An FTS of two was associated with a mortality rate of 0.1%, while FTS of one increased to 6.1%. Having neither an SBP above 100mmHg or GCS-M of six (FTS = 0) had a mortality rate of 41.4%.

A random convenience sample of 216 patients transported by HEMS in Texas (USA) identified that the absence of similar markers (GCS-M <6 and SBP <90mmHg) was independently associated after multivariate analysis with the need for LSIs (95% of these patients had at least one LSI applied).[47]

Another retrospective registry analysis from Iraq used a slightly modified FTS (cutoff at $GCS_{total}$<8) applied to 536 battlefield casualties, finding a similar predictive accuracy for massive transfusion and mortality to the more complicated Revised Trauma Score. [48]

Similarly, in a retrospective review of 1,144 adult patients, a number of triage algorithms were applied and compared. With reasonably similar results for sensitivity and specificity, the most significant predictors for severe injury of the triage components were GCS-M and blood pressure.[42] The radial pulse character, in the prehospital setting, has been associated with a 29% mortality in those with a weak or absent pulse, and three percent with a strong pulse.[49]

The use of GCS alone may have a strong predictive value for mortality and relevant triage category, with a similar performance to START, Fire Department New York (FDNY; New York USA), and Careflight triage systems in a head-to-head comparison based on 530,695 patients recorded in the US National Trauma Data Bank.[50] A retrospective trauma registry analysis in North Carolina (USA) of 29,573 patients also found GCS-M as an effective predictor of mortality.[51]

Based on these assumptions, a tool that incorporates the parameters of GCS-M and radial pulse will have a reasonable association with mortality and may predict triage category almost effectively as current primary triage tools.

The Rapid Assessment of Mentation and Pulse (RAMP) triage system uses essentially the same parameters as FTS (GCS-M and radial pulse) to allocate to three triage categories: Immediate, Delayed, and Expectant.[52] The removal of a fourth category simplifies the algorithm and makes it more amenable to apply in situations of evolving threat and high physiologic stress. Specifically designed for tactical incidents, responders allocate a patient's triage category by assessment of the ability to obey simple commands (GCS-M = 6) and the presence of a radial pulse. The absence
of numbers, parameters, or complicated algorithms makes this "tactical triage" system easy to recall and apply in high-stress and distracting environments such as CCTAs.

A triage tool needs to identify more than just an association with mortality rates; it must also identify those who have the most to gain from appropriate and timely management. To make RAMP more applicable to this criterion, the SALT "global sorting" initial approach can be utilized to determine which patients to begin the individual triage process on first.[53] Verbal commands are used to have anyone who can mobilize to walk to a given direction or area, and then ask patients to wave. Victims still lying still or with obvious life threats can then be assessed, followed by those who can wave but not mobilize. Once an individual patient is assessed, RAMP also incorporates the rapid application of necessary LSIs into the triage process. This is identical to the Norwegian tactical triage system.

### Life-Saving Interventions

To improve the way triage was performed by paramedics after the 2015 London bombings, the need for clinical intervention during the initial triage process was evaluated. At that stage, London Ambulance Service (LAS) used the Major Incident Medical Management and Support (MIMMS) principles that kept the first medical personnel on-scene in a strictly triage allocation role, with no clinical interventions being undertaken. The MIMMS was adapted following this review to include the rapid application of LSIs in conjunction with the allocation of triage categories.[23]

With testimony from bystanders providing care at the Underground during the 2015 London bombings stating that there were multiple exsanguinating victims,[54] the need for incorporation



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of LSIs into the initial approach of a triage system is clear, with a number of other incidents also ratifying this concept.[55,56]

The application of LSIs requires definition of exactly what a LSI in the hyperacute phase of a mass-casualty incident is. One expert consensus paper sought to define LSIs in order to better understand the parameters of assigning an "Immediate" triage category.[57] While some of the 32 LSIs defined are relevant for inclusion in a rapid triage process, the majority are not, including interventions such as Rapid Sequence Intubation (RSI) and interventional radiology for hemorrhage control. The LSIs in the setting of prehospital triage should be rapid, use minimal equipment, and be targeted to preventable causes of death, which therefore make the LSIs specified by the SALT triage system an appropriate balance between saving lives and providing care to the maximum number of victims, especially in high-threat incidents:[53]

- Severe hemorrhage control (tourniquets, wound packing, and/or direct pressure);
- Basic airway management (nasopharyngeal adjuncts and prone/recovery position);
- Application of vented chest seals and needle decompression of tension pneumothorax; and
- Administration of Chemical, Biological, Radiological, or Nuclear (CBRN) antidotes.

The application of swift and effective hemorrhage control has been shown to have a significant effect on decreasing mortality if applied prior to the onset of shock.[58] The earlier these interventions can be applied will be not only be life-saving, but will also reduce the patients further resource requirements.

A tactical triage system should allow for LSIs to be applied during the process of rapid patient assessment, due to risk of sudden exsanguination or deterioration.

Novel systems are under development which may simplify the approach to some high-threat incidents in the future, such as a point-of-care ultrasound (POCUS) triage tool proposal for categorization of victims from hostile vehicle attacks.[59] Continued research into innovative models and validation of existing ones will refine the triage process to make it more applicable and relevant for high-threat environments such as CCTAs.

## Limitations

This paper focuses on triage in CCTAs; however, the application of triage in intentional mass-violence incidents of other modalities, type, and motivation may hold unknown differences. The information gleaned through comparison of these CCTAs may be limited by the small number of attacks included, and further research should be conducted to assess the applicability of findings in other settings.

## Conclusion

Most CCTAs pose a challenge to responders in their unsafe, overwhelming, and dynamic environments. Recent events have shown significant barriers exist in the application of triage systems, including algorithms and tools, tags, patient movement, and warm zone triage.

Triage tools currently in use are not well-suited to the highly stressful and dynamic setting of tactical events such as CCTAs, particularly in the initial or tactical triage stage. Some tools are designed for, or could be adapted to, the tactical triage setting, with retrospective validation of parameters. The use of an adapted tactical triage system is recommended for use in the warm zone of an intentional mass-violence incident, and any high-threat or tactical response.

Further prospective research is required to validate effective triage tools for dynamic tactical situations, and innovative models incorporated into current triage systems.


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