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February 6th, Kahramanmaraş earthquakes and the disaster management algorithm of adult emergency medicine in Turkey: An experience review

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EMAT EMERGENCY MEDICINE ASSOCIATION OF TURKEY

Abstract:

This compilation covers emergency medical management lessons from the February 6th Kahramanmaraş earthquakes. The objective is to review relevant literature on emergency services patient management, focusing on Koenig's 1996 Simple Triage and Rapid Treatment (START) and Secondary Assessment of Victim Endpoint (SAVE) frameworks. Establishing a comprehensive seismic and mass casualty incident (MCI) protocol chain is the goal. The prehospital phase of seismic MCIs treats hypovolemia and gets patients to the nearest hospital. START-A plans to expedite emergency patient triage and pain management. The SAVE algorithm is crucial for the emergency patient secondary assessment. It advises using Glasgow Coma Scale, Mangled Extremity Severity Score, Burn Triage Score, and Safe Quake Score for admission, surgery, transfer, discharge, and outcomes. This compilation emphasizes the importance of using diagnostic tools like bedside blood gas analyzers and ultrasound devices during the assessment process, drawing from 6 February earthquake research. The findings create a solid framework for improving emergency medical response strategies, making them applicable in similar situations.

Keywords:

Disaster medicine, earthquakes, emergency department, mass casualty incidents, triage

Introduction

Over the past two decades, earthquakes have become the third most common global disaster with 552 reported incidents.[1] Two earthquakes with magnitudes of 7.7 and 7.6 struck Türkiye on February 6, 2023, causing damage in Pazarcık and Elbistan districts of Kahramanmaraş and extending to Syria.[2] Over 50,783 people died and 107,204 were injured in 10 cities.[3] Many hospitals in affected regions closed or limited services to ground floors after

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aftershocks. Due to the importance of emergency departments (EDs) in disaster response, emergency medicine professionals were mobilized nationwide, and field hospitals were quickly established.[2] Medical professionals working together to address this crisis stressed the need for effective management algorithms. Emergency responder insights led the Emergency Medicine Association of Turkey to recommend improved triage and patient management.

Global health-care systems use standardized triage systems and algorithms for disasters and routine operations. Triage decisions are influenced by the patient characteristics, the triage decision-maker, and the health-care service environment. These factors differ greatly in disasters. Thus, ED algorithms should be replaced by disaster triage and recovery algorithms.[4] Triage optimizes resource use and timing while prioritizing patient care, especially in disasters.[5,6] Disaster triage algorithms should assess and intervene quickly.

Koenig's 1996 Simple Triage and Rapid Treatment (START) and Secondary Assessment of Victim Endpoint (SAVE) triage algorithms for earthquake victims are innovative and dynamic.[7] Many victims of the February 6th earthquakes in 10 provinces sought emergency services independently, with family help, or through local resources due to the high number of injuries. This made EDs disaster site extensions. Koenig's ED algorithms enabled rapid triage, immediate interventions, and efficient ED throughput during this crisis, which is crucial for mass casualty incidents (MCIs). Triage systems and algorithm-based management promote ethical, fast, and accurate disaster response and align with disaster literature, which sees artificial intelligence and machine learning as promising tools.[8]

This systematic review examines search and rescue, prehospital, ED, and follow-up strategies after the February 6th earthquakes. It uses Koenig's 1996 START and SAVE triage algorithms to improve disaster patient management. This review critically evaluates the practicality of these recommendations in an ED setting by integrating a wide range of literature on these recommendations with empirical experiences of managing patients in EDs during the February 6th Kahramanmaraş earthquake. It also emphasizes the need, value, and areas for improvement of a comprehensive triage algorithm framework for future earthquakes and MCIs. The goal is to establish a disaster resource and improve protocol.

Medical Search and Rescue

Disaster Medical Assistance Teams, such as Turkey's National Medical Rescue Team (UMKE), a Type 2 Emergency medical teams by the World Health Organization, are vital to disaster search and rescue missions. UMKE, the 30th team worldwide to achieve this status, must stay motivated during disasters to reduce rescue times.[9] These missions are complicated, as shown by the 1988 Armenia earthquake rescues 13–19 days after event.[10] First, navigate collapsed structures and treat victims' medical needs, including intravenous (IV) or intraosseous hydration.[11] Quick intervention to reduce complications is essential for victims' health.[12]

Rescue teams transport injured patients to hospitals or call centers for coordination. Multiple victims were rescued from one location during the February 6th earthquake, demonstrating the efficiency of search and rescue while coordinated ambulances manage transportation. To avoid secondary injuries, cervical collars must be used during extraction. Türkiye conducts systematic search and rescue operations, including victim access, with medical personnel joining immediately. After the earthquake, the UMKE ATAK project improved medical team involvement in accessing victims, optimizing rescue, and providing quick, effective care.[13]

The Prehospital Process

Prehospital medical interventions stabilize earthquake survivors before hospital admission. Scene assessment, triage, critical injury primary examinations, on-site medical management, and victim transport to medical facilities occur during this phase.[14] Quick and effective prehospital care is crucial because "smiling death" refers to sudden clinical deterioration or death within 20 min of rescue.[15] Recent studies show that MCIs prolong this phase, emphasizing the need for careful management of potential complications such as significant bleeding, internal organ damage, fluid shifts, and reperfusion injury inflammation.[16] Improving outcomes and preventing further harm to earthquake survivors requires prompt prehospital intervention.

In civilian settings, pressure dressings, tourniquets, and hemostatic agents improve survival, reduce blood transfusions, and have few side effects when treating extremity bleeding.[17] Their efficacy, especially for life-threatening hemorrhages, is acknowledged despite limited evidence.[18,19] Hospital responses to MCIs must include blood transfusion strategies because early transfusions control deadly hemorrhages.[20] Comprehensive patient care requires ED disaster transfusion policies. Recently, normal saline, which is readily available and easy to store, is found as effective as packed red blood cells (RBCs) or lyophilized plasma for prehospital hemorrhagic shock management.[21] Resuscitative endovascular balloon occlusion of the aorta may help manage severe hemodynamic instability prehospital, but the research is limited.[22] Hemodynamic monitoring and fluid resuscitation are needed for organ injury-related bleeding.

Third spacing soon after entrapment causes early erythema and widespread edema as venous return from damaged areas stops. This fluid loss may worsen other dehydration.

Reperfusion of tissue after ischemia releases trapped cellular breakdown products, electrolytes, and biological mediators, causing local and systemic effects from crushed tissue damage and a systemic inflammatory response. After extrication, rapid systemic effects cause hypovolemic shock and other diseases. Tourniquets should only be used to control extremity bleeding prehospitally, as their use to prevent systemic toxicity is debatable. Tourniquets should not be used to isolate a crushed limb to prevent potassium and other cellular contents from entering circulation.[23]

In the prehospital phase of earthquake injury management, triage, blood pressure monitoring, cardiac monitoring, electrolyte balance assessment, fluid therapy, opioid or ketamine analgesia, and hypothermia management must adapt to environmental conditions. Nitric oxide (NO), an intracellular biomodulator, is studied for reducing mortality due to hypovolemia in trapped victims.[24-26] NO activates soluble guanylate cyclase to increase cyclic guanosine monophosphate production, relaxing smooth muscle, and vasodilating injured muscles.[27,28] NO regulates vascular diameter and blood flow, so excessive production may harm muscle and vascular health.[29] Although direct studies on NO's systemic effects are lacking, its potential to reduce earthquake victims' early mortality is acknowledged. Understanding hypovolemic shock and NO may lead to new disaster treatments, emphasizing the need for innovative approaches to improve survival rates.

Evacuation and Transport

After the February 6th earthquakes, Türkiye evacuated and treated injured people in multiple stages, especially in hard-hit provinces.[30] At first, local and field hospitals, including UMKE and international health forces, stabilized, and treated victims. Once stable, victims were transported to the less affected central provinces of Adana, Mersin, and Diyarbakir, including by sea [Figure 1]. Air transfers to Istanbul, Izmir, and Ankara were necessary to manage earthquake victims [Figure 2]. This novel three-tiered strategy, Türkiye's first disaster response strategy, has guided future disaster preparedness. In Diyarbakir, a major secondary transfer center, 61.0% of victims sought medical attention within 3 days, with 37.7% being transferred from affected areas. Mersin handled evacuees similarly, while Ankara hospitalized or treated and discharged many air-transferred patients.[31-34] This pattern of patient movement to central cities after the earthquakes shows the disaster's widespread impact and the need for better mass casualty evacuation and treatment.[35] Türkiye's experience has become part of emergency preparedness, emphasizing the need for structured, efficient disaster management.

Patient Identification and Tracking in Emergency Department

In the context of disasters, the identification of injured individuals, referred to as disaster victim identification, emerges as a crucial process for the management of victims following the event. This process encompasses their initial treatment, advanced interventions such as dialysis and surgery, informing the relatives of the injured, and managing the community response. The earthquakes on February 6th in Kahramanmaraş highlighted the pressing need for patient identification techniques that would improve ergonomics, safety, reliability, traceability, and the overall quality of care. Studies conducted during this period demonstrated that the mortality rate among patients who were not identified in the ED was higher compared to those who were identified.[36] Despite their numerous disadvantages, paper-based methods continue to be the most commonly utilized due to their simplicity in identification, triage, and documentation processes.

Emergency Department Triage

Disaster triage includes primary triage at the scene for initial intervention and transport, secondary triage in the ED for resuscitation and care area selection, and tertiary triage post-ED or before surgery/intensive care for critical care.[37] Quick evaluation to assign the right care within resource constraints is the goal. Triage systems' ability to optimize resource allocation or outcomes is unclear.[38] Recent studies emphasize the importance of integrating rapid intervention with triage to improve disaster response.[39]

Emergency triage in Turkey uses a five-category algorithm to classify patients under normal conditions. The START model, which integrates triage with emergency interventions for disaster management, creates a pretriage area at the ED entrance during disasters. This 1980 Newport Beach Fire Department and Hoag Hospital method provides structured and immediate patient care. Since the February 6th earthquakes, this model has been enhanced with the START-A concept, emphasizing the need for immediate pain management post-triage, reflecting an evolution in triage practices focused on rapid response and patient comfort [Figure 3].[25,38,40,41] Early, high-quality, safe analgesia is advised for MCIs.[39,42] Transmucosal fentanyl lozenges, inhaled methoxyflurane, and

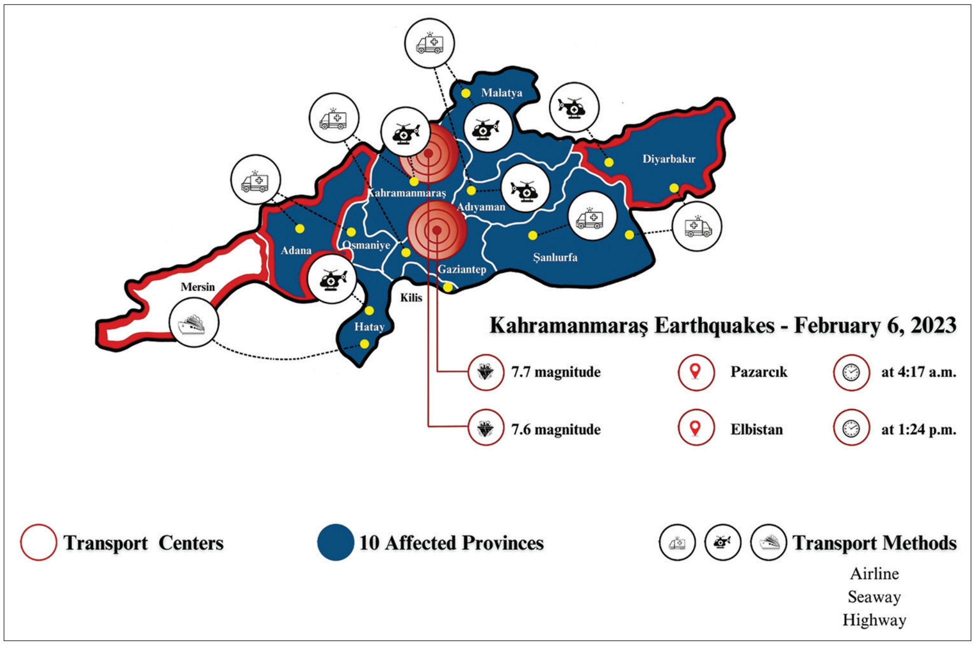

Figure 1: The local transportation strategy employed during the earthquakes in Kahramanmaraş, Turkey: Transport health centers

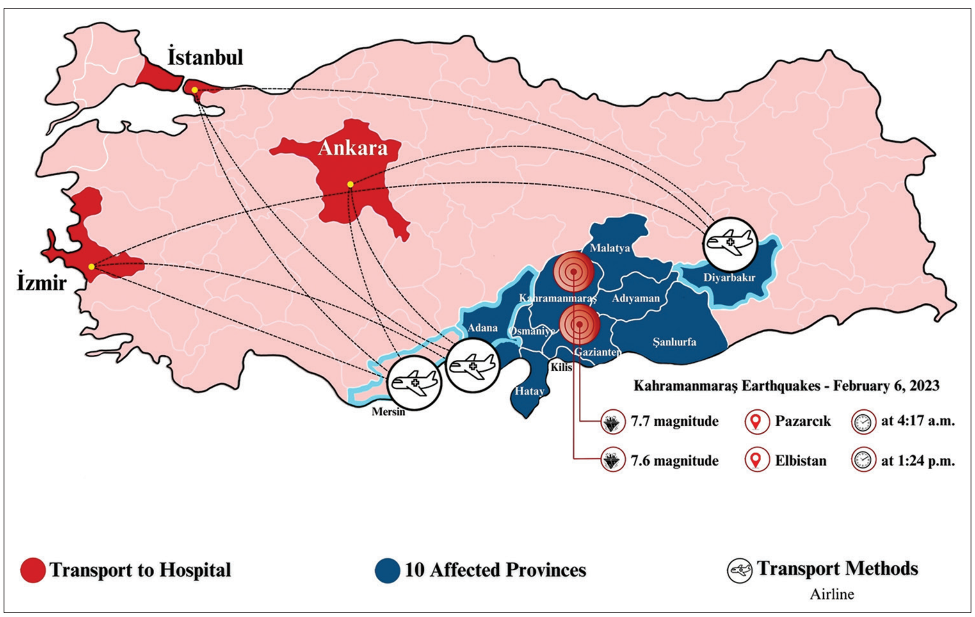

Figure 2: The national transportation strategy utilized during the earthquakes in Kahramanmaraş, Turkey

sublingual sufentanil may provide faster pain relief than IV morphine and ketamine.[24] MCIs are traumatic, so all options must be explored to reduce victims' suffering. Literature and field experiences support pre-triage, immediate intervention, and analgesia for resource management in EDs during large-scale emergencies.

Secondary Victim Endpoint Assessment in Emergency Department

In addition to START-A, which prioritizes patient analgesia, Koening proposed SAVE after START.[7] The SAVE team's main goal was to identify highly likely survivors at the scene while managing resources in the face of a high casualty count. The February 6th earthquakes caused so many casualties that the injured self-presented and deceased were brought to the EDs by the relatives.[2] On February 6th, researchers tested the SAVE algorithm in EDs for the first time.

SAVE uses the Mangled Extremity Severity Score (MESS) for crushed extremities, the Glasgow Coma Scale (GCS) for head trauma, and the Burn Triage Score (BTS) for burns.[7] According to transport center research, MESS

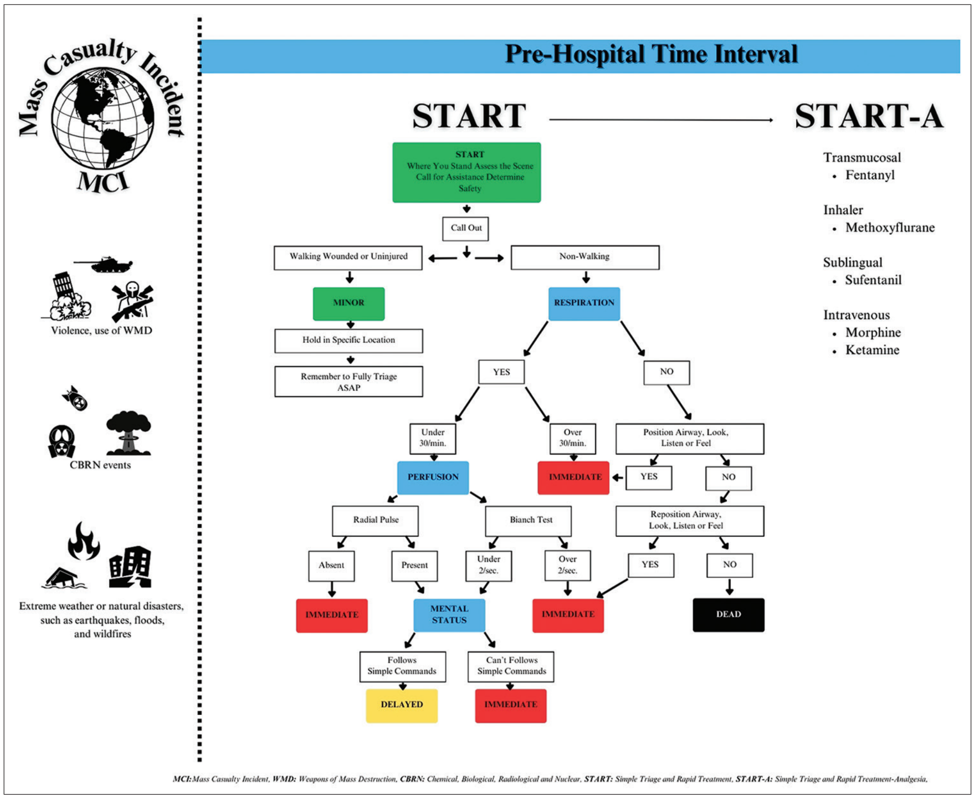

Figure 3: Model highlighting the need for urgent pain management after triage: Simple Triage and Rapid Treatment-A

may be useful for surgical triage of earthquake-related limb crush injuries.[43] The SAFE-QUAKE scoring system was introduced by a study emphasizing the importance of determining dialysis need in earthquake victims. This system, which considers entrapment duration (<45 h), pH levels (>7.31), creatinine levels (<2 mg/dL), lactate dehydrogenase levels (<1600 mg/dL), and alanine aminotransferase-to-alanine aminotransferase ratio (<2.4), has a 99.29% negative predictive value for excluding dialysis in earthquake-related injury cases. This scoring system may become a fourth parameter for SAVE, helping health-care providers identify disaster-affected patients at high risk of acute kidney injury (AKI) and dialysis [Figure 4].[44]

After the February 6th earthquakes, studies on patients reaching EDs by themselves or by ambulance showed that the START-A and SAVE algorithms can manage urgent surgical and dialysis needs. While research on the GCS for head trauma and the BTS postearthquake is still underway, Advanced Trauma Life Support® (ATLS®) and the American Burn Association have long recommended them for triage.[45] GCS-simplified neurological exams improve targeted head trauma assessments.[46] GCS, a key factor in earthquake trauma inpatient mortality, emphasizes the need for cautious initial resuscitation in patients with scores of 8 or better due to the high mortality risk in those with low GCS scores deemed unsuitable for treatment.[7,47,48]

SAVE's BTS is based on ABA guidelines for modern burn care and triage.[49] SAVE uses the ABA triage algorithm to guide patient management. In challenging conditions, a patient with burns covering up to 70% of the body surface area is considered nonsalvageable and requires significant medical resources and triaged to the "expectant area."[7] While not often reported in the February 6th earthquakes, tent fire victims experienced carbon monoxide poisoning and burns.[50]

The Modified SAVE algorithm (including GCS, MESS, BTS, SAFE-QUAKE) following START-A can help plan treatment outcomes for MCI patients in the ED. Use of START, START-A, and SAVE for primary, secondary, and tertiary triage allows rapid intervention and decision-making for post-MCI patient outcomes. SAVE triage and START-A can manage MCI ED resources.

Emergency Department Recognition of Crush Syndrome

Crush syndrome and rhabdomyolysis are often confused. Rhabdomyolysis breaks down muscle cells, releasing products that affect bodily functions. Muscle weakness, dark urine, with a history of muscle injury and serum creatine kinase levels five times the normal limit, often exceeding 5000 units/L, are used to diagnose rhabdomyolysis. Direct compression in

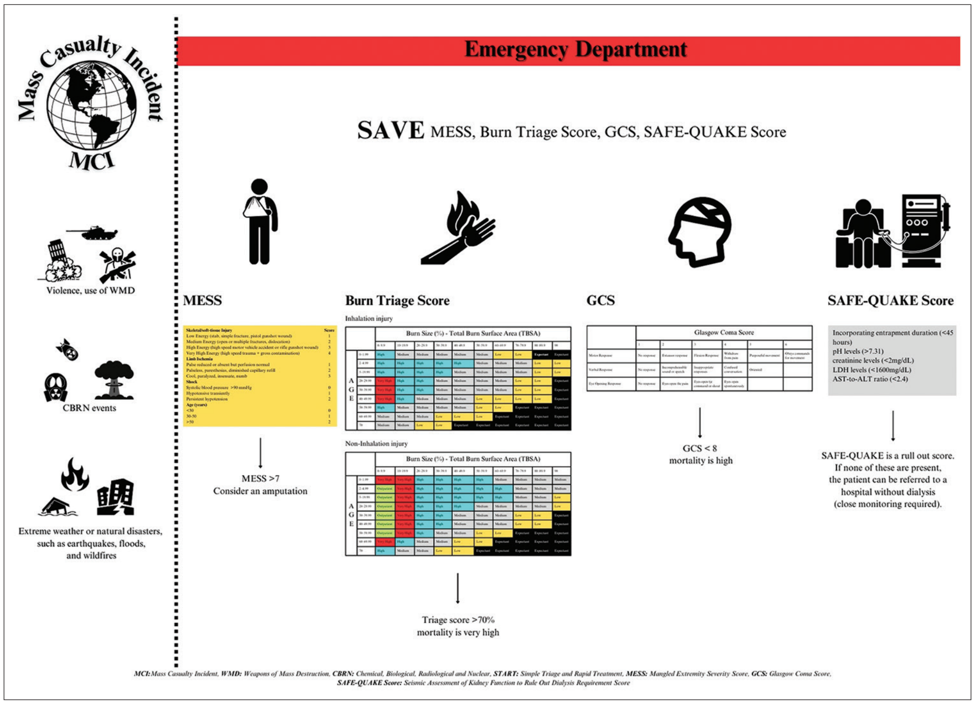

Figure 4: Developed after the February 6 earthquakes, secondary assessment of victim endpoint

earthquakes causes Crush syndrome, muscle crushing from prolonged entrapment. Similar muscle breakdown and kidney damage can cause renal failure. This includes acute respiratory distress syndrome, dysrhythmias, coagulation disorders, hypovolemic shock, and psychological trauma.[51] Compressive forces and myoglobinuria, indicated by a positive heme on urine dipstick with fewer than 5 RBCs microscopically, are used to diagnose both conditions.[52,53] For proper patient care, health-care professionals must be aware of these distinctions for ED diagnosis and treatment.

Dialysis for Emergency Department Crush Syndrome Patients

Before the February 6th earthquake, research showed that following earthquakes over 6.4 magnitude, the death-to-injury ratio could vary between 1:2.5 and 3.0, depending on local conditions, with 2%–20% of injuries potentially causing Crush Syndrome.[54-57] The need for post-earthquake dialysis may be underreported.[34] Earthquake victims develop acute tubular necrosis and AKI due to Crush syndrome, hypotension, and hypoperfusion caused by heme, myoglobin, and urate crystal.[58]

Rhabdomyolysis, hyperkalemia, hyperphosphatemia, and myoglobinuria in Crush Syndrome-related AKI strain hospitals and dialysis centers. After a disaster, dialysis demand increases, requiring surge plans, medical equipment, and possibly victim relocation. In Crush syndrome AKI cases, SAFE-QUAKE's SAVE algorithm and the Turkish Kidney Foundation recommend rapid assessment and liberal dialysis indications.[11]

Dialysis criteria include serum potassium above 6.5 mmol/L, severe acidosis, elevated blood urea nitrogen and creatinine, uremic syndrome symptoms, and persistent oliguria or anuria after fluid resuscitation. These guidelines help earthquake victims make informed dialysis decisions and emphasize the importance of early detection and monitoring to reduce mortality. International Society of Nephrology's Renal Disaster Relief Task Force promotes early dialysis need identification during disasters.[59] Clinicians collaborate with disaster relief teams in EDs to provide effective patient care and management after such events.

Emergency Department Crush Injury Management

Earthquakes can cause severe fractures, internal organ damage, Crush syndrome, burns, extremity injuries, abdominal and head injuries, and thoracic trauma.[60] Sarı *et al*. found that extremity wounds were most common among survivors of all ages trapped under rubble after the February 6th earthquakes.[32] Compression, muscle mass, and duration determine the severity.[61] Entrapment causes extremity injuries in adults and children after earthquakes, requiring more surgery than other traumas.[62,63] After an earthquake, crush injuries, which include bone and soft-tissue trauma, are among the most serious injuries. Initial treatments focus on controlling hemorrhage from penetrating injuries and hemodynamic stabilization, including immobilizing the injured extremity and cervical spinal segments with cervical collars.[64] Significant bleeding requires multidisciplinary treatment and immediate stabilization by vascular surgeons.

Extremity crush injuries can cause acute compartment syndrome, which threatens limb viability. Preventing limb loss requires early detection and treatment. The main treatment for compartment syndrome is fasciotomy. However, resource constraints and the risk of poor outcomes and infection have led to a conservative approach to fasciotomy postearthquake.[65,66] Fasciotomy in earthquake-induced AKI doesn't increase mortality but does affect dialysis duration and sepsis.[67] Even in disasters, fasciotomies should be done in operating rooms to save time and improve wound care.[68] Fasciotomy is reserved for acute compartment syndrome with severely reduced or absent distal pulses. Resource availability and unnecessary procedures must be considered. Late intervention and prophylactic fasciotomy for severe crush injuries are discouraged due to the high risk of widespread myonecrosis. In resource-limited settings, fasciotomy should be performed cautiously, and patients should be monitored for wound sepsis, rhabdomyolysis, and renal failure.

Amputation and systemic complications in early treatment of severe injuries are most often predicted by the MESS severity score.[69] The MESS assesses injury severity based on skeletal and soft tissue damage, limb ischemia, duration, hemorrhagic shock, and age. The reliability of MESS postdisaster, especially after mass ED presentations, is limited, but research post-February 6th suggests that MESS may be useful for surgical triage of earthquake-related limb crush injuries.[42] After February 6th, 26% of Crush syndrome patients were amputated due to prolonged rubble isolation, poor circulation, or severe muscle necrosis.[70]

MESS scores aid surgeons' reasoning in making limb salvaginge decisions. Age, shock, tissue damage, and circulation are assessed. MESS scores above 7 often predict limb loss, suggesting amputation, while scores below 7 favors limbs saving, and possibly requiring fasciotomy. Amputation may increase during mass casualty events due to resource constraints.[7,23] Disaster decision-making requires surgery staff and equipment planning.

Diagnostic Processes and Management in the Emergency Department Amid Disasters

EDs are vulnerable to patient influx and disaster-related issues such as power outages, equipment damage, and staff shortages. Point-of-care technologies such as electrocardiogram, blood glucose measurement, bedside ultrasonography, and blood gas analysis are crucial now.[71] When conventional laboratory services fail, these technologies are essential for patient care.

To treat critically ill disaster victims, electrolyte levels, complete blood count, and coagulation profiles must be assessed. Modern analyzers measure pH, the partial pressure of oxygen (pO_2), the partial pressure of carbon dioxide (PCO_2), bicarbonate (HCO_3), glucose, and electrolytes in arterial and venous blood gas samples.[72-74] These bedside tools allow quickly identifying and treating life-threatening imbalances, reducing the need for extrastaff. These analyzers assess respiratory parameters to determine prognosis and plan respiratory care. Emergency patient care is improved by including such analyzers in ED disaster preparedness.

Disaster-stricken areas lack facilities, equipment, and personnel, increasing bedside imaging demand. Bedside ultrasonography, including Focused Assessment with Sonography for Trauma, was effective after Hurricane Katrina, 9/11, the 2006 Lebanon War, and the 2010 Iran earthquake.[75,76]

Emergency Department Fluid Therapy Management

IV fluid treatment is essential for disaster victims who received inadequate field treatment. Isotonic solutions are preferred because overhydration can cause hyperchloremic metabolic acidosis, so hypotonic or hypertonic crystalloid solutions should only be used in cases of hypernatremia or hyponatremia, respectively.[76,77] Using vital signs and urine output as indicators for fluid therapy, crystalloids should be given at 15–20 mL/kg/h for children and adults (and 10 mL/kg/h for older adults).[78] Bedside ultrasonography can measure the inferior vena cava diameter instead of central venous pressure to assess fluid status.

Conclusion

The February 6th Kahramanmaraş earthquakes damaged Türkiye, but left a unique legacy for disaster preparedness and response in the disaster literature differentiated by its emergence, affected population, and management. A comparison of this earthquake with past earthquakes and their management algorithms suggests a new ED management algorithm. On-field earthquake management protocols are well-documented in the literature, but the pre-hospital phase, ED process, in-hospital management, and referral processes following START Triage and modified with SAVE for referral strategies are complementary and form a cohesive whole [Figure 5].

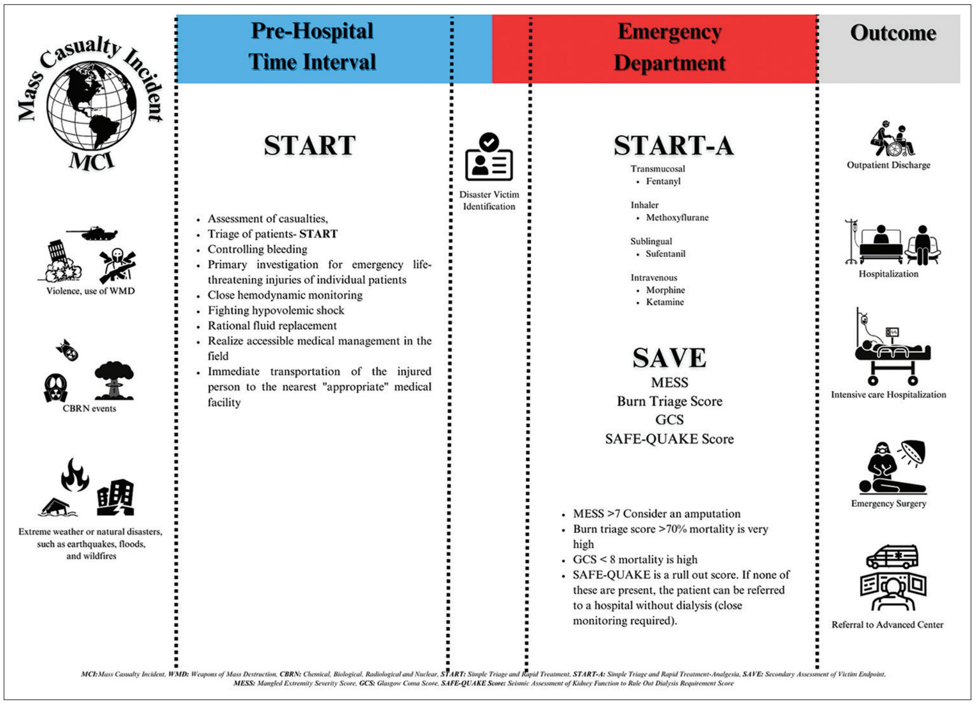

Figure 5: Emergency department management: Integrated algorithm for enhanced mass casualty incident response

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Author contributions

SY: Conceptualization, methodology, investigation, software, resources, data curation, writing – original draft, review and editing, supervision. ACT: Conceptualization, methodology, investigation, software, resources, data curation, writing – review and editing. OK: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. MT: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. NU: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. MI: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. DP: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. MMY: Conceptualization, methodology, investigation, software, resources, data curation, writing – supervision. SY: Conceptualization, methodology, investigation, software, resources, data curation, writing – original draft, review and editing, supervision.

Conflicts of interest

None declared.

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