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A New Method of Matrix-Based Triage for Nuclear Disasters

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Abstract

During nuclear disaster, infrastructure is severely damaged and injuries are often combined with trauma/burns and whole-body radiation. This makes triage difficult, especially when resources are severely deficient. To solve this problem, in this article, the authors have suggested a new less technology-dependent radiation dosimetry and quick triage using a specially designed triage matrix during nuclear disasters.

Keywords
- rapid triage
- clinical radiation dosimetry
- nuclear disasters

Nuclear disaster may occur due to explosion/problems in reactors, for example, the Fukushima Daiichi nuclear disaster[1] and Chernobyl disaster,[2] or atom bomb blast. These can cause human extinction.[3] Radiation exposure in disaster situations may be external, internal (inhalation, ingestion, or absorption via a contaminated wound), or a combination of both. The World Health Organization (WHO) supports the assessment of preparedness and development of national plans to address the critical capacity gaps for natural, planned (medical, occupational), or accidental situations (https://www.who.int/news-room/questions-and-answers/item/radiation-and-health?gclid=Cj0KCQjwnMWkBhDLARIsAHBOftonagJEg7V_zondRLBaQtTKlVN-Dr3cQPwe1lT1QFe5lqygconT1qQaAggNEALw_wcB).

When a victim is exposed to more than 0.3 Gy or 30 rad of whole-body radiation in a short time, acute radiation syndrome (ARS) occurs.[4–7] Three types of ARS have been advised (https://www.cdc.gov/nceh/radiation/emergencies/arsphysicianfactsheet.htm):

- **Bone marrow syndrome** (hematopoietic syndrome): The full syndrome will usually occur due to destruction of the bone marrow with a dose between 0.3 and 10 Gy (30–1,000 rad); severity of ARS is dose dependent. This results in reduced count, infection, and hemorrhage.
- **Gastrointestinal (GI) syndrome:** This occurs due to GI tract changes, and bone marrow changes in mild form may occur at as low as 4 to 6 Gy, but the full syndrome usually occurs at 10 Gy (1,000 rad). Survival is extremely unlikely.
- **Cardiovascular (CV)/central nervous system (CNS) syndrome:** The full syndrome due to collapse of the CV system and increased intracranial pressure following cerebral edema and increased intracranial fluid occurs with a dose greater than 10 to 50 Gy (5,000 rad). Death occurs within 3 days.

Depending on the level of exposure, the recovery process lasts from several weeks to up to 2 years.

With increased power struggle and greed to become a superpower, there is increased risk of nuclear disasters. Recent conflicts between various nuclear powers have increased the risk further. Drawing from past experiences in disaster management, it is widely recognized that inadequate financial support, limited infrastructure resources,

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Table 1 Important clinical sign and symptoms, significant changes in blood cell count, and prognosis at different radiation exposure doses

Exposure dose (Gy)	Whole body radiation exposure following nuclear blast				
	≤2	>2–4	>4–6	>6–10	>10
Important signs and symptoms	Nausea and vomiting for ≤2 d	Nausea and vomiting for >2 d	Bloody diarrhea ≤4 d	Bloody diarrhea >4 d	CNS symptoms soon after exposure
Second day lymphocyte count	No significant change	Significantly low	Significantly low	Significantly low	Expires within hours after exposure
9th day platelet count	No significant change	No significant change	No significant change	Significantly reduced	
10–14th day survival	Survival certain	Survival possible	Survival unlikely		

absence of well-defined plans, and a dearth of effective leadership and organizational support can exacerbate the magnitude of losses. Nuclear disaster presents an even more complex disaster situation as it leads to damage of infrastructure (transport, health care, lack of radiation protection for personnel) in wider areas, exposure to radiation, injuries due to blast, and burn due to damage to petrol pumps, etc., leading to fire. Hence, thorough preparedness is needed to minimize damage.[4] The need for a humanitarian global work force[8] and provision of emergency funds for nuclear disasters cannot be overemphasized.

Depending on the exposure dose of radiation, various complications like hematological changes, infection, GI losses of fluid and electrolytes, bleeding, and immunosuppression can occur. Survival is unlikely at radiation exposure dose of between >4 and 10 Gy and survival is impossible at radiation exposure above 10 Gy due to central nervous system damage. Hence, triage of victims becomes difficult as minor injuries with radiation exposure of 10 Gy, and victims with larger area burn or injury with radiation exposure of <2 Gy may survive. Hence, to maximize survival with minimal wastage of resources, quick dosimetry with minimal use of technology is desirable in disaster situations[4] (►**Table 1**).

Triage of combined burn injury and radiation-induced injury has been classified as minor, moderate, and major combined injury by Kumar and Jagetia.[4] They suggested that initially triage of thermal and other injuries and treatment should be done as in other disasters, because signs of radiation and radiation dosimetry may take a few days. All bum victims of combined thermal and radiation injury should undergo hematological evaluation for approximate radiation dosimetry for deciding prioritization of patient care. In victims of combined thermal, radiation, and other injuries, priority should be decided after evaluating the other injuries (like severe abdominal, thoracic, and head injury) carefully.

To simplify triage further, a two-step triage would help save more lives:

- *First triage:* Thermal and other injuries as in other disasters.
- *Second triage:* Second triage will be done after symptoms and signs of radiation exposure become apparent and the result of radiation dosimetry is available. Less technology-dependent quick dosimetry will be useful as advised by Kumar and Jagetia.[4]

For the second triage, it is better to have a specially designed nuclear triage matrix (►**Fig. 1**). A triage matrix should be made for each patient with the status of the patient marked on the printed matrix form by an experienced/treating physician. Now designated persons like nurses and paramedics may shift to the area that will be marked on the matrix form for management of that type of patients. Victims of severe injury and patients with radiation exposure ≥4 to 10 Gy should receive symptomatic treatment and least priority. The senior author, after having practiced clinical medicine, believes that we cannot leave patients alone or eliminate any patient in disasters in usual situations.

The broad treatment plan in different triage areas (TAs) will be as follows:

- TA 1: First priority for definitive treatment.
- TA 2: Second priority for definitive treatment.
- TA 3: Third priority for definitive treatment.
- TA 4: Fourth priority for definitive treatment.
- TA 5: Fifth and sixth priority (initial symptomatic treatment).
- TA 6: Seventh, eighth, and last priority (initial symptomatic treatment; >4–10 Gy exposure with any total body surface area [TBSA] burn).

Till adequate resources are available, victims (selected for TA 5 and 6 in the matrix form shown in ►**Fig. 1**) who are unlikely to survive or are certain to die must be taken to a separated zone (TA 5 and TA 6) for symptomatic treatment to minimize the sufferings of the victims (►**Table 2**). Further

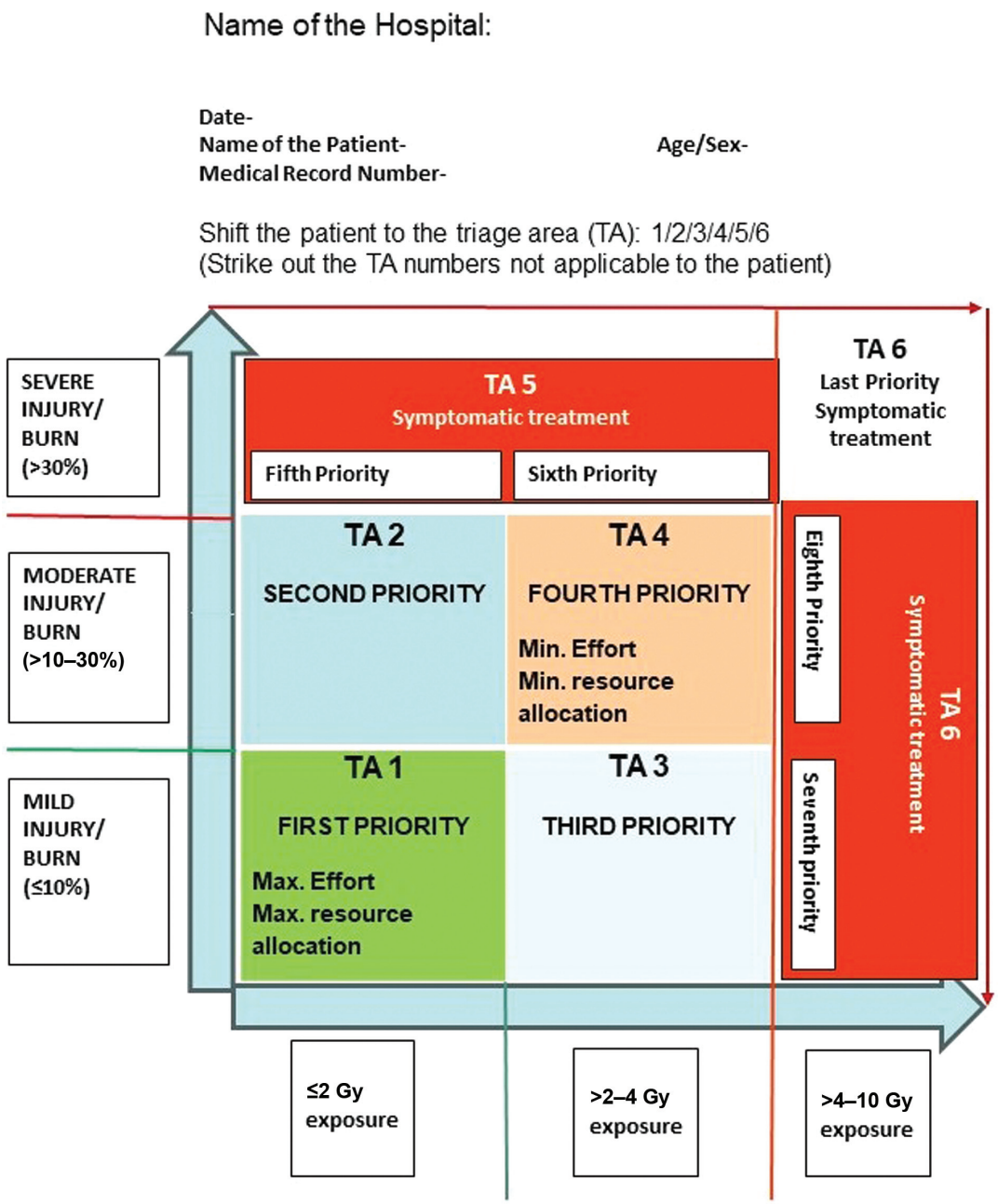

Fig. 1 Nuclear disaster triage matrix form. TA, triage area.

Table 2 Triage of the patients based on total body surface area (TBSA) and radiation exposure dose

Sl. no.	TBSA	Radiation exposure (Gy)	Triage area (TA)
1	Burn ≤10%	≤2	TA 1 (first priority)
2		>2–4	TA 3 (third priority)
3		>4–10	TA 6 (seventh priority)
4	Burn >10–30%	≤2	TA 2 (second priority)
5		>2–4	TA 4 (fourth priority)
6		>4–10	TA 6 (eighth priority)
7	Burn >30%	≤2	TA 5 (fifth priority)
8		>2–4	TA 5 (sixth priority)
9		>4–10	TA 6 (last priority)

treatment in TA 5 and TA 6 areas will depend on periodic reassessment by clinicians and availability of resources.

Conflict of Interest
None declared.

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