Mass causality events and Nuclear reactor accidents
- Lessons learned from the earthquakes and Fukushima Daiichi Nuclear Power Plant Accident -

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Training Meeting on Biodosimetry in the 21st Century (2013.06.11)
HICARE & IAEA
Medical response to MCE

EMS
- ICS (Incident Command System)
- First responder rescue
- Casualty collection
- Triage
- Initial treatment
- Transportation to the appropriate medical facilities
  - Primary distribution
    - Controlled primary distribution
    - Semi-controlled primary distribution
    - Spontaneous primary distribution

Hospitals
- Hospital ICS
- Triage
- Immediate treatment
- Surge capacity and transportation to other medical facilities
  - Outside Diversion
  - Secondary distribution (Secondary relocation, inter-facility transfer)
  - Triage hospital
What happens in a disaster stricken area:

- Lack of initial information, confusion
  Telephone line is busy or unavailable (or shut down)

  **No news is bad news!**

- Victims are not distributed appropriately
  Patients visit hospitals by all means!

- Disruption of traffic
  Not only structural damages of the road, but concentration of traffic to the remaining streets make traffic congestion worst

- Functional incapacitation of hospitals
  Disruption of life-line, structural damages of hospitals lead to partial or complete incapacitation
Ota H: Simulation of prognostic survival curve after an earthquake
Purpose of Triage

◇ Right Patient
◇ Right Place
◇ Right Time

Sieve, and/or sort patients

（MIMMS Advanced course）
START Triage
(Simple Triage and Rapid Treatment)

http://www.start-triege.com/
Disaster medical system in Japan

Disaster area

Triage Site

Triage, treatment and transportation

DMAT

Non-disaster area

Disaster hospitals
- Dispatch DMAT
- Supply medical resources
- Provide definitive treatment

Inter-hospital transfer
DMAT  
(Disaster Medical Assistance Team)

• Specially trained medical teams which are engaged with emergency medical activities in the disaster area in the acute phase after disaster occurrence (approx. 48 hours)
• Consists of one doctor, 2 nurses and one logistics
• Usually dispatched to the designated disaster hospital
• Major tasks of DMAT include establishment of CSCATT of the hospitals, support of SCU activities and the disaster HQ of the prefecture.
Consequences of the Great East Japan earthquake

- Nearly 20,000 people were killed in the disaster, most of them lost their lives by tsunami.
- In Iwate, Miyagi and Fukushima, 78.9% of all hospitals were severely damaged.
- The remaining hospitals provided medical care for more than 2,000 injured in the initial 3 days after the quake.
- Disruption of communication network was so devastating that some areas were left isolated in spite of huge amount of medical needs.
- 380 DMATs (1800 medical personnel) were dispatched to the disaster stricken areas. However they could not reach those who most needed medical care due to lack of effective communication.
- This natural disaster was accompanied by a severe nuclear accident.
Radiation Emergency Medical System in Japan
Background

September 1999; A criticality incident at a JCO uranium-conversion plant (“the nuclear criticality incident at Tokai-Mura”) occurred. Three workers were exposed to a massive dose of radiation, resulting in the death of two of them (INES; Level 4). In this accident, the importance of integrated critical care was recognized.

December 1999; The Nuclear Disaster Special Measures Law was enacted.

2003; The Nuclear Safety Commission of the national government issued the “Recommended Forms for Radiation Emergency Medicine”. The emergency response system has been enhanced according to the particular type of nuclear accidents such as a major release of radioactivity from a nuclear power plant or a massive dose of radiation.
Primary Radiation Emergency Medical Hospital (57 Hps)
Secondary Radiation Emergency Medical Hospital (33 Hps)
Tertiary Radiation Emergency Medical Hospital
Western block; Hiroshima University
Eastern block; National Institute of Radiological Sciences

Nuclear Plant Prefectures
Neighboring Prefectures
Regional Tertiary Radiation Emergency Hospital located prefectures

Hiroshima University
Fukushima
National Institute of Radiological Sciences

Radiation Emergency Medical System in Japan
A big earthquake (M 6.8) hit Niigata prefecture and inflicted significant damages to Kashiwazaki Nuclear power plant (2007.07.06)

Magnitude 6.8 earthquake

Fire broke out at a transformer substation of No. 3 reactor building

Turbine building of No.2 reactor

Spent fuel pool of No.6 reactor building
Loss of power, communication

Loss of function of the Nuclear Disaster center (HQ)
Evacuation of all residents, patients and medical personnel

Collapse of radiation emergency medical system
<table>
<thead>
<tr>
<th>date</th>
<th>time</th>
<th>events</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/3/11</td>
<td>14:46</td>
<td>A great earthquake hit the eastern Japan, followed by huge tsunamis.</td>
</tr>
<tr>
<td></td>
<td>19:03</td>
<td><strong>State of atomic emergency was issued by the national government</strong></td>
</tr>
<tr>
<td></td>
<td>21:23</td>
<td>Evacuation from 2 km zone and in-house evacuation from 2 to 10 km zone was ordered.</td>
</tr>
<tr>
<td>2011/3/12</td>
<td>5:44</td>
<td>Evacuation from 10 km zone was ordered for 48,272 residents.</td>
</tr>
<tr>
<td></td>
<td>15:36</td>
<td><strong>The first hydrogen explosion occurred at the No. 1 reactor. Four workers were injured.</strong></td>
</tr>
<tr>
<td></td>
<td>18:25</td>
<td>Evacuation from 20 km zone was ordered. Residents left by car and busses.</td>
</tr>
<tr>
<td>2011/3/13</td>
<td></td>
<td>Evacuation of 2,200 patients at hospitals and facilities was arranged. Most of them were reallocated to out-side hospitals. However, approximately 840 patients remained left within the 20 km zone.</td>
</tr>
<tr>
<td>2011/3/14</td>
<td>0:47</td>
<td>Emergency evacuation order was issued for patients in hospitals and facilities within the 20 km zone.</td>
</tr>
<tr>
<td></td>
<td>11:01</td>
<td><strong>The second hydrogen explosion occurred at the No. 3 reactor. Eleven workers were injured.</strong></td>
</tr>
<tr>
<td>2011/3/15</td>
<td>6:00</td>
<td>Severe damages of No.2 reactor, and explosion of No. 4 reactor occurred.</td>
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<tr>
<td></td>
<td>11:00</td>
<td>Radiation levels soared from 0.09 in am to 24.08 μSv/hour in the evening in Fukushima.</td>
</tr>
<tr>
<td></td>
<td>15:00</td>
<td>In-house evacuation from 20 to 30 km zone was ordered.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evacuation of all residents within 20 km zone was completed.</td>
</tr>
</tbody>
</table>

**Chronology of events in Fukushima**
1. Fukushima Nuclear Disaster Management Center
2. Futaba Kosei Hospital*
3. Fukushima Prefectural Ohno Hospital*
4. Imamura Hospital*
5. Minami Soma city General Hospital*
6. Soso Health Care Office
7. Fukushima Rosai Hospital*
8. Fukushima Prefectural Government Office
9. Fukushima Prefectural Medical University**

* Primary radiation emergency hospital
** Secondary radiation emergency hospital

8 Hospitals, 1240 patients
17 nursing facilities, 983 patients

20 km zone
Fukushima Daiichi Nuclear power plant

8 Hospitals, 1240 patients
17 nursing facilities, 983 patients
Dispatch of the Radiation Emergency Medical Assistant Teams to Fukushima
Loss of life during evacuation from 20 km zone
When the first explosion occurred on March 12th, approximately 2200 patients were hospitalized within 20 km zone. Many of them were transported by SDF helicopters to Nihonmatsu Kyousei Center and other facilities by March 13th. However, no medical personnel attended during or after evacuation.
As of March 14th, at least 840 patients remained within 20 km zone. The national government ordered all the patients to evacuate.

A screening site for patients evacuated from hospitals and facilities within 20 km zone was set up at the Soso Health Care Center, 26 km north of the plant.
Most of the evacuees were elderly and many of them had underlying medical problems. Therefore, radiological survey was performed in the vehicles. No significant contamination with radioactive materials was found among those patients.

Evacuation continued until late at night. As the situation of the damaged power plant became more volatile, more evacuees were rashly transported by police vehicles. The vehicles were jam-packed with patients and residents.
Radiological contamination was found on the hands and boots of those who were involved in outdoor activities such as police officers or fire department personnel.
Late in the night, patients were required to step out of the buses because admitting facilities were not determined. They were temporarily housed at a meeting room of the Soso Health Care office without heat or medical supplies. The patients had been on the bus for more than 24 hours without medical cares during evacuation.

Sixty patients died during or soon after evacuation. Hypothermia, dehydration and/or deterioration of underlying medical problems were suspected causes of death.
In the Fukushima Daiichi Nuclear Power Plant accident, what we have seen,
✓ difficulties in reallocating patients forced them to stay in the confined space of the transporting vehicles for long hours.
✓ Many patients died during or soon after evacuation.

On the other hand,
✓ no significant contamination was found in the evacuated patients from the 20-km area despite the fact that 48 hours had already passed since the first explosion. These facts suggest the effectiveness of indoor sheltering for protection from radioactive plumes.
Therefore, we conclude that,

- In contrast to physical injuries caused by collapse of buildings or tsunami, radiation itself does not create any immediate life-threatening conditions. Rather, ill-prepared evacuation may increase the health risk of hospitalized patients or the elderly.
- In the case of nuclear disasters, therefore, evacuation for these vulnerable people should be carefully performed with medical arrangements.
Collapse of radiation emergency medical system
Information board on injured workers (Fukushima, March 14th)

1. C-spine injury, susp. (C-spine injury, susp) → 福島医大 (Fukushima Medical U.) → 4000 cpm

2. Dislocation of shoulder J (Dislocation of shoulder J)

3. Contusion of the thigh (Contusion of the thigh)

4. Laceration of the thigh (Laceration of the thigh) → 福島第一 (Fukushima Daini NPP) → 20:32 放射性

5. Contusion of the ankle (Contusion of the ankle)

6. Contusion of the chest and abdomen (Contusion of the chest and abdomen)

7. Contusion of the back (Contusion of the back)

8. Contusion of the back and abdomen (Contusion of the back and abdomen)

9. Contusion of the back, ankle (Contusion of the back, ankle)
Medical responses for patients who suffered injuries following the explosion of No. 3 reactor building on March 14th.
As for emergency medical systems,
✓ difficulties in finding hospitals to provide care for injured workers with contamination were observed. Fortunately, none of them suffered life-threatening injuries. However, collapse of radiation emergency hospitals may have resulted in preventable death for those with severe trauma.

Therefore,
✓ more hospitals are required to provide emergency care for patients with radiological contamination, considering combined disasters such as earthquakes and nuclear accidents.
Lack of information on radiation dose
Serial changes of radiation levels at 7 sites in Fukushima prefecture from March 12th through 23rd. This graph was depicted using the data reported by the Fukushima Prefectural government on March 24th.
Simulated radiation levels at 9:00 and 21:00 on March 15th, when massive radioactive materials were released from the No. 2 reactor of the Fukushima Daiichi Nuclear Power Plant. South-west spread of radioactives was observed at 9:00 (left). In the evening, however, the distribution shifted toward the north-west area due to changes in the wind direction (right). The bottom bars indicate radiation levels (μSv/h).

Estimated accumulation doses of Cs-134 and 137 (Bq/m²)

- 3,000,000 - 30,000,000
- 1,000,000 - 3,000,000
- 600,000 - 1,000,000
- 300,000 - 600,000
- < 300,000

Chernobyl
1,480,000Bq/m² <: Closed Zone
555,000Bq/m² <: Permanent Control Zone
The medical teams were exposed to radiation risk,
✓ due to lack of information on radiation.
✓ We should understand the patterns of spread of nuclear plumes. Nuclear plume does not spread in a concentric fashion. It spreads discontinuously and changed its direction quickly by wind direction, geographic, and weather.

Therefore, we need
✓ more monitoring devices and posts in place. Information on radiation should be readily available for all personnel involved.
Re-establishment of radiation emergency medical system in Fukushima
Critical issues discussed at the first medical HQ meeting in Fukushima

- Establish the medical control panel to organize the activities
- Screening for evacuees including hospitalized patients
- Re-build the radiation emergency medical system in Fukushima
Re-establishment of the radiation emergency medical system

J-village
(Japanese Football Association Training Site)
Rescue and evacuation of an injured worker

Decontamination and treatment at Fukushima Medical University
Decontamination of the workers
Activities at J-village medical clinics
Emergency room
On-site emergency room of Fukushima Daiichi NPP
Injuries and diseases treated at Fukushima No1. Nuclear Power Plant
Total irradiation dose (>100 mSv) of workers who were involved in recovery operations at Fukushima No1. Nuclear Power Plant (Mar. 11 to Dec. 31)
*Max: 678.08mSv (ext. 88.08mSv, int. 590mSv)
Total irradiation dose (<100 mSv) of workers who were involved in recovery operations at Fukushima No1. Nuclear Power Plant (Mar. 11 to Dec. 31)

TEPCO Fukushima Nuclear Power Plant Emergency Medical System Network
Lessons learned from Fukushima accident

1. Evacuation from 20 km zone was accompanied by loss of life, and significant difficulties were encountered to determine hospitals for evacuated patients and injured workers. Most of the medical needs after the accident were not related to radiation. We therefore applied the general principles in emergency and disaster medical management in Fukushima.

2. Lack of information on radiation hindered emergency medical activities. Also, it adversely affected understanding of the situations by medical personnel and citizens. More information on radiation should be readily available for every person involved.

3. We should prepare for combined disasters, i.e. a nuclear accident following a natural disaster or terrorist attacks. Considering priorities in medical management in radiation emergency, contingency plans should be developed in accordance with general disaster medical approaches.