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Report

Current Situation of Triage Methods for Exposed Patients in the Acute Phase of a Nuclear Disaster

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Patients with exposure to radiation are encountered in the event of a nuclear disaster and/or radiation accident. However, in Japan, there are no uniform rules or laws such as how to do triage for exposed patients. This study aimed to collect information for develop a triage method for exposure patients in the acute phase of a nuclear disaster. We surveyed research academic articles and collected information from radiation emergency medical institutions. In the academic articles survey, five triage-related articles were found that can be used in the acute phase of a nuclear disaster. Furthermore, on surveying radiation emergency medical institutions, the Radiation Emergency Medical Management in the United States of America provided useful information. Although situations involving radiological emergencies in a large number of people exposed to radiation are rare, it is necessary to establish on-site judgment criteria and triage methods in response to radiation disasters.

Key words: radiation accidents, nuclear disaster, exposed/contaminated patients, triage methods

1. Introduction

Triage is used to determine the priority of treatment and delivery in patients in situations with a large number of patients e.g., in cases such as earthquakes, tsunamis, and landslides. In the event of large disaster, triage is used according to the degree of urgency and severity of the patient to provide the best medical care for the largest number of patients in a situation where human and material resources are limited[1-3]. In Japan, the Simple Triage and Rapid Treatment (START) and the Triage Sieve and Sort method are used at disaster scenes[1, 3-5].

When a nuclear disaster, radiation accident, or nuclear terrorism event occurs, a large number of patients are expected to get injured not only due to trauma but also due to exposure and contamination. Especially in patients exposed to high doses, rapid dose assessment is required, and patients may need transplantation or cytokine therapy for treating acute radiation syndrome (ARS)[6-9]. However, patients exposed to radiation without experiencing trauma are considered to have no injuries before the onset of prodromal symptoms, according to triage involving physiological evaluation, such as START; therefore, these patients may be at risk of delayed delivery and treatment. Although it is unlikely that these

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Table 1. Summary of search key words and results

Key Words	Search hit		
	CiNii	J-stage	PubMed
triage contamination	3	17	26
triage each country	1	36	114
triage disaster medicine radiation	2	11	19
triage radiation medicine	6	24	124
triage radiation	9	31	339
triage radiation contamination	1	7	13
radiation contamination transport	7	225	108
radiation medicine contamination transport	0	33	6
casualty contamination handing	0	5	0
start triage	9	57	124
the great east japan earthquake triage	13	37	12
the great east japan earthquake radiation contamination		28	
the great east japan earthquake radiation contamination casualty	0	3	0
triage nuclear disaster	3	16	66
triage radioactive contamination	1	6	11
triage internal exposure	0	14	18
triage external exposure	0	5	8
triage exposure	3	42	315
triage radiation exposure	3	18	206
radiological triage	3	20	162
nuclear disaster casualty	1	19	74
nuclear disaster casualty external exposure	0	6	0
nuclear disaster casualty internal exposure	0	8	1
nuclear disaster internal exposure	15	91	57
Total	108	843	1830
		2781	

patients would be at risk of dying, decontamination may not be performed and they may remain contaminated.

The safety report by the International Atomic Energy Agency[10] describes the early clinical symptoms of ARS patients. ARS is diagnosed based on symptoms such as vomiting and headache, which depend on the dose and time of exposure. If a patient has been exposed to more than 10 Gy, the chances of survival are very low. However, patients with acute exposure to less than 4 Gy have been reported to be successfully treated by choosing the appropriate treatment[6, 8, 9]. Therefore, considering the possibility of encountering a large number of patients exposed to high radiation doses in events such as radiation accidents and nuclear terrorism, development of a primary triage that can be applied for radiation emergencies is urgently necessary.

Therefore, in this study, we researched academic articles and collected information from radiation emergency medical institutions in each country to develop a triage method for exposed/contaminated patients in the acute phase of a nuclear disaster.

2. Methods

2.1. Academic articles search

We searched J-stage, PubMed, and CiNii for related academic articles with keywords such as “triage”, “radiation,” and “disaster medical care”. The target articles were those published between March 2011 (after the Fukushima Daiichi Nuclear Power Plant accident) and June 2018. All three databases were searched by “OR search” using the same keywords, and all the hit articles were counted. Of these articles, only the articles suitable for this study were included. Given that this study aimed to collect information of triage methods useful in the acute disaster phase, reports on molecular biological evaluation (that cannot be performed on the disaster scene) and radiation dose evaluation using non-portable measuring instruments were excluded. The list of search words and the number of hit academic articles are summarized in Table 1.

2.2. Survey of domestic and foreign radiation emergency medical institutions

We examined the websites of radiation emergency medical institutions in Japan, Korea, France, and the

Table 2. The papers describing the triage of the exposed patients in the acute phase of a nuclear disaster

Title	Information
Biodosimetry: Medicine, Science, and Systems to Support the Medical Decision-Maker Following a Large Scale Nuclear or Radiation Incident.	Coleman CN *et al.* Radiat Prot Dosimetry. 2016
Using the model of resource and time-based triage (MORTT) to guide scarce resource allocation in the aftermath of a nuclear detonation.	Casagrande R *et al.* Disaster Med Public Health Prep. 2011
Triage and treatment tools for use in a scarce resources-crisis standards of care setting after a nuclear detonation.	Coleman CN *et al.* Disaster Med Public Health Prep. 2011
Scarce resources for nuclear detonation: project overview and challenges.	Coleman CN *et al.* Disaster Med Public Health Prep. 2011
Allocation of scarce resources after a nuclear detonation: setting the context ?	Knebel AR *et al.* Disaster Med Public Health Prep. 2011

United States that have promoted nuclear disaster response systems to identify any information that would be useful for developing a triage method. The organizations surveyed were the Nuclear Regulation Authority (NRA; Japan), the National Institute of Radiological Sciences (NIRS; Japan), Korea Institute of Radiological & Medical Science (KIRAMS; Korea), Institut de Radioprotection et de Sûreté Nucléaire (IRSN; France), and the United States Department of Health and Human Services (HHS; USA).

3. Results

3.1. Academic articles on triage in the acute phase of radiation accident/nuclear disaster

The total number of hits using the keywords was 2,781 (Table 1). However, the number of hits described was in duplicate, because some articles are counted by entering keywords and some articles have appeared as hits multiple times because it contained more than one of the keywords used. After excluding academic articles related to molecular biological evaluation and radiation dose evaluation using non-portable measuring instruments, only 5 articles related to the research purpose were extracted (Table 2).

For example, the first article in Table 2 provided an overview of the resources and tools available for planning and responding to nuclear explosions and large-scale nuclear explosions. Because nuclear explosions occur in a resource-constrained environment, important triage decisions should be made while pay attention in a fair and widely used and most important lifesaving manner. The second article in Table 2 described a tool called the model of resource and time-based triage (MORTT), which was developed to test the results of triage to save as many patients as possible after a nuclear explosion. By simulating using MORRT, it is possible to know the necessity of medical resources and hospital staffs in the event of the acute phase after a nuclear terrorism. For third, fourth, and fifth articles are related to the triage method that proposed by HHS. Details are given in the next section.

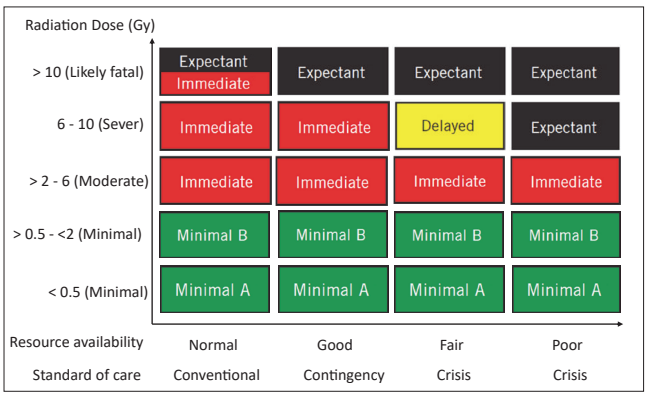

Fig. 1. Triage card for radiation emergency released by the Radiation Emergency Medical Management. (A) Triage card for exposure patients without trauma. (B) Triage card for exposure patients with trauma. "Minimal A" and "Minimal B" are defined as follows: Minimal A: Those with physical dose estimates below 0.5 Gy according to location need not report for medical evaluation. Joining a registry may be suggested after the incident. Minimal B: Consider repeating both biodosimetry and clinical reassessments, especially at high end of this dose range[11].

3.2. Information about triage for exposure/trauma patients from radiation emergency medical institutions

Useful information on triage during a nuclear disaster were not observed on the homepages of the NRA, NIRS, KIRAMS, and IRSN. However, the Radiation Emergency Medical Management (REMM) website of the HHS proposed a triage method for survivors of nuclear

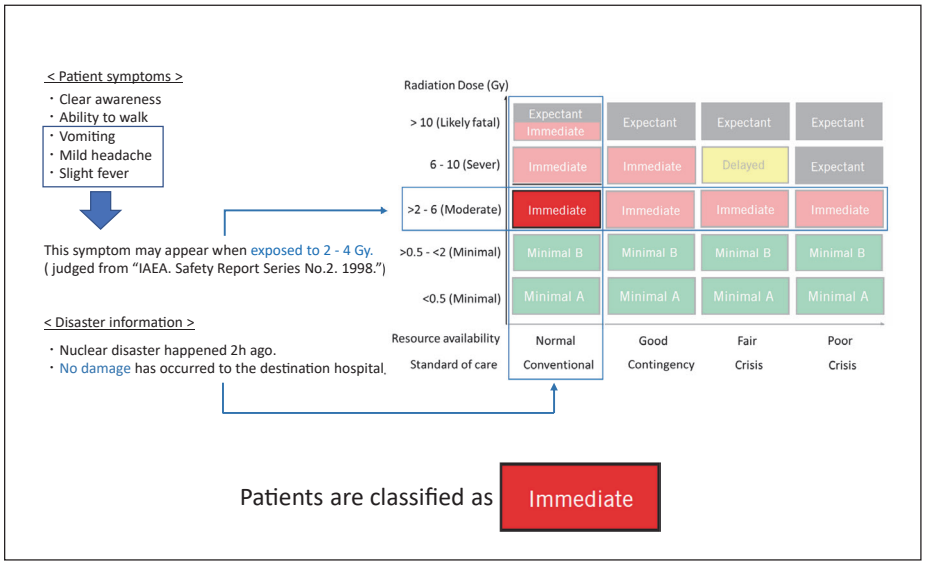

Fig. 2. Process of using the triage card released by the Radiation Emergency Medical Management. This process assumes that the patient complains of vomiting, headache, and mild fever (acute radiation syndrome signs after exposure to 2–4 Gy[10]) within 2 hours of the accident and that nearby medical facilities are operating normally. The patient is assigned to the Immediate (red color) category based on the table.

terrorism; this method was publicly available on the website[11]. Figure 1 shows a part of the triage method proposed by the REMM.

We explain how to use triage method proposed by the REMM, assuming that the following situations and patients are occurring:

- There are patients vomiting, mild headache, and slight fever within 2 hours of the accident.
- When natural disasters have not occurred and the nearby medical institutions are operating normally.

In the above situation, the middle row is selected (as shown in Figure 2) because vomiting, mild headache, and slight fever, which appear within 2 hours of the accident, appear on exposure to 2–4 Gy[10]. Even if an accident occurs, there is no damage to nearby hospitals; thus, as the normal operation and medical equipment are sufficient, the leftmost column is selected as shown in Figure 2. Therefore, this patient is classified in the Immediate (red color) category.

Using the START method, this patient would be triaged into the lowest priority (green color) category owing to consciousness and ability to walk. The evaluation items of the START method are mainly physiological parameters, such as consciousness, pulse and respiratory rate. The symptoms such as vomiting, diarrhea and headache, which symptoms observed with exposure, are not considered. In the triage method proposed by the REMM, patients assigned to the low priority (green color) are those with less than 2 Gy exposure whose symptoms are relatively mild and do not require special treatment. In the horizontal axis, four cases are provided so that triage can be performed according to the situation of the nearby medical institution and the number of medical resources. Among the exposure doses that require treatment, patients exposed to 2–6 Gy have moderate-to-severe symptoms and have the highest probability of survival; thus, they are assigned to the Immediate group, which is given the highest priority. However, exposures above 6 Gy are very severe or fatal, and these patients are less likely to be rescued than those exposed to radiation doses of 2–6 Gy. Even if such patients alive, they are classified into the black death category and treatment is postponed to ensure effective use of resources. Figure 1B shows the triage used for patients with trauma and exposure.

4. Discussion

Early dose assessment and appropriate treatment options are essential for high-dose exposure patients. Methods of dose assessment for exposure patients include assessment of chromosome and blood cell counts, biological dose assessment, such as that with electron spin resonance, and dose reconstruction[12-13]. These dose assessments are essential in the acute phase and subacute phase to build a therapeutic strategy, but these assessments cannot be implemented at the disaster/accident site (super acute phase). Therefore, it is essential to establish criteria for determining which patients should be preferentially delivered to which medical institution at a multi-patient disaster/accident site.

In this study, we introduced a triage method for patients with exposure and injuries, in addition to surveying the related literature and homepages of radiation emergency medical institutions. Furthermore, REMM in the US provide useful information of triage for exposed patients. However, no information was available on triage of contaminated victims. In Japan, a new nuclear disaster prevention system was launched following the accident at the Fukushima Daiichi Nuclear Power Plant due to the 2011 Great East Japan Earthquake; organization of medical institutions at the time of a nuclear disaster is being promoted after revision of the nuclear disaster countermeasures guidelines in 2015[7, 14]. Although situations involving radiological emergencies in a large number of people with radiation exposure and contamination may be rare, a more robust radiation emergency response is required to establish judgment standards and triage methods at the field level.

Conflict of Interest

The authors declare that they have no conflict of interest.

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