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Critical care transport and management in Earthquake catastrophes: Lessons from Japan

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ABSTRACT:

Japan's experience with large-scale earthquakes has led to the development of a highly structured and adaptable disaster response system. This review highlights key lessons in critical care transport and disaster management from historical events such as the Hanshin-Awaji Earthquake (1995), and the East Japan Triple Disaster (2011). The "Point-Line-Plane" framework categorizes disasters by their geographical scale and helps guide tailored medical strategies. Critical care and emergency physicians must navigate the challenges posed by each disaster type, including triage, evacuation logistics, and continuity of care for vulnerable populations. The importance of Disaster Medical Assistance Teams (DMATs), staging care units, air transport, and chronic care networks in disaster response is highlighted. Previous experiences also emphasize proactive planning, multidisciplinary coordination, and robust healthcare infrastructure for better outcomes.

Keywords: Earthquake; Critical care; Transport; Catastrophes

INTRODUCTION

The World Health Organization (WHO) defines a disaster as a sudden ecological event of sufficient scale to overwhelm local resources and necessitate external aid [1] with varying types (e.g., natural, man-made) and distinct characteristics and responses [2]. The March 28th earthquake which impacted several areas in Thailand and Myanmar, including several hospitals [3], exposed a lack of preparedness across sectors, particularly in evacuation risk assessment, patient transport, and managing subsequent complications. This review presents the key insights into disaster medicine and roles of critical care physicians based on Japan's extensive experience with large-scale earthquakes.

DISASTER SEVERITY CLASSIFICATION

Natural disasters require medical needs which vary significantly depending on the scale of disaster. These disasters could be divided into 3 groups as following:

- Point disasters represent a specific location affected by a disaster such as fires, traffic accidents with immediate focus on patient survival, immediate needs (first aid, evacuation, prevention of secondary injuries), and localized response efforts.
- Line disasters represent affected area as line or belt shaped such as tsunamis, tornadoes, and typhoons. These situations necessitate rapid evacuation and setting up shelters. Since shelter life is often expected to be prolonged, continuous care including food, water, hygiene, and environmental comfortability should be established through to the recovery phase.
- Plane disasters represent large-scale disasters affecting multiple regions or infrastructure networks (e.g., widespread floods, wars, major earthquakes) requiring extensive multi-agency aid for transportations, logistics, and preventing secondary damage.

Earthquakes are one of the most lethal types of natural disaster causing approximately 820,000 deaths globally since 2000 [1]. Their severity presents challenges beyond immediate infrastructure damage and resource scarcity, extending to long-term healthcare needs (including infectious disease prevention and chronic care) requiring sustained multi-organizational efforts. The incident in Bangkok on March 28, 2025, serves as an example for "Point" disaster, where a building under construction collapsed with construction workers trapped under the debris due to an earthquake. The same earthquake which originated from Myanmar caused significant damage to an entire region near Mandalay and illustrates Plane disaster which required regional coordination and comprehensive preparedness strategies.

KEY MESSAGES:

Drawing from experiences with large earthquakes like the Hanshin-Awaji and East Japan Triple Disasters, Japan has built an adaptable disaster response system, "Point-Line-Plane" framework to guide medical strategies. Emergency and critical care physicians must navigate challenges of limited resources to maximize the outcome, relying on multidisciplinary coordination, robust infrastructure and proactive planning for effective disaster responses.

PROBLEM 1: ISOLATED DISASTER ("POINT" DISASTER)

Isolated disasters emphasize the need for operational zones to ensure structured and safe emergency response. Effective management involves search and rescue, patient stabilization, and systematic triage with color-coded areas of care for prioritizing victim transport to appropriate medical facilities [2] (Figure 1). These principles of systemic priority response are essential parts of Medical Management and Support (MIMMS) system [3] (Figure 2).

Lesson 1: The Amagasaki Rail Crash (April 25, 2009)

The Amagasaki rail crash occurred during the morning rush hour, resulting in 107 deaths and 562 injured. In response to this mass casualty incident, 20 Disaster Medical Assistance Teams (DMATs) were dispatched to provide emergency medical support (Figure 3).

Transportation modes:

The relief effort involved 10 helicopters, 117 ambulances, 140 privately owned volunteer vehicles, and 102 police

Colour-coded Triage Categories	
Red	• **First priority** • Life-threatening shock or hypoxia (can likely be stabilized and, if given immediate care)
Yellow	• **Second priority** • Injuries with systemic implications, but not yet in life-threatening (likely wait 45-60 minutes without immediate risks)
Green	• **Third priority** • Localized injuries without systemic implications (unlikely to deteriorate for several hours)
Black	• **Dead**
Blue	• **Catastrophically injured** • Slim chance for survival regardless of care (some categorized as "Black")

Figure 1. Illustrated the color-coded categories depending on injury severity and prognosis. Beyond the patient's immediate condition and urgency, triage should consider prognostic factors like age, pre-existing conditions, alongside with resource availability.

CSCATTT for disaster response	
Command & **C**ontrol	Overall Command of operations **Medical command** : managing the medical aspects
Safety	Self (rescuers), Scene, Survivors
Communication	Communicate between command roles **Options** eg. Verbal, Speaker, Landlines, Radio, Hand signals, Internet
Assessment	Establish magnitude of the incident & resources required
Triage	Prioritizes casualty evacuation & treatment **Primary** : Priority of evacuation (from scene) **Secondary** : Priority of treatment (at treatment area)
Treatment	Deliver care to sustain the casualties for evacuation under limited resources
Transport	Transport to treatment facilities Platforms considered according to distance, capacity and severity (Ground, Air, Water)

Figure 2. Illustrates the CSCATTT principle to enable effective management of the medical aspects of major incidents as part of the Medical Management and Support (MIMMS) system.

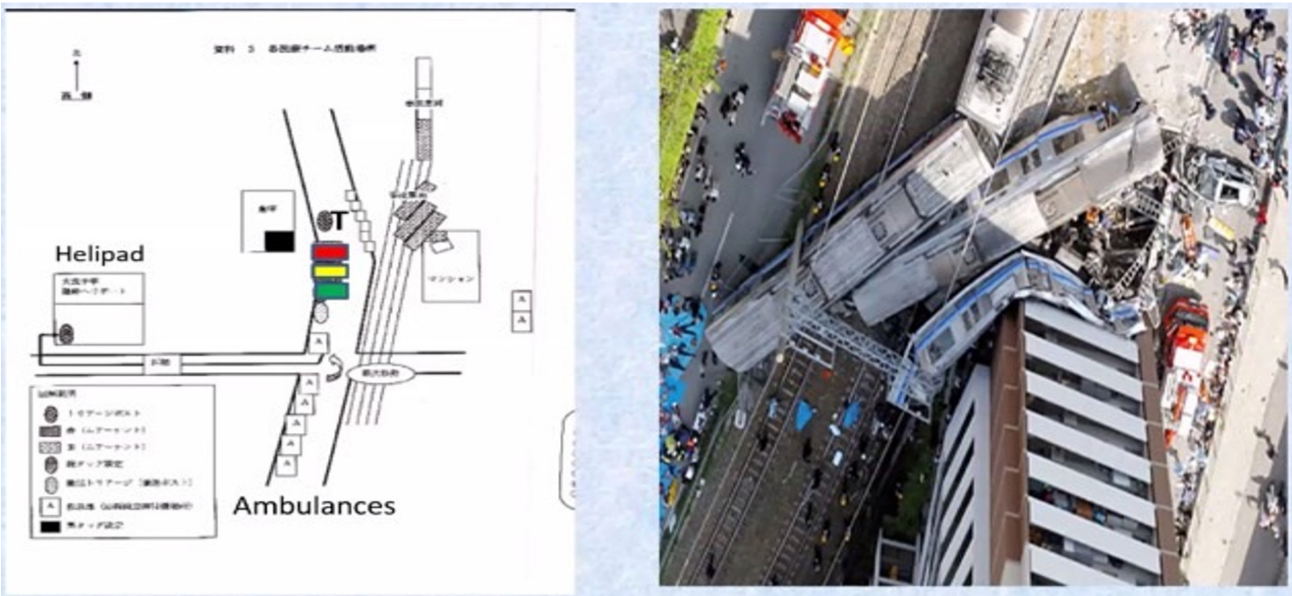


Figure 3. Illustrates the layout of emergency response zones at the crash site, highlighting key positions such as the helipad, ambulance access routes, and color-coded triage areas. The accompanying aerial image captures the crash scene, including the coordinated rescue operations.
Source: (Left) Report of the investigation committee of the Society of Disaster Medicine (Japan); (Right)The Asahi Shimbun

vehicles, including buses. There were 33 secondary inter-hospital transfers, reflecting the complexity and scale of patient redistribution.

Conclusion of operations:

The incident occurred at 09:18 on April 25. The first EMS team arrived at 09:24 and by 10:01, the Hyogo Emergency Medical Center (HEMC) team established a triage post. Medical teams provided critical interventions including fluid resuscitation, chest drainage, hemostasis and ventilatory support. At 07:08 on April 26, the final survivor was successfully rescued. Nearly 24 hours after the crash, all medical teams had completed their operations and withdrawn from the site.

In total, the response included 51 doctors, 41 nurses, and 13 paramedics. Notably, three severely trapped victims received critical interventions, including intravenous fluids, medications, and endotracheal intubation while still under debris. The case highlights the utility of point-of-care testing (POCT) and rapid diagnostics in confined and urgent conditions.

Lesson 2: The Fukuchiyama Fireworks Explosion (August 15, 2013)

On August 15, 2013, a gas explosion during riverside fireworks festival in Fukuchiyama caused 3 deaths and 59 injured.

Limitations on this event:

On-site triage efforts were hindered by the dark and narrow environment, rendering initial medical response ineffective.

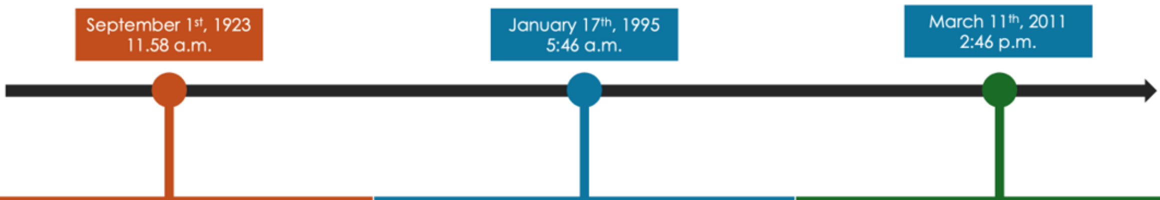
Conclusion of operations:
At 19:50, 7 DMATs were dispatched. A total of 55 victims were transported to City Hospital, the only tertiary care facility in the region. Inter-hospital transfers, prioritized by triage severity, commenced at 21:45 and were completed by 01:00 the following morning.

PROBLEM 2: MAJOR EARTHQUAKES ("PLANE" DISASTERS)

Drawing lessons from past events, particularly the Great Kanto Earthquake, the Great Hanshin-Awaji Earthquake, and the Great East Japan Earthquake, has been crucial in strengthening Japan's disaster management capabilities [4]. These earthquakes mark significant turning points of Japan's disaster response strategies (Figure4).

Lesson 1: The Kanto Great Earthquake (1923)
Occurred during a time without organized emergency medical services (EMS) and the military played crucial roles instead in crisis management. Resulted in over 105,000 deaths with 90% of the victims perished in fires. In response, the government advocated for new city planning and progression of earthquake research.

Lesson 2: The Hanshin-Awaji Great Earthquake (1995)
Caused extensive infrastructure damage in concentrated areas including surface transportation which hindered EMS operations and resulted in over 6,400 deaths [5] (Figure 5). In response, Japan established Disaster Medical Assistance Teams (DMATs) with a national network of disaster base hospitals and communication liaisons along with air transport network. These efforts were further supported by the founding of the National Hospital Organization (NHO) Disaster Medical Center to advance research in disaster medicine.



Great Kanto Earthquake	Great Hanshin-Awakji Earthquake	Great East Japan Earthquake
Magnitude of 7.9	Magnitude of 7.3	Magnitude of 9.0
105,000 Deaths (90% from burn injuries)	5,500 Deaths (Mostly crush/suffocated)	18,000 Deaths (90% from drowning)
290,000 houses destroyed	110,000 houses destroyed	120,000 houses destroyed
Economic damage 5.5 billion yen (37% GDP)	Economic damage 9.6 trillion yen (2% GDP)	Economic damage 16.9 trillion yen (3% GDP)
Fire in concentrated areas No EMS systems	**Ground transport collapsed No Air transport system**	**Tsunami Nuclear power plant accident**

Figure 4. Summarizes the major earthquakes in modern Japanese history and their respective impacts on disaster planning.

Figure 5. Illustrates the central area of Kobe City (Hanshin Awaji Express Highway) with high-density urban layout greatly intensified the 1995 disaster's impact on transportation and emergency accessibility.
Source: Kyodo News (An information medica of Japan)

Disaster medical assistance team (DMAT):

Disaster Medical Assistance Teams (DMATs), typically composed of four to five doctors, nurses, and allied health staff, are rapidly deployed to disaster zones to deliver immediate medical care [6]. These mobile units also collect medical intelligence to guide response strategies, including rescue and evacuation efforts.

The role of the Japanese Society for Intensive Care Medicine (JSICM) in disaster response:

Following the Hanshin-Awaji Earthquake, JSICM developed an information network among its members to enhance emergency medical coordination. It functioned as a hub for managing inter-hospital transfers from disaster-affected areas and reported ICU availability within 48 hours after the disaster.

Lesson 3: The East Japan Triple Disaster (2011)

The triple disasters involved a massive earthquake, followed by a tsunami and a nuclear power plant accident. Most infrastructure including medical institutions became non-functional, highlighting the urgent need for long-distance patient transport systems. A comprehensive patient transfer system was deployed [7-9].

During the acute phase:

In the immediate aftermath, the focus was on treating traumatic injuries and providing continued care for refugees (particularly those with chronic illnesses) and large-scale evacuation. After the tsunami, identification of deceased individuals also took priority. Regarding nuclear contamination, rapid evacuation was imperative, but defining a safe evacuation radius proved to be challenging.

Patient evacuation and transport:

Many vulnerable populations such as elderly patients were relocated hastily without adequate planning resulted in over 100 deaths either during transit or within 18 months of the evacuation. Further challenges arose from the limited air transport. Sendai Airport, a critical logistics hub, became inoperable for 33 days post-disaster, delaying essential relief and medical transfer operations. This underscores the necessity for tailored-designed emergency strategies and the establishment of staging care units.

Staging care unit:

The Staging Care Unit (SCU) served as a designated area where personnel, vehicles, or aircraft can pause for rest, resupply, and the transfer of patients during extended disaster operations (Figure 7). The units were implemented at 2 Airports and a military base as intermediate hubs for organized evacuation of patients from affected zone [10]. This effort is further strengthened by active cooperation with the Air Force for inter-agency disaster response operations.

Air transport:

Air transport plays an essential role in geographically isolated areas for timely evacuation, medical support, and relief delivery (Figure 8). In addition, drones have emerged as innovative tools, offering rapid delivery of medications, aerial surveillance capabilities, and logistical support at Noto Peninsula Earthquake in 2024.

Adaptation to TSCCM (Thailand context):

Lessons from the Japanese disaster response system may be adapted to the Thai Society of Critical Care Medicine (TSCCM) by strengthening national ICU bed availability reporting, establishing a centralized critical care coordination platform, and formalizing the role of intensivists in disaster command structures. The integration of critical care transport networks, rapid response teams, and inter-hospital communication systems would significantly enhance Thailand's preparedness for future large-scale disasters.

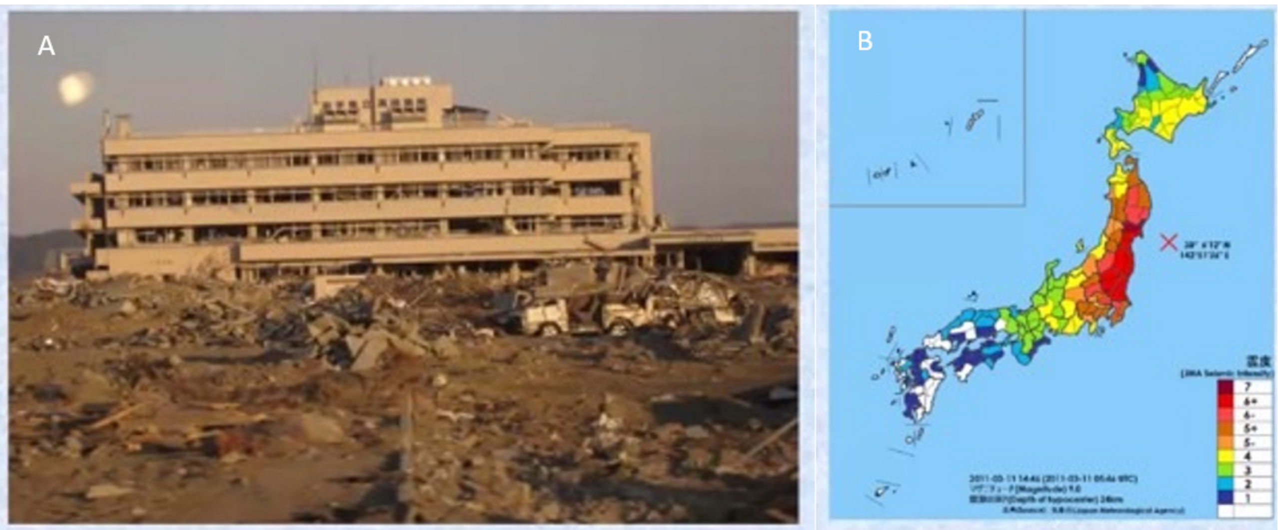


Figure 6. (A) Takaka hospital building effected by the tsunami and was rendered non-functional. (B) The origin of the earthquake from the east coast of Honshu with vast areas of eastern Japan effected by the triple disaster tsunami and nuclear reactor accident.

Source: (A) Picture taken by a dispatched medical personel; (B)Wikipedia: 2011 Tohoku earthquake and tsunami

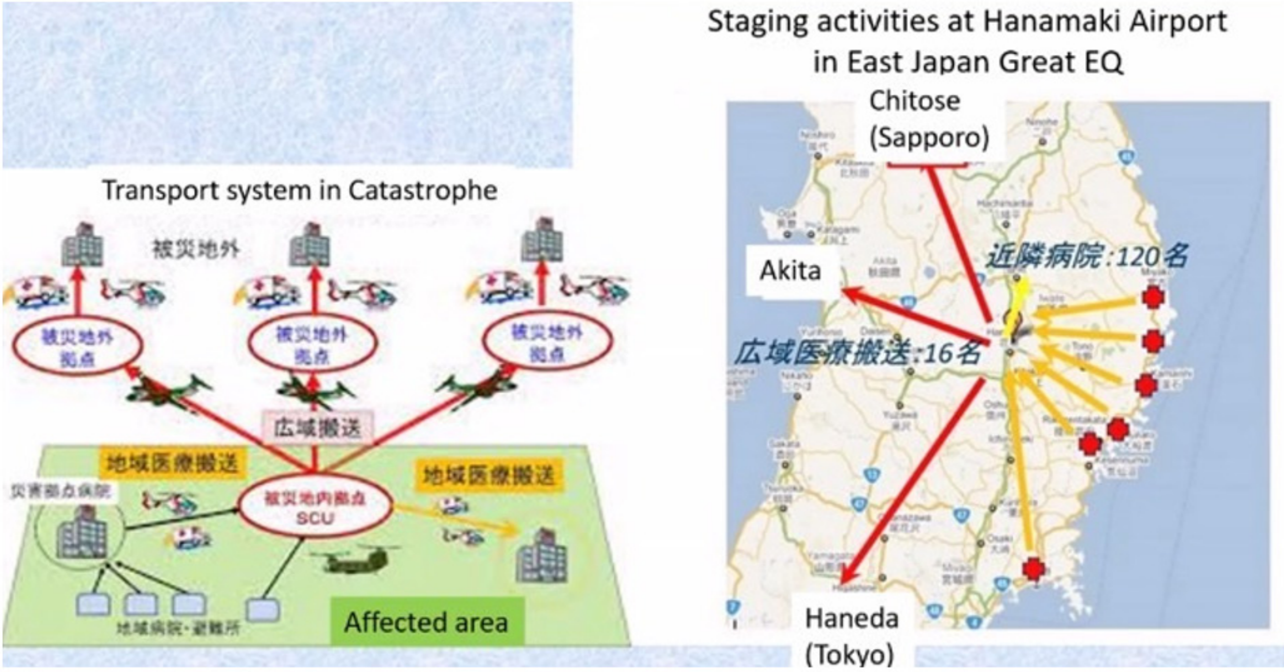


Figure 7. Illustrates Staging Care Unit (SCU) including maps and diagrams that illustrate the medical transport system connecting the disaster area to regional hospitals in Akita, Chitose (Sapporo), and Haneda (Tokyo).
Source: (Right) Japan Red Cross Wakayama Medical Center News. CSCATTT トランスポート（搬送）②｜日赤和歌山情報局 Hot（ほっと）｜日本赤十字社 和歌山医療センター ; (Left) Ichi Medical Center Disaster Manual.<4D6963726F736F66742057 6F7264202D208744967B95B6814091E693F18EED837D836A83858341838B8140>

Figure 8. Illustrates different models/units of helicopter transport during disasters in Japan. Dr. Heli: A specialized medical helicopter for injured patients; Fire Department Helicopter: A multi-purpose aircraft utilized for rescues and logistical support; CH-47 "Chinook": A military transport helicopter for logistics and personnel movement; U.S. Forces Support: Relief supplies delivered by U.S. military aircraft, demonstrating international cooperation.

Continuity of chronic care:

The Great East Japan Earthquake posed significant challenges to vulnerable patients requiring chronic care such as hemodialysis. Only 14% remained operational in Miyagi prefecture [11]. The Japanese Society for Dialysis Therapy (JSDT) utilized a nationwide network system and enables real-time information sharing, resource reallocation, and safe transfer during disasters. Mobile Pharmacies were also mobilized to serve as on-site pharmaceutical units, helping bridge the last-mile gap by delivering medications directly to effected areas.

Continuous improvement in disaster management planning:

The Noto Peninsula Earthquake (2024) is recognized as a significant seismic event with over 240 mortalities [12]. Several operational issues such as infrastructure disruption including limited air transport due to Poor weather conditions and insufficient available landing zones. The prefectural disaster response plan also had not been updated, exposing gaps in preparedness. It underscores the urgent need for resilient infrastructure, updated disaster management plans, and flexible, multi-modal transport strategies to ensure an effective response.

Role of Critical Care Medicine Teams during major disasters:

Critical Care Medicine Teams play a pivotal role in disaster response beyond conventional ICU care. During large-scale disasters, intensivists and anesthesiologists are essential in managing ICU surge capacity, reallocating limited critical care resources, and supporting resuscitation efforts in high-acuity zones (red areas). Their expertise is particularly critical when large numbers of patients require immediate surgery, mechanical ventilation, or advanced hemodynamic support.

In such settings, anesthesiologists and intensivists often provide frontline resuscitation for unstable patients awaiting urgent surgical intervention, ensuring physiological stabilization prior to definitive care. Rapid Response Teams (RRT) and Critical Care Outreach Teams further extend critical care expertise to emergency departments, operating rooms, shelters, and general wards, helping to prevent clinical deterioration and reduce preventable mortality.

These multidisciplinary critical care systems, when integrated into national disaster plans, enhance resilience and continuity of care throughout all disaster phases.

CONCLUSION

Japan's earthquake history offers critical insights into managing large-scale disasters with complex healthcare demands. The Point–Line–Plane disaster framework provides a practical model for disaster planning across different scales of impact. Large-scale events require robust systems for long-distance patient transport, ICU surge capacity management, continuity of chronic care, and strong multi-agency coordination.

Recent disasters have revealed persistent gaps in transport logistics, infrastructure resilience, and outdated preparedness plans, underscoring the need for continuously updated and adaptable disaster strategies. Critical care physicians, anesthesiologists, and intensivists must actively engage in disaster preparedness, contribute to scalable critical care system design, and collaborate across disciplines to maintain standards of care during catastrophic events.

ACKNOWLEDGEMENT

None

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