Chapter IV

Patient Relief Activity Records

[Essays and Research Publications]

This chapter analyzes the necessity to record all medical treatment during patient relief efforts at the time of the disaster and convey this information to future generations. The events have developed new historical objectives of protecting the health of citizens from nuclear accidents and sharing the knowledge gained by our university with the world.

Journal of Orthopedics and Traumatology, Vol. 55 No.3 2012, "Experiences from the Massive Earthquake: Lessons for Posterity" published by Kanehara & Co., Ltd.

Reflecting on the Great East Japan Earthquake

A message From Fukushima Medical University

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Summary

The March 11, 2011 Great East Japan Earthquake was calamitous and historically unprecedented. Moreover, the operational failure at the nuclear power plant, which led to the radiation contamination of a densely populated area, has been a first-of-its-kind scientific challenge for humanity and our modern society. First, the administration of Fukushima Medical University (FMU), who saw their hospital become the last outpost of safety, has been called upon to be a central communication source that is unified and open to all. Second, we have been called upon to illustrate leadership and the ability to make prompt decisions without the luxuries of time or consultation. Those exercising leadership in a confused and disconnected situation are inevitably confronted by discord. However, initiative and swift actions must be taken and issues must be prioritized if matters are to be brought under control. In other words, leaders must show consistency and authority; their responsibilities are akin to guarantees stipulated in business contracts. If these actions are systematically executed, staff members will be afforded a measure of relief and will be able to band together in the face of challenges.

Key Words: *Great East Japan Earthquake, tsunami, Fukushima Daiichi nuclear accident*

Introduction

At 2:46 pm on March 11, 2011, the largest earthquake on historical record struck. The ensuing tsunami swallowed multitudes of people, leaving many dead and missing. This alone was an unprecedented calamity. Further damage, however, came in the form of electrical outages at the Fukushima Daiichi nuclear power plant, located along the Pacific coast of Fukushima Prefecture. The plant went offline and control of its machinery was lost. Then, on March 12 and 14, hydrogen explosions tore through the plant. Disasters of a scale and description that the populace could not have imagined became a reality. This paper focuses on the nuclear disaster, explains the circumstances faced by FMU, and describes our responses to them. In light of the situation's rapidly evolving nature, this study presents the lessons that must be communicated to posterity.

I. Impact of the Nuclear Disaster on the Region's Medical Infrastructure

On March 12, evacuation orders were issued to residents within a 20-kilometer radius of the nuclear power plant. The area had 70,000–80,000 residents, with approximately 62,000 becoming refugees.

The total number of hospital beds available at medical institutions within the 20-kilometer radius was approximately 500, excluding those in geriatric facilities. Of the four hospitals designated as primary radiation treatment institutions, three were shut down by the disaster and one was limited to outpatient care. This must be taken into careful consideration when reviewing the locations and capacities of primary radiation treatment institutions.

The four institutions providing mental health care lost access to their facilities, which were within the 30-kilometer radius of the disaster. Emergency care facilities were also damaged and their patients became evacuees as the facilities were unable to fulfill their health care roles. Only two hospitals outside the 30-kilometer radius were able to maintain their in-patient services. Two other hospitals, a prefectural hospital and a hospital established by JA Zenkouren, had been slated to merge as of April 1. This merger aimed at bolstering medical infrastructure in the area of the nuclear accident in Fukushima Prefecture. However, due to their extreme proximity to the nuclear power plant, they sustained irreparable damage, making it impossible to proceed with the amalgamation.

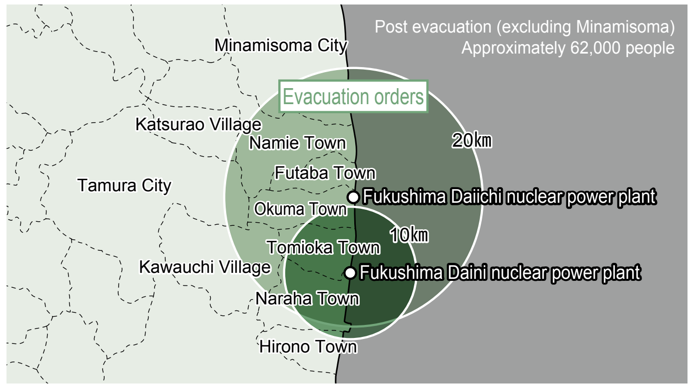

Figure 1: The March 12 Evacuation Order for a 20-kilometer Radius of the Fukushima Daiichi Nuclear Power Plant.
The order was applicable to 70,000–80,000 people.

Chart 1: Comparison of Damage among Fukushima, Iwate, and Miyagi Prefectures

Iwate and Miyagi		Fukushima
Earthquake	>	Earthquake
Tsunami	>	Tsunami
		Nuclear power plant accident
‖		‖
+ → 0		+ → -
A manageable/recoverable calamity ⇩ Heeding existing knowledge and policies ‖ Great Hanshin-Awaji Earthquake		Unmanageable/unrecoverable calamity ‖ Citizens: anxious, fearful, and angry Sustained radiation contamination ⇩ Necessity of responses for which there is no precedent

The emergency evacuation of residents after the nuclear accident drastically changed the demographics of this particular area as well as the entire prefecture. The elderly population decreased slightly, but the change was rather extreme for the younger demographic. In addition, patient demographics also changed. Naturally, there was a shift in the types of diseases requiring treatment and an urgent need to re-establish nursing care services.

II. Comparison of Damage among Fukushima, Iwate, and Miyagi Prefectures (Chart 1)

Despite being called the Great East Japan Earthquake, the extent of damage to Japan's eastern prefectures differed markedly. The decisive factor was the presence of the nuclear power plants. The heretofore unknown element of radiation contamination that accompanied the nuclear accident developed anxiety, fear, and anger in Fukushima's residents. Moreover, previous references exist for recovery from damage limited to an earthquake and tsunami; however, this is not the case for recovery from nuclear accidents.

III. Psychological Burden due to the Nuclear Accident (Chart 2)

Radiation contamination from the unprecedented nuclear accident is undeniably causing severe mental and physical effects. Residents' flight as refugees from the prefecture or elsewhere within the prefecture, as well as the increasing suicides and the surging mortality rate, indicate only some aspects of the aftermath.

IV. Our Response as a University

As a university, we divided our response into emergency efforts (lasting approximately one month) and mid- to long-term efforts. Policy approaches for the latter were under consideration immediately after the disaster, the same time as we implemented our emergency response.

1. Conceptualizing the Great East Japan Earthquake

We decided to approach this event as a compound,

Chart 2: Psychological Burden due to the Nuclear Accident

- Patients from facilities within the 30-kilometer radius of the accident
  3-month fatality numbers 300% of last year's numbers
  Yomiuri Shimbun
  July 2, 2011
- Number of evacuees
  Fukushima (16,642) > Miyagi (12,874) > Iwate (6,127)
  ⇩ No timeline in sight for their return home
  Should be able to return home soon
- Number of deceased or missing cases
  Miyagi (11,808) > Iwate (6,886) > Fukushima (1,863)
  Evacuee statistics as of July 14, 2012 (Cabinet Office)
  Deceased/missing statistics as of July 31, 2012 (National Police Agency)
- Rapid increase in suicides
  In contrast to the falling or steady numbers of suicides in Iwate and Miyagi Prefectures, Fukushima has shown a year-on-year increase for three consecutive months from April 2011.
  Sankei Shimbun
  July 16, 2011
- Fukushima Prefecture's population drain, topping 2,000,000 people, shows no signs of abating.
  Iwate and Miyagi Prefectures have seen an influx of people.
  Nikkei Shimbun
  September 7, 2011
  September 30, 2011

Figure 2: Emergency Campus-Wide Meetings Including All University Employees

complex disaster that was both natural and manmade. The natural disaster was the earthquake, tsunami, and nuclear accident; whereas the manmade disaster was the series of impacts on commerce, agriculture, fisheries, industrial products, early childhood education, and other levels of schooling. Recently, we have been faced with challenges, which are both friend and foe, superseding our professions as doctors and physicians; this is because we stand on the front lines of the battle. These challenges include the so-called "information damage" caused by the tangled mass of emerging information, which is necessarily related to our responsibilities or actions as health care professionals.

2. University Policies

1) Sharing Information and Educating the Public

The initial information that a nuclear crisis was bearing down upon us due to explosions in the cores of the nuclear reactors was an immense shock to the FMU faculty. With evacuation as a viable option, we decided that maintaining regular operations at the hospital would not be possible. In April, campus-wide meetings were held two or three times per day (later changing to once per month) (Figure 2); by November, a total of 42 meetings had been held. During these meetings, risk communication experts informed us that "Radiation is scary, but ignorance, indifference, and bias are scarier." In addition, the importance of combating misinformation with the power of science was communicated to us. In other words, it is up to medical professionals to present a fundamentally objective stance to society. This includes objective data that is accurately interpreted.

Apart from the campus-wide meetings, executive manager meetings were held simultaneously, during which strategies were formulated and prompt decisions were made. A total of 81 meetings were held by November. These meetings reflected the university leaders' belief in their entire faculty. The facts that support activities must not sacrifice the security of support workers, and that the proper sharing of information is a life and death situation for the implementation of decisions and actions and greater organization, were reiterated.

2) Accepting and Transporting Patients to FMU

The treatment and hospitalization of patients from medical institutions in the evacuation area began on March 12 (Figure 3). Procedures were divided into responses to the nuclear accident, disaster medicine during the supercritical period (immediately after the earthquake), and treatment for evacuee patients during the critical period (after the supercritical period). Two wards at FMU hospital were emptied, and extra beds were accommodated in the available shared spaces. After triage, 173 patients were hospitalized on the premises (Figure 4).

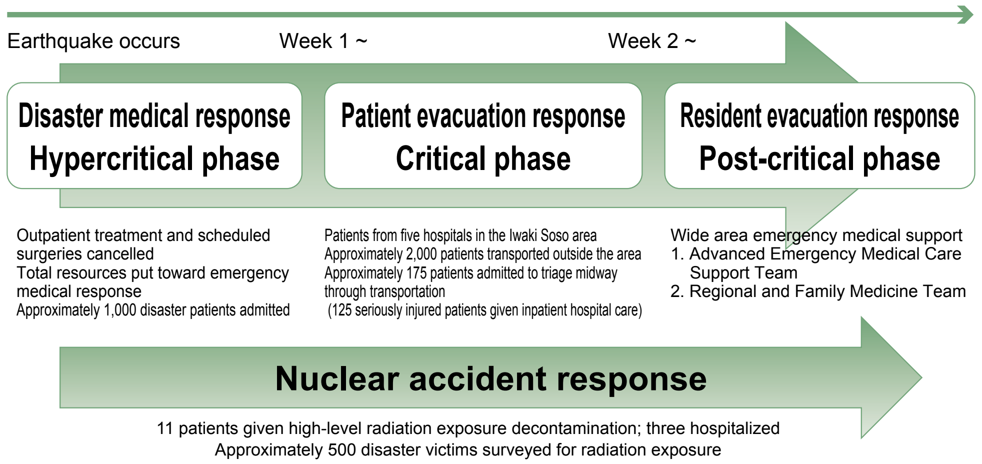

Figure 3: FMU's Activities

Temporary beds set up in the hospital entrance area (picture taken March 13)

Ambulances on call to transport patients for temporary admittance (picture taken March 21)

Figure 4: Onsite at FMU Hospital: Admitting Patients

A system similar to the function of a telephone switchboard was used for patients who could not be easily placed. These patients were first temporarily admitted into other medical institutions. After triage, the patients were transferred to other institutions or nursing care facilities. Clearly, this system will be effective during future disasters.

3) Handling Rumors

Immediately after the nuclear accident, the presidents of Nagasaki University (a secondary radiation treatment institution) and Hiroshima University (a tertiary radiation treatment institution) were requested to serve as visiting risk communication experts on behalf of FMU, Fukushima Prefecture, and Fukushima's citizens. Using the functional phrase "appropriate alarm," communication and education efforts were carried out to actively inform university faculty, prefectural authorities, and hub hospitals. These efforts provided peace of mind and reduced trauma.

Part of the collateral damage at the university was new students withdrawing due to rumors and speculation. To address a large numbers of these students, an emergency press conference was called upon to explain the state of affairs in Fukushima.

Six months after the accident, a conference for international experts, titled "Radiation and Health Risks: Considering the Case of Fukushima through the Eyes of International Experts," was held on-campus by the Nippon Foundation. This conference brought under one roof specialists such as radiologists and radiation protection experts among others from 14 countries and two international medical associations. The post-conference announcements and the hours-long press conference (held until all audience questions were exhausted) elevated the understanding and knowledge of media organizations.

4) Collaboration with Partner Institutions

a) FMU and Fukushima Prefecture

Unlike the Japan Self-Defense Forces, FMU is not a fully autonomous, self-sufficient entity. Thus, FMU

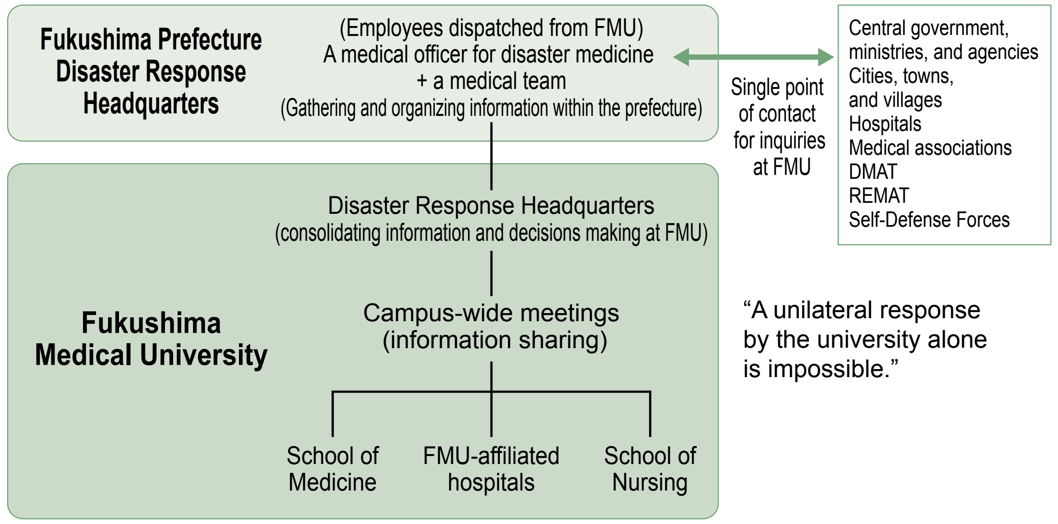

Figure 5: Collaboration between FMU and the Prefecture to Respond to the Nuclear Accident

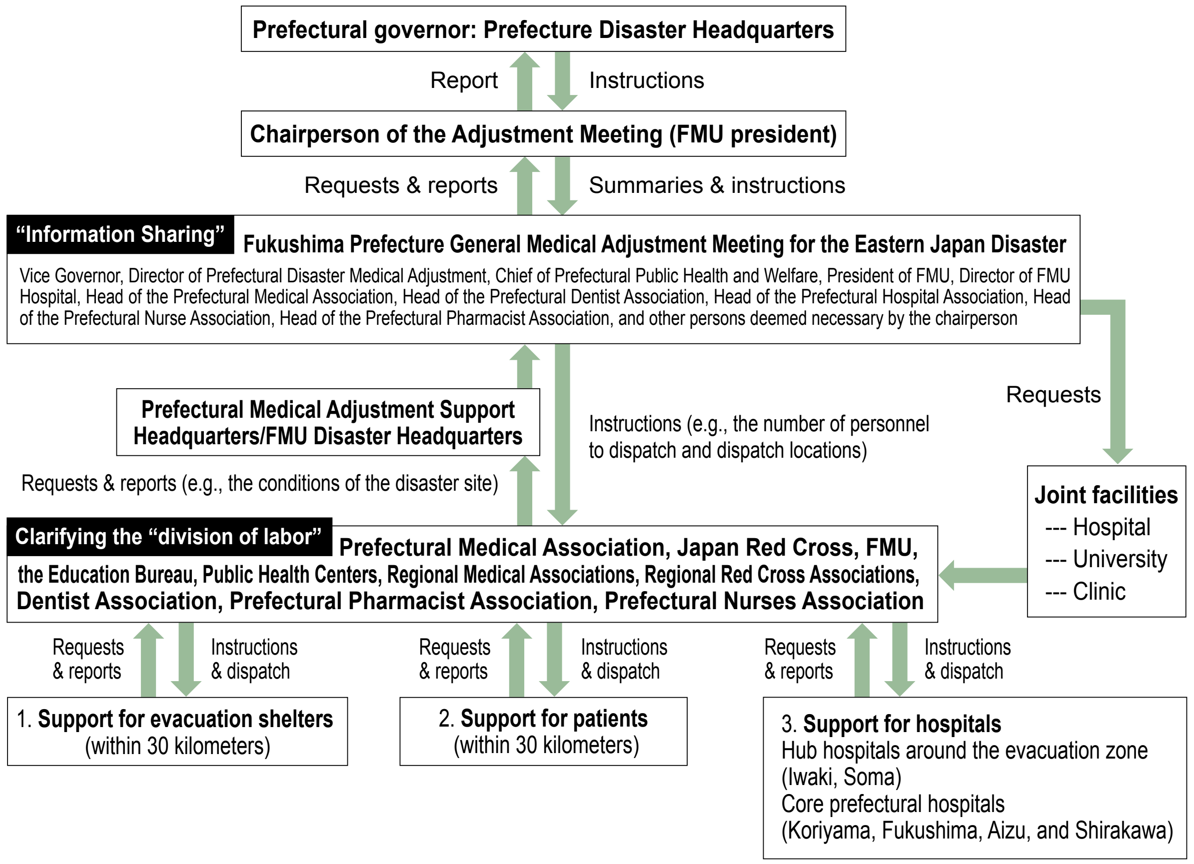

Figure 6: Medical Support Infrastructure in Fukushima Prefecture

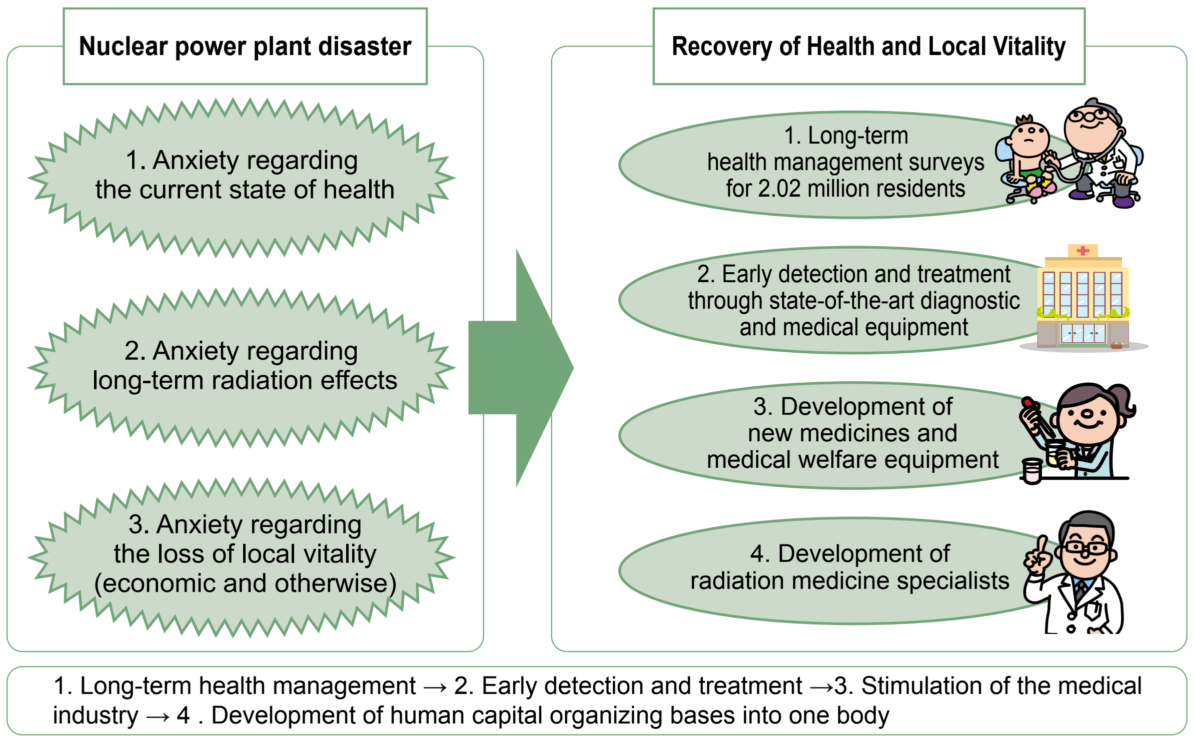

Figure 7: FMU's Vision for Recovery

needed help or collaboration. FMU's collaboration with the prefecture for the administration of the university was essential. To this end, FMU and Fukushima Prefecture formed a dual organization immediately after the earthquake (Figure 5). No collaborative structure with other organizations within Fukushima Prefecture had been established. Therefore, upon the advice of the Ministry of Education, Culture, Sports, Science and Technology, we established Fukushima Prefecture's Medical Support Body.

Furthermore, since substantial measures were considered to be necessary in the mid- and long-run, after the critical phase after the accident, a cooperative framework was also established with Nagasaki and Hiroshima Universities. In addition, a council meeting was held by the governor of the prefecture to initiate policy discussion on medical treatment for victims of the nuclear disaster. FMU and six other research organizations participated in an event focused on the effects of radiation. The organizations gathered from across Japan and included the National Institute of Radiological Sciences (NIRS), Hiroshima University, Nagasaki University, Kyoto University, the Radiation Effects Research Foundation (RERF), and the Institute for Environmental Sciences (IES). The universities and research organizations were called upon to implement the cooperative efforts detailed below. Said efforts included the Prefectural People's health management survey and other health management surveys for the future.

3. FMU's Support for Medical Care (Chart 3)

1) Responses during the Critical Period after the Disaster

While endeavoring to continue providing routine

Chart 3: Contributions that FMU can Make for Fukushima's Present and Future Well-Being

1. Radiation treatment and health care for workers handling the nuclear accident
2. Responding to the medical emergency and evacuation order
   1) Specialists making medical rounds of evacuation shelters
   2) Surveying the 20–30 kilometer area around the plant and providing medical support
   3) Dispatching physicians to hub hospitals within the evacuation area
3. Ways to help recovery in Fukushima
   1) Recovering regional medical infrastructure
      • Build a Fukushima-wide (All Fukushima) system (centralized and collaborative)
   2) Restoring Fukushima as a prefecture where parents and children can live with peace of mind
      • Long-term measures to handle the impacts of long-term, low-dose radiation exposure

care and conducting health examinations, FMU was also faced with the sudden responsibility of emergency medical duties. In particular, this included postmortem examinations primarily performed by the life sciences faculty, medical rounds of evacuee shelters by teams of specialists, surveys and medical care—with the aid of the Self-Defense Forces—within the 20–30-kilometer evacuation zones, and the dispatch of physicians to hub hospitals surrounding these zones.

2) Formulating and Implementing Recovery Projects

A recovery plan was formulated under the slogan "Fukushima: Hope in the midst of adversity." The guiding philosophy of these projects was transitioning from destruction, loss, and reflection to reconstruction, hope, and progress; in other words, it meant recovering from the situation caused by the nuclear disaster (Figure 7). A step that was immediately implemented was the health management survey of children, focusing on illnesses such as thyroid cancer, which spanned over a period of 30 years. Another step was an impact survey of residences within the disaster area to assess the extent of radiation contamination. We envisioned the establishment of a new organization to implement these projects. At the same time, we formulated a model for a university that would be more resilient to future natural disasters. In the recent disaster, we struggled to cope with the loss of water supply. Thus, the new model has been built around a robust lifeline of equipment and utilities, patient transportation hubs, functionality for temporary hospitalization and observation, and in-patient care.

V. Lessons from the Massive Earthquake and Nuclear Accident (Chart 4)

First, this earthquake, tsunami, and ensuing nuclear accident revealed Japan's inadequate preparedness for a calamity of such intensity levels. Second, for a country that has atomic energy at the helm of its national energy policy, the education of citizens and health care workers about radiation is insufficient. Third, the number of engineers and academicians involved with atomic energy is limited and their demographic appears to be an aging one. Fourth, confusion was observed in the chain of command when the emergency was at its peak. Fifth, there was a muddied distinction between "safety" and "peace of mind." The untimely debate hindered discussions. Sixth, we must recognize the importance of having a single point of contact for information that is broadly shared. Seventh, communicating information is absolutely vital. Eighth, infrastructure for evacuees was insufficient. And finally, during the emergency, it was

Chart 4: Lessons from the Massive Earthquake and Nuclear Accident

● Japan's emergency preparedness (for catastrophic events) is inadequate
An over-compartmentalized bureaucracy; only short-term risk avoidance
⇨ A new Fukushima Model must be formulated and implemented

● For a country that has atomic energy at the helm of its national energy policy, the education of citizens and health care workers with regard to radiation is inadequate
⇨ Educational curricula must be re-examined (compulsory and secondary education)
⇨ Science writers and science "translators" need to be educated
⇨ Risk communicators should be trained

● Engineers and academicians for atomic energy are an aging demographic
⇨ We need to train young engineers and researchers

● Confusion in the ranks of those issuing orders
⇨ Exercising leadership
Leadership is the responsibility of administrators
• A unanimously agreed-upon leader is necessary
"No one told me" is a phrase that must be expunged
Karl Marx's words prove true: "The road to hell is paved with good intentions."
• Determining priorities
What can be done at one time is limited when working hours and manpower are limited
• Ad hoc measures are crucial
• A multitude of issues suddenly arrive that require attention and decisions
⇨ Do not let yourself be consumed by tiny details!
Win the war, ignore the petty skirmishes

● There is confusion regarding the difference between "safety" and "peace of mind"
Peace of mind is a psychological matter and safety is a matter of cost
There is no such thing as absolute peace of mind and completely assured safety

● A "single point of contact" and "broadly-shared information"
Information is a varied mix of valuable and worthless elements ⇨ people and places to sort information are needed
⇩
Neglecting this leads to a confused disaster site and further collapse

● Sharing/conveying information is critical
This assuages the anxiety of staff members and the public

● Infrastructure (environmental support) for evacuees
— At present, the consideration paid to maintaining mental and physical well-being is insufficient
Most important is an understanding that people who feel caged and restricted (in evacuee shelters) will suffer health issues from lack of physical activity

● Information from outside that is lost within the organization
Cases exist when those in charge do not know how to treat certain information, so they simply archive or hide it internally.

unfortunate that some information received by the organization was lost in the commotion.

VI. Lessons for Posterity

1. Preconditions for Maintaining Hospital Operations

I considered myself to be a lifeline of the hospital, but securing the hospital's real "lifeline" needs to be reconsidered. The first case in point is water. In general, one ton of water is needed per day for each hospital bed. To meet this need, wells are a possible option. Next we need stocks of medicine, fuel (oil and gasoline), and food.

Too much of focus on weak operational efficiency in the recent years affected our response system during the last crisis. Third, the conditions for outsourcing must be closely examined. Outsourced services, such as food and emergency helicopters, can be withdrawn at the whim of the provider; this fact must be taken into account with. Finally, there is electricity. Although FMU did not experience trouble, in light of a major disaster such as the nuclear power plant accident, secondary and tertiary backup electrical systems are necessary.

Chart 5: Lessons for Posterity

● **When faced with a crisis, rather than treating that crisis as a horrific event, think of it as an "opportunity to grow stronger," then strive to overcome it.**
On Providence, Seneca
⇨ Take on the challenge with pride and confidence!

● **1. In a time of hysteria, there are those in society who will seize on only half of a comment and attack by reacting only to partial reports.**
2. Words that turn their back on "justice" to criticize others are always in vain. (Hiroyuki Kano)
3. Those who sound such alarms always do so from a place of safety.
Don Quixote, Miguel de Cervantes
⇨ Courage is not the absence of fear, but the ability to push forward with dignity in spite of it.
The Burden of Proof, Scott Turow
⇨ Life involves confronting insurmountable obstacles. At those moments, crying aloud does no good. All we can do is grit our teeth and persevere as we move forward. (Kensuke Ito)
⇨ People must play the cards that life has dealt them. There is no sense in complaining over an unlucky hand

● **In areas where certain scientific cause–effect relationships cannot be established, an approach that exceeds scientific logic is necessary**
Yoichiro Murakami
Yomiuri Shimbun, August 1, 2011
⇩
The necessity to unite safety and peace of mind

● **The leadership expresses a clear message of gratitude for those working in and around the disaster (I acknowledge you)**
॥
An "ignorance is bliss" or "hands-off" approach is futile during an emergency

● **Criticism through the luxury of 20/20 hindsight causes confusion (entirely different from normal, non-disaster events)**
9.11: All passenger planes across the entire U.S. were ordered to land immediately
⇨ Lauded as a wise decision
⇨ Later criticized and questioned as to "Who gave the order?"
3.11: "Long–term, 30–year monitoring of (2,000,000) residents' health" was immediately called for
⇨ Residents were afforded a measure of relief
⇨ Later criticized as "impossible" and only liable to bring "discouraging results"

● **The wider public needs skills gleaned from experts**
Experts with disaster management skills
⇳ Keitaro Hasegawa
A newly informed public using these skills
⇩
Disaster prevention; minimal damage

2. Lessons for Posterity

Let me enumerate the lessons that must be conveyed to future generations, not limited to health care professionals, as learned from this unprecedented catastrophe.

While responding to this disaster, a number of proverbs came to mind. These learnings are not only limited to major catastrophes but also apply to times of emergency. Future generations should take careful note.

First, an individual approach to a formidable obstacle completely changes, whether it is perceived as a negative or positive opportunity.

Second, during emergencies, there is little time for arguments regarding theoretical and practical applications. Thus, the people around must, as much as possible, provide support and cooperate with those implicated in the disaster. There are more than a few maxims that could be cited to support the dangers of neglecting this point.

Third, in unanticipated events, courage is truly necessary; however, this courage should not be free from fear. Fear has to be held within oneself so that action and decisiveness can prevail. In reality, no one will come rushing to our help if we merely cry and complain.

Safety and peace of mind occupy opposite poles.

Safety is a scientific matter and peace of mind is a psychological and economic matter. However, for an unprecedented disaster such as the recent one, Yoichiro Murakami's words of advice bear merit.

In ultimate tests such as this, it is vital for leaders to send a message to those who are laboring so earnestly. The message is "We recognize your effort. We are grateful for your work."

The most disconcerting thing to be endured by those implicated in a disaster, as I earlier alluded regarding certain maxims, is to have people enter into the fray once the dust has settled and offer criticism buttressed by hindsight. One expects there to be room for improvement and room for uncovering a better course of action by placidly looking back on decisions made under duress. This is all the more reason why leaders must show consistency and authority in times of emergencies, even if instantaneous decisions can only be deliberated upon. When third parties who were not present and did not have complete data offer criticism, it is truly painful for those who take the necessary actions to bear.

And finally, in extreme circumstances, the people of a nation need to follow wise leaders. However, fate ultimately turns on whether wise leaders exist in the administration or at the actual site of the disaster.

(This is a paper for a lecture presented at the 60th conference of the Eastern Japan Association of Orthopedics and Traumatology, jointly held with the 51st conference of the Kanto Society of Orthopedics and Traumatology.)

Gastroenterological Surgery, April 2012, Vol. 35 No. 4 (Issue 434, Herusu Publishing)

Special Report from Fukushima on the Great East Japan Earthquake: Hope in the Midst of Adversity, Part 2

The Role of Transmitting Information in Disaster Medicine

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Introduction

Soon after the earthquake, with the failure of all communication systems, even verifying the safety of the physicians in our department was difficult. On the day of the earthquake, our department compiled a mailing list, and we immediately disseminated information from the first disaster response meeting held on the same day at 12 am at Fukushima Medical University (FMU). This mailing list, which included other related hospitals, played a vital role in information sharing. It made possible the sending of information, which FMU gathered as a medical base, to all related facilities. At the same time, we were able to gather information about personal and material damage at each hospital, and the status of their medical care. Anxiety and lack of information on radiation from the accident at Tokyo Electric Power Company's Fukushima Daiichi nuclear power plant was particularly severe. Nevertheless, this mailing list updated physicians with the latest news, thus facilitating the relief of their anxieties.

The physicians of our department, the hospital, and other hospitals had to face the disaster from their respective standpoints. Physicians were dispatched from our department to work with the medical rescue group of the prefecture's Disaster Response Headquarters, which served as a bridge between the hospital and the prefectural government. These physicians played an important role, as did the young physicians dispatched to medical facilities within 5 kilometers of the Fukushima Daiichi plant, and were forced to evacuate from the expanding evacuation zone with their patients. This article vividly recounts each of their on-the-ground experiences during the disaster.

A Disaster Medicine Coordinator's Perspective

When thinking about providing medical care during a disaster, one needs to consider how to coordinate with medical professionals as per their specialties both inside and outside the disaster areas. It is important to deliberate with government agencies over the type of medical care currently needed in disaster areas and the level of medical care that can be provided. From this viewpoint, FMU has collaborated with the medical rescue group since immediately after the disaster, and has dispatched a number of physicians, including Disaster Medical Assistance Team (DMAT) physicians. These physicians were appointed as disaster medical coordinators from Fukushima Prefecture to facilitate the smooth coordination of work.

Given below are six important points to consider while transmitting information on disaster medical care:

1) Robustness: not breaking down in times of disaster
2) Stability: enduring sudden increases in the demand for communication
3) Universality: extensively transmitting accurate information
4) Promptness
5) Ease of use: anybody can transmit information
6) Bidirectional systems

Did the tools used in this past disaster fully meet all these conditions of functionality? Unfortunately, no. A portion of the prefectural government offices were damaged by the earthquake and therefore unusable, so the Disaster Response Headquarters was hastily established in *Fukushima Jichi Kaikan* adjacent to the prefectural offices. To add to these circumstances, not enough landlines were functional right after the disaster. Nippon Telegraph and Telephone Corporation (NTT) then set up a temporary preferential phone line to secure a connection between FMU and the headquarters; however, the lines in both the hospitals in severely damaged coastal areas and the core hospitals in Fukushima were still unstable.

Table 1: Timeline of Explosions at Tokyo Electric Power Company's Fukushima Daiichi and Daini Nuclear Power Plants

March 12	Dropping levels of coolant water in Daiichi plant's Unit 1 Reactor -> pressure release valves opened, evacuation of those within 3 kilometers and indoor refuge for those within 10 kilometers of the Daiichi plant -> some hours later, evacuation of those within 10 kilometers Evacuation of those within 3 kilometers and indoor refuge for those within 10 kilometers of the Daini plant Hydrogen explosion at Daiichi plant's Unit 1 Reactor -> destruction of the reactor building -> evacuation of those from within 20 kilometers of the Daiichi plant and 10 kilometers of the Daini plant
March 14	Hydrogen explosion in the Daiichi Unit 3 Reactor -> destruction of the reactor building
March 15	Sound of explosion at the Daiichi Unit 2 Reactor, fire at the Daiichi Unit 4 Reactor -> indoor refuge orders for those within 20–30 kilometers from the Daiichi plant

Although the penetration rate and battery life of the internet, cell phones, and other portable gadgets have progressed enormously, these gadgets and services could not maintain their robustness or stability in the more severely damaged areas from the earthquake and tsunami. Relay base stations were damaged by the earthquake and tsunami, causing a narrowing in their coverage areas and an inability to respond to the increase in communication demands; however, conditions differed among service providers. At the time, it was difficult to contact physicians who worked at a hospital about 3 kilometers from the Fukushima Daiichi plant and were given emergency evacuation orders with their patients. Those involved believe that the lack of information and disruption in communication systems impeded their ability to request for support. In short, the inability to share damage reports is an indication of the severity of the damage.

During the disaster, social networking services and other networks facilitated the quick transfer of information across the country, including information about the needs of disaster areas, the most appropriate transfer routes and methods, the locations of aid supplies, and the amount of aid available. But those of us who were active in the disaster area had no time to check this information; thus, further research is needed to validate the contributions such information made to rescue efforts.

1. Evacuation and Information Transmission after the Fukushima Daiichi Plant Accident

The 3-kilometer evacuation zone set up on the day of the disaster was gradually expanded (Table 1). Thus, inpatients within the zone had to be transferred. At first, they were transferred to the indoor refuge zone, 20–30 kilometers from the Fukushima Daiichi plant. However, due to the lack of water, food, heavy industrial oil, gasoline, and pharmaceuticals, medical facilities in the 20–30-kilometer zone could no longer support medical functionality. This condition necessitated a more widespread transfer of patients. Therefore, teams comprising members from the Cabinet Office, DMATs, the FMU disaster medicine coordinators, Self-Defense Forces, the coast guard, fire departments, disaster prevention departments, and police departments began the widespread transfer of patients to disaster base hospitals in neighboring prefectures (please see the Cabinet Office's disaster prevention information webpage http://www.bousai.go.jp/3oukyutaisaku/kouiki.html).

This task involved the transfer of approximately 450 patients, who on March 18 were hospitalized in medical facilities within 20–30 kilometers from the Fukushima Daiichi plant. These patients were relocated to disaster base hospitals in Niigata, Gunma, Tochigi, Saitama, and Ibaraki prefectures between the 19th and the 21st. However, the nuclear disaster complicated the widespread medical transfers from Fukushima. Patients leaving the medical facilities had to be screened for radiation contamination at points set up outside the 30-kilometer zone. In addition, only a limited number of staff was allowed into the 20–30-kilometer indoor refuge zone (Image 1). To conduct the transfers more efficiently, the staff permitted into the 30-kilometer zone shuttled back and forth (from the medical facilities within the zone to the screening points), and another team led patients from the screening points to the disaster base hospitals.

On March 19, the medical transfers were conducted using land transportation, and on the second day (20th), we expected Coast Guard and Self-Defense Force helicopters to help with the transfers. However, bad weather permitted only one airlift in the morning. Thereafter, all transfers were conducted on the ground and our work continued into the night.

The physicians and staff at the receiving hospitals were of enormous help. I would like to use this opportunity to once again express my gratitude to them. Immediately after the earthquake, medical facilities transferred patients who could walk voluntarily, or those in relatively good condition, to facilities in less damaged areas of the prefecture. They used their own routes or were provided help by the prefecture's Disaster Response Headquarters. A majority of these patients were either elderly or in conditions that would render them reluctant to be transferred. These patients were first brought to FMU Hospital, and the following day, they continued on to their destination hospital. A list of transfer patients is extremely important for this type of successive transfer, and the relevant medical facilities had to make this list in one evening. Some of the patients who had emergency hospitalizations because of the earthquake and tsunami had to be transferred without us knowing their identity or family information (we did not know the names or health insurance information for many patients). In retrospect, the ruptured functionality of government offices at the time was an unavoidable situation.

Image 1: Medical Rescue Group of the Prefecture's Disaster Response Headquarters

Image 2: Location of Hospitals and Care for Evacuee Patients

2. Medical Support and Information in the Evacuation Centers

After the widespread medical transfers settled down, we began coordination of medical support for the evacuation centers. We initiated this together with the prefecture's health and welfare department and physicians from physician associations at the prefectural, district, and city levels. Many evacuation centers established across Fukushima received medical support mostly from district and city physician associations immediately after the earthquake. Thus, district and city physicians associations first gathered on-the-ground information for us to grasp the current situation and convey it to prefectural physician association. They also shared information about medical teams such as the Japan Medical Association Teams (JMATs) who were requested to come. Here, too, the work was bogged down by a lack of information and disruption in communications. One of the reasons was determining who had established the evacuation center. Evacuation centers were set up by the prefecture or municipalities. Sometimes the department-in-charge differed among municipalities, and this made gathering information difficult. Heading to the disaster area with mutual distrust and anger, I found that the government buildings themselves were damaged and the officials inside were literally working round-the-clock. I vividly remember my embarrassment at having become frustrated without knowing the true situation. I clearly realized the importance of physical robustness not only of our information systems but also of our government offices. We must build information transmission systems that connect the prefectural, district, and city physician associations with the prefectural government. They must be resilient enough to fully function in times of disaster.

(Toshihiko Fukushima)

A Physician Working in Soso

In April last year, Fukushima Prefectural Ono Hospital, 4.2 kilometers from the Fukushima Daiichi plant, and the Futaba Kosei Hospital, 3.3 kilometers from the plant and run by JA Fukushima Kosei Association, were in the process of amalgamation (Image 2). The new hospital was expected to be both a core hospital with 25 full-time physicians and 370 beds—more than 30% of the beds in Futaba—and a secondary emergency medical base with Fukushima's second multi-purpose helicopter.

Futaba Kosei Hospital, March 11, 2011

Cracks ran through the concrete floors, water tanks split open, and the stench of gas filled the rooms. I tried to head to the hospital ward, but the corridor to the third floor had collapsed. Racing up to the ward, I saw objects scattered everywhere, but thankfully no casualties. The staff gathered, and quickly and carefully took patients down the emergency stairwell on wheelchairs, stretchers, and mattresses. The air outside was cold. We made beds by simply bringing together two benches in the waiting area, and placed covers and futons on litter patients. At that moment, the tsunami warning sounded, alerting us to the tsunami that was a few meters tall and gushing toward us. Hunting for space to house over 100 patients, we led patients to the second floor of the psychiatry ward. After transporting them by litters, I glanced out at National Route 6 and saw that it was blocked with traffic. Going up to the roof, I saw the tsunami had advanced about 300 meters inland. I am the only full-time surgeon at my hospital. Preparing for the transfer of emergency patients, the internal medicine physicians, gynecologists, part-time orthopedic surgeons, psychiatrists, and nurses gathered in the emergency outpatient area; I was put in charge of triage. Many emergency patients suffered trauma from the rubble after the earthquake. However, as time progressed, an increasing number of patients were falling victim to the tsunami. The rescue squads shared with us the frustration and agony they felt seeing people swept away by the tsunami and not rescued because they were too far away. Unfortunately, many patients transported to our hospital were tagged black during triage. At 7 am, a cesarean section that was temporarily stopped because of the earthquake was finally completed. It was a life born during a disaster.

Meanwhile, I heard rumors of radiation leaking from the nuclear power plant.

A DMAT from Niigata University arrived in the middle of the night and provided us with much-needed encouragement. We received three seriously injured patients with aspiration pneumonia contracted by ingesting seawater, pelvic fracture, and peritonitis. Our hospital is located 3.3 kilometers from the nuclear power plant, and at 8:50 pm on March 11, an evacuation zone with a radius of 2 kilometers around the plant was ordered, only to be farther extended at 9:23 pm, to 3 kilometers. However, we did not receive that information.

March 12

Just past 7 pm, a news channel made an announcement that the prime minister had ordered the evacuation of residents within a 10-kilometer radius. About 20 Self-Defense Force members and police personnel wearing tyveks* arrived and assisted with the evacuation operations. Concurrently, we were ordered to seek refuge indoors and stop patient transfers for close to three hours. We later learned that it was because of a leak at the nuclear power plant.

At first, we transported ambulatory patients by bus, but we also had many litter patients. So we transported them using the Self-Defense Force's large, twin-engine helicopter. Evacuating past the nuclear power plant by car, we heard what sounded like fireworks. We later learned that this was a hydrogen explosion in the Fukushima Daiichi plant's Unit 1 Reactor. Evacuating along National Route 288, we drove under a bridge along the Joban rail line that had collapsed.

March 13

We began to transfer most of our evacuees to the Fukushima Gender Equality Center in Nihonmatsu, which was about 70 kilometers from the hospital. Radiation surveillance showed that there was no need for decontamination. After this, some of the patients were evacuated to the Saitama Super Arena in Saitama City, Saitama. I went to Saitama City as well.

(Shotaro Fujita)

Fukushima Prefectural Ono Hospital, March 11, 2011

We learned from the news (television and radio) that the earthquake had a magnitude of 8.8 and that many people were missing because of the tsunami. We also had many staff members whose houses were washed away or who could not contact their family. We medical professionals were strongly aware that we were also victims of the disaster. The next morning at 6 am, evacuation orders were issued because of the danger from the nuclear power plant. We used large buses and ambulances to evacuate patients and staff to a clinic in Kawauchi, which was 20 kilometers inland. Immediately after, we heard about the nuclear power plant explosion and that the evacuation zone had been expanded to within a 20-kilometer radius. We were forced to move yet again. The staff was in turmoil from the fear of this invisible danger. The System for Prediction of Environment Emergency Dose Information (SPEEDI) data released at a later date showed that radiation levels were exceedingly high in Kawauchi. If we had known this beforehand, we would have chosen a different evacuation route. Using the town office's satellite phone we were able to contact our department at the school and secure an intake hospital. After shuttling the patients by disaster helicopter, ambulances, or minibuses, we had to look after ourselves; we were victims too. Some left for evacuation centers where family members were staying; others went searching for their family members in different evacuation centers. Presently, I am a surgeon in a hospital 120 kilometers away from the plant, with enduring thoughts of my colleagues who lost their hospital but persisted in their roles as medical professionals until the very last patient was transferred.

(Yasuhide Kofunato)

Conclusion

These were the reports of the young faculty who fulfilled their duties toward the patients of their hospitals, which cannot be rebuilt and are located in areas deemed difficult to return to in the future. Our major source of information was mass media such as the TV, and the lack of accurate information stoked our anxieties and fears. In the midst of this massive confusion, it was a blessing to have a large group of medical professionals who fulfilled their responsibilities as medical professionals. I can still vividly remember my sense of relief at seeing the physicians safely return to our school after transferring all the patients to intake support hospitals, and receiving reports that there were no abnormalities in the radiation surveillance. What we must not forget is the marked ability of surgeons to steer us away from crises. Some important points for future surgical education are the ability to promptly and appropriately act and make decisions under extreme situations, and the development of knowledge, skill, and character to support such abilities, actions, and decisions.

*Tyvek: non-woven polyethylene fibers that are used in uniforms for those working in areas exposed to radiation

Am J Respir Crit Care Med. 2012;186(12)1309-10

Impacts of the 3/11 Disaster in Fukushima on Asthma Control

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To the Editor:

The Great East Japan Earthquake and tsunami on March 11, 2011, resulted in the Fukushima nuclear power plant accident, which consequently led to a massive emission of radioactive substances. We investigated the effect of this complex disaster on individuals with asthma, who have been treated and followed up regularly in the outpatient clinic of Fukushima Medical University Hospital, located 57 km away from the Fukushima Daiichi nuclear power plant. An interview by their attending doctors was performed to evaluate changes of dwelling, changes in lifestyle, and availability of antiasthmatic drugs. Psychological and asthma control status of the patients were evaluated using a visual analog scale (VAS) (1).

Seventy patients with asthma (28 mild persistent, 24 moderate persistent, 12 severe persistent, and 6 the most severe) were enrolled. All the patients were treated with inhaled corticosteroids (ICS) before the disaster. All of them experienced the earthquake stronger than 6+ by Japan Meteorological Agency seismic intensity scale. They were evaluated 3 to 12 weeks after the disaster with regard to physical damage, status of evacuation, and availability of antiasthmatic drugs. In addition, asthmatic symptoms, asthma control, and anxieties about the disaster and their asthma were evaluated by the VAS analysis. They were asked to evaluate their situation by a −10 cm to +10 cm scale (−10 cm = worst or the most anxious; 0 cm = no change; +10 cm = improved significantly or no anxiety). Although physical damage was not reported, 6 subjects (8.6%) had lost their homes and were living in a shelter. In 6 patients (8.6%), ICS became unavailable and was discontinued. The deterioration rate of asthma was significantly higher in the ICS-discontinued group compared with the ICS-continued group (66.7% and 15.6%, $P < 0.0001$, respectively). VAS analysis of 64 ICS-continued patients revealed that 46 (71.8%) experienced anxiety about the disaster. The anxiety rate was significantly higher among females and those who required evacuation ($P < 0.05$). The deterioration rate of asthma was also significantly higher in the patients with anxiety regarding the disaster ($P < 0.05$) (Figure 1). The patients' location did not affect their asthma control.

In Japan, the effects of earthquakes on asthma exacerbation have been reported, but the results were inconsistent (2–4). In this study, it is clarified that the continuous use of ICS is the important factor for asthma control during the disaster. Although the severity of asthma was relatively high, only two patients experienced severe asthma attacks requiring emergency room visit. This also suggests the importance of reestablishing the drug supply system after the large disaster. In this disaster, the Japanese government allowed pharmacists to supply drugs without prescription if they could confirm the drugs that the patients regularly used. This emergent change in policy worked very well, and a majority of the patients suffering from chronic diseases could get their drugs. In this study, only 10% of the subjects had trouble getting antiasthmatic drugs.

However, deterioration of asthma control was also observed in patients who could continue their ICS. Regarding this, VAS analyses revealed that deterioration is significantly related to emotional stress such as anxiety about the disaster and their having asthma. Fagan and colleagues also reported the importance of psychological stress on asthma during the September 11, 2001, terrorist attacks in the New York City metropolitan area (5). It is also known that central cognitive processes may influence not only the interpretation of asthma symptoms but also the manifestation of measurable changes in immune and physiologic markers of asthma (6).

Our study has some limitations. Due to the disaster, it was not possible to evaluate the parameters such as airway responsiveness, bronchial reversibility, and induced sputum analysis. The number of participants was relatively small because the study was done at a single center in the middle of the unexpected huge, complex disaster.

However, the results of present investigation suggest that the stable supply system of antiasthmatic drugs (especially ICS) and the psychological support system for the patients are important to maintain asthma control during disaster conditions.

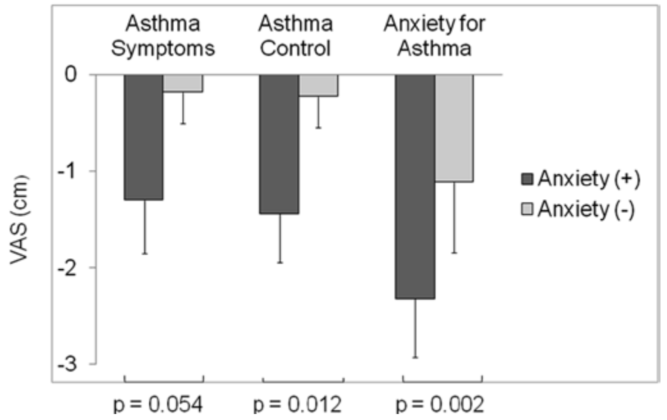

Figure 1. Relationship between anxiety regarding the disaster and the state of asthma. Anxiety about the disaster was evaluated by the visual analog scale (VAS) (−10 cm to +10 cm, the most anxious to no anxiety, respectively). When the scale was between −10 and 0 cm, it was defined as anxiety (+); when it was between 0 and +10 cm, it was defined as anxiety (−). In the anxiety (+) group, scores for asthma symptoms, asthma control, and the anxiety about their asthma were significantly lower than those in the anxiety (−) group. Each *bar* represents the mean ± SD.

Author disclosures are available with the text of this letter at www.atsjournals.org.

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Fukushima J. Med. Sci.,Vol. 57, № 2, 2011

Lessons from Chernobyl

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(Received July 8, 2011, accepted September 7, 2011)

Abstract : The Chernobyl disaster on April 26, 1986, led to the emission of radioactive substances such as iodine-131 and radioactive cesium. As the Soviet Union did not control food distribution and intake, residents were exposed to high levels of internal radiation, leading to the internal radiation exposure of the thyroid gland by iodine131. As a result, the number of people who had thyroid cancer increased drastically among those who had been under 15 years old at the time of the accident. The age predilection is about to move to 25 or older. However, there has been no scientific evidence of impacts for solid tumor other than thyroid cancer, leukemia, benign diseases, or inheritance including unborn babies. On the other hand, the accident was thought to have caused social unrest and mental damage which had far more impact than that caused by radiation exposure.

In this paper, we would like to summarize the impacts on the health of the people in Chernobyl compared to those caused by the accident at the Fukushima Daiichi Nuclear Power Plant.

Key words : *Chernobyl Nuclear Power Plant, internal exposure, thyroid cancer, iodine131*

INTRODUCTION

The accident took place on Apri1 26 in 1986 at the Chernobyl Nuclear Power Plant located 130 km north from Kiev, the capital of Ukraine. The reactor 4 exploded and caught fire. This was to be the worst radiation disaster in history. At the time no specific information was publicized due to the cold war. Lack of information and fear of invisible radiation caused panic around the world. Substantial international support began only after 1990 when the Soviet Union stepped towards disorganization along with perestroika (economy reform) and glasnost (publicity).

The scientific knowledge we learned from health impacts on inhabitants around the Chernobyl Nuclear Power Plant and workers in the plant provides us with critical information when considering countermeasures for health impacts on the people and workers involved in the accident at the Fukushima Daiichi Nuclear Power Plant.

In this study, we would like to briefly explain health impacts caused by the accident in Chernobyl and study similarities and differences in the accident in the Fukushima Daiichi Nuclear Power Plant. We would like to consider the lessons which must be learnt from the accident in Chernobyl.

EMITTED RADIOACTIVE NUCLIDES AND COUNTERMEASURES FOR INTERNAL EXPOSURE

For the Fukushima Daiichi Nuclear Power plant, we have to wait until inspections reveal details of radioactive nuclides emitted in the accident. In Chernobyl, one of the dominantly emitted radioactive nuclides was assumed to be harmless xenon 131. Some of the other nuclides have short half-life such as that of iodine-131 of which is eight days and tellurium-132, which turns into iodine-132 within a very short period of time. Radioactive cesium which has a relatively long half-life was also thought to be included[1] (Table 1).

Since iodine 131 and radioactive cesium were the

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Table 1. Radionuclide emitted in the accident at the Chernobyl Nuclear Power Plant (Modified the data in Reference 1)

Radionuclide	Half-life	Radiation	Emission amount (PBq)*
Neptunium 239	58 hrs	β-rays, γ-rays	95
molybdenum 99	67 hrs	β-rays, γ-rays	>168
tellurium 132	78 hrs	β-rays, y-nys	1,150
xenon 133	5 days	β-rays, γ-rays	6,500
iodine 131	8 days	β-rays, γ-rays	1,760
barium 140	13 days	β-nys, γ-rays	240
cerium 141	33 days	β-ays, γ-rays	196
ruthenium 103	40 days	β-rays, γ-rays	>168
strontium 89	52 days	β-rays	
zirconium 95	65 days	β-nys, γ-rays	196
curium242	163 days	α-rays	
cerium 144	285 days	β-rays, γ-rays	116
ruthenium 106	1 year	β-rays, γ-rays	>73
cesium 134	2 years	β-rays	
plutonium 241	13 years	β-rays	
strontium 90	28 years	β-rays	
cesium 137	30 years	β-rays, γ-rays	85
plutonium 238	86 years	α-rays	
plutonium 240	6, 850 years	α-rays, γ-rays	0.042
plutonium 239	24,400 years	α-rays, γ-rays	0.030

*PBq is equivalent to 10^{15} becquerel.

dominantly emitted substances in Chernobyl, it is thought that this is the similar case in Fukushima. However, whereas only trace quantities of radioactive strontium and plutonium, which led to safety concerns regarding MOX fuel, were found outside the Fukushima nuclear power plants, a significant amount of those radioactive materials was released in Chernobyl. The emitted amount (approx. 520 TBq) in Chernobyl was approximately seven times more than that in Fukushima as of today even though these two accidents are in the level 7 of INES.

Among the substances mentioned, radioiodine, especially iodine-131 is thought to be the one which most affected people's health around Chernobyl. Iodine 131 accumulated in thyroid glands particularly through food intake and resulted in internal exposure. Infants in Chernobyl also suffered internal exposure due to the intake of milk containing high density of iodine-131. Because the Soviet Union then did not control either food distribution or intake, people were unaware of ingesting contaminated milk, vegetables, water, etc. This was considered to be the main reason of internal exposure[2].

The most dominant nuclide emitted during the accident at the Fukushima Nuclear Power Plant was iodine-131. Another major component of the emissions was radioactive cesium (cesium-134 and cesium-137) , which has long half-life. Iodine-131 was detected in various produce including food, drink, and beef cattle immediately after the accident. Panic was caused not only through the reality of the accident but also by the widespread of groundless rumors through media and the Internet. As a countermeasure, the Japanese government specified values of radioiodine and cesium contained in food and drink as the provisional standard. They regulated shipping produce with higher content of radioiodine and cesium in order to prevent people from ingesting contaminated foods and drinks. We must remember the tough decision taken by the people working in the primary sector of industry in Fukushima Prefecture. Without this sacrifice, the chance of internal exposure to contaminated food could not be decreased. This countermeasure was taken based on the experiences of internal exposure in Chernobyl described above. Careful health evaluation is still required from now on , however, we assume the impact on people's health that we will see in the future will be far different from those in Chernobyl even though the accident was categorized in the same level seven.

IMPACTS ON HEALTH OF PEOPLE IN CHERNOBYL

In 2006, 20 years after the Chernobyl accident, the World Health Organization (WHO) evaluated impacts on health of people in Chernobyl dealing with International Atomic Energy Agency (IAEA). The materials the group of experts examined were mainly internationally-reviewed manuscripts. They also used publications in countries around Chernobyl (The Republic of Belarus, Russian Federation and Ukraine). Those experts primarily evaluated two health-related issues[3]. One of the issues was health impacts which were directly related to radiation exposure, and the other was diseases that were not thought to be directly related to radiation exposure, however, the relation with the accident could be in doubt. After the evaluation, they submitted a report to the relevant governments.

The results showed the drastic increase of thyroid-gland cancer among children who had been younger than 15 years at the time of the accident. According to the report, nearly 5,000 operations of thyroid-gland cancer have been implemented for children in this age group in Russian regions around Chernobyl, Ukraine, and The Republic of Belarus by 2002 (the number of operations increased to 6,000 by 2006). The age predilection is about to move to 25 or older to middle aged. As described above, the increase in thyroid cancer in infants attributed to excess internal exposure to thyroid gland via ingestion of radioiodine immediately after the accident. It is possible to assume that the chronic iodine deficiency at that time further increased the number of sufferers[4]. Additionally, the occurrence frequency of thyroid cancer in infants and the dose of internal exposure to the thyroid gland had positive correlation[4]. It was very fortunate that 99% of patients had good prognosis and survived after the operations. Radioiodine therapy after the total extirpation of the thyroid gland against lung metastasis showed significant effects and metastasis treatment had a high cure rate[6]. However, the problems of long prognosis, recurrence, and other complications still remain and further tracing and appropriate treatment are essential.

On the other hand, no increase in leukemia has been seen among citizens including infants and adults though that was primarily concerned from the experiences of atomic-bomb survivors in Hiroshima and Nagasaki. This is probably because people in Hiroshima and Nagasaki suffered mainly from external exposure while it was internal exposure to radioiodine immediately after the accident in Chernobyl. Despite the fact that enormous efforts were expended to analyze genetic abnormality of radiation-induced thyroid cancer, the analyses have not been able to distinguish between induction by radiation and spontaneity at the molecular level[7].

Apart from thyroid cancer, increase in solid cancers, benign diseases, genetic effects, or effects on unborn babies among residents living around the Chernobyl Nuclear Power Plant has not been scientifically demonstrated. However, social unrest and mental damage caused by the accident is thought to be more serious than the physical damage due to direct radiation exposure. Especially those who were forced to evacuate immediately after the accident and those who were forced to move have issues related to social and economic unstableness. In addition, problems of current health fears and strong anxiety over health impacts on future generations have come up. A paucity of scientific research is available on psychological effects and many psychological effects are not determined as health disorder. The WHO report mentioned above states that what the residents are suffering from is at a potential subclinical level which is not clinically identified as abnormal. The report also requires future resolution.

When we look at the current situation in Fukushima, we should see the radiophobia brought by mass media. Rumors have widely spread among the residents due to lack of accurate information. The same fear has been found in other areas including Tokyo metropolitan area even though they are far from Fukushima. This panic like phenomena can be attributed to the internet societies which magnified irresponsible groundless information or rumors. To provide accurate information and thorough mental care is critically required in order not to let people in Fukushima, especially mothers and their children, have the similar fear of potential health problems that people had in Chernobyl. Farmers and workers engaged in the primary industries are under another threat. Primary industries have been thriving in Fukushima, however, their products are vulnerable to harmful rumors or misinformation. The people are anticipating financial damages and some have even committed suicide because of the fear of the future. Immediate action must be taken to prevent such tragedy. A correct information source and the proper passing of information by the media are required in health risk communication with regards to radiation. However, preceding those, the health risk communication requires individual awareness of risk to understand and judge risk. To develop such risk awareness, mutual trust must be built between the information source, media, and recipients of information.

IMPACT ON WORKERS' HEALTH IN CHERNOBYL

Radioactive fallout caused internal exposure among residents in Chernobyl. However, workers who were in the nuclear power plant when the accident happened and those who did the recovery operation after the accident had a potential risk of high-level external exposure. The same is true in the Fukushima Daiichi nuclear power plant. In Chernobyl, 134 people were diagnosed with acute radiation syndrom (ARS). ARS killed 28 of them immediately and 19 of them died due to various reasons between 1987 and 2004. According to the follow-up survey for the workers who registered in the emergency work in the Russian Federation, 116 people died because of solid cancers and 110 people died due to cardiovascular diseases. However, causality with radiation exposure is unknown. The survey also identified that 24 death cases were attributed to acute leukemia, however, the cause was difficult to prove since the average radiation was 115 mSv[5]. Another follow-up survey conducted for the decontamination workers in the Ukraine reported that 18 workers died due to acute leukemia and their radiation exposure was between 120 and 500 mSv[6]. The impacts on cardiovascular and immune systems of the decontamination workers have been argued in Chernobyl, however, until today, nothing explicit has suggested the relation between radiation exposure and the impacts. Analysis of other confounders and long-term accurate investigation and examination are essential.

Currently, the uppermost radiation exposure is specified as 250 mSv for the workers in the Fukushima Daiichi Nuclear Power Plant. Although this value is recommended by International Commission on Radiologica1 Protection (ICRP), long-term follow-up is needed for the workers as well as monitoring their potential cancer risk. Establishing a system to protect the well-being of citizens in Fukushima Prefecture and the decontamination workers is urgently required.

CONCLUSION

Despite the fact that almost half year has passed since the disaster, we are still recovering from the nuclear accident. Those who were forced to evacuate have been suffering from unbearable agony. It is crucially important to learn lessons from the accident at the Chernobyl Nuclear Power Plant, which happened 25 years ago, in order to revive Fukushima and to provide the citizens with a sense of security.

In this paper, we wrote evidences which were approved by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), IAEA, WHO, and other autholized organizations because we believe that scientists are required to be sensitive to the accuracy of information when they send it to the society. Unfortunately, some professionals have presented health impacts in Chernobyl through mass media when that fact was not internationally agreed with and we think that is beneath one's dignity.

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Journal of Clinical Psychological Medicine, Vol. 40, No. 11

Lessons from Fukushima: Psychiatric Care after Radiation Exposure

Study of Newly Admitted Psychiatric Patients after the Fukushima Nuclear Power Plant Accident

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Key Words: *Fukushima nuclear disaster, radiation contamination, psychiatric symptoms, inpatient, manic state*

1. Introduction

On March 11 2011, the Great East Japan Earthquake struck our Fukushima Prefecture. The prefecture suffered not only the damage caused by the earthquake and tsunami but also radioactive contamination from the hydrogen explosions at Tokyo Electric Power Company's Fukushima Daiichi nuclear power plant, which continue to impose problems. As reported by Kario et al., the white coat hypertension has only worsened after the Great Hanshin-Awaji Earthquake[4, 5]. Natural disasters such as earthquakes and tsunamis cause enormous stress, while a nuclear disaster has characteristics of longer, continuous exposure to serious concerns and stresses as victims are faced with invisible radioactive contamination. There have been few reports on the changes of the clinical status of psychiatric patients under the rare circumstances of human habitat being jeopardized by radiation, such as the Hiroshima and Nagasaki bombings, the Three Mile Island accident, and the Chernobyl disaster. Unlike the several articles on the Chernobyl nuclear disaster[2, 3, 6], which were compiled about 10 years later, this study reports the status immediately after the disaster occurred. In this report, we review the survey results of psychiatric patients who were newly admitted to psychiatric wards in Fukushima Prefecture after the earthquake and nuclear disaster. Also, we discuss the patients' characteristics and the possible effects caused by the fear of radiation exposure.

2. Method and Subjects

1) Method

A questionnaire survey was conducted in 30 hospitals. These included psychiatric hospitals and psychiatric departments of general hospitals registered under the Fukushima Society of Psychiatry and excluded those that lost functionality due to the earthquake, tsunami, and nuclear power plant accident as of May 24, 2011.

2) Subjects

Subjects were patients who were newly admitted to the psychiatric hospitals or departments in Fukushima Prefecture between March 12 and May 11, 2011. Those who were transferred due to damage to their hospitals were excluded.

3) Survey Contents

The following items were surveyed for each patient: age, gender, period from the earthquake to hospital admission, damages to their homes, psychiatric diagnosis prior to the earthquake, status on admission, diagnosis on admission, type of admission, living conditions prior to admission (three options: home, evacuation center, and others), the degree of association between the fear of radiation exposure and admission evaluated by the doctor in charge. The respondents were asked to rate each item on a scale of 1–3 (1 = Associated, 2 = Somewhat associated, and 3 = Not associated). In case of multiple answers, we categorized the respondents judging from the information they wrote in the additional space provided. Those difficult to classify were grouped under "others." For psychiatric diagnosis, ICD-10[11] was used.

The characteristics of newly hospitalized patients in Fukushima prefecture after the Fukushima nuclear disaster WADA Akira, KUNII Yasuto, MATSUMOTO Jynya, ITAGAKI Shuntaro, MIURA Itaru, MASHIKO Hirobumi, YABE Hirooki and NIWA Shin-Ichi
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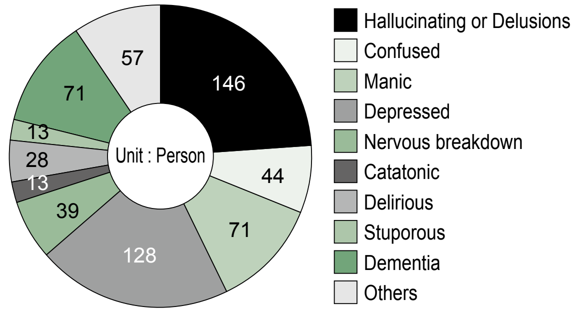

Figure 1. Conditions of New Patients on Admission

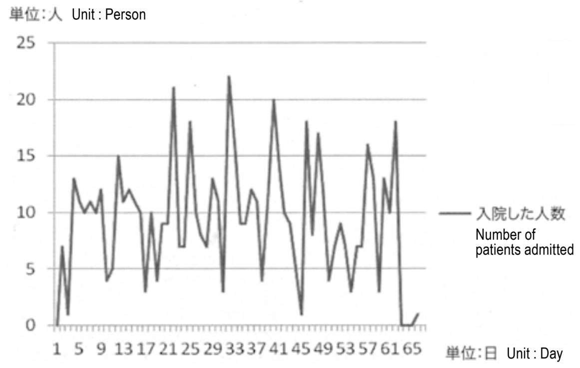

Figure 2. Period from the earthquake to the date of new patient

The clinical status on admission was determined from the 14 statuses and syndromes, defined in Teruo Okuma's book titled Modern Clinical Psychiatry[7].

3. Results

Of the 30 facilities that were mailed questionnaires, 26 responded. We summarize the statistics of 610 patients newly admitted. We excluded cases in which questionnaire information was missing, such as admission diagnoses, and transfer cases from damaged psychiatric and medical wards or facilities. The results of the survey statistics are provided below (results in percentage are rounded up to the nearest decimal point).

1) Following are the survey results for 610 patients newly admitted after the disaster.

The age distribution of newly admitted patients was as follows: 17 (2.8%) were aged 10–19, 67 (11.0%) were 20–29, 106 (17.4%) were 30–39, 84 (13.8%) were 40–49, 90 (14.8%) were 50–59, 110 (18.0%) were 60–69, 56 (9.2%) were 70–79, 67 (11.0%) were 80–89, and 13 (2.1%) were over 90 years. The gender breakdown was 299 males (49.0%) and 311 females (51.0%). The housing condition was as follows: 71 patients (11.6%) had damaged houses, 536 patients' (87.9%) houses suffered no damages, and three (0.5%) were unknown. The living condition prior to admission was as follows: 488 patients (80.0%) lived in their own houses, 81 (13.3%) lived in evacuation centers, 39 (6.4%) lived in other places such as their relative's houses, and two (0.3%) were unknown.

Psychiatric diagnoses prior to the earthquake by ICD-10 classification were as follows: 80 (13.1%) were in F0 (organic including symptomatic and mental disorders), 33 (5.4%) in F1 (mental and behavioral disorders due to psychoactive substance use), 187 (30.7%) in F2 (schizophrenia and schizotypal and delusional disorders), 137 (22.5%) in F3 (mood [affective] disorders), 45 (7.4%) in F4 (neurotic, stress-related, and somatoform disorders), two (0.3%) in F5 (behavioral syndromes associated with physiological

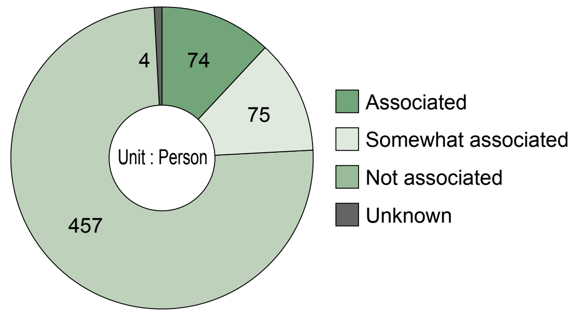

Figure 3. Number of Patients Whose Admissions are Associated with Radiation Exposure

disturbances and physical factors), 11 (1.8%) in F6 (adult personality and behavioral disorders), 20 (3.3%) in F7 (mental retardation), nine (1.5%) in F8 (psychological development disorders), 12 (2.0%) in "others including epilepsy", and 74 (12.1%) had no history of psychiatric diagnosis.

Diagnoses on admission by ICD-10 classification were as follows: 114 (18.7 %) were in F0 (organic including symptomatic and mental disorders), 39 (6.4%) in F1 (mental and behavioral disorders due to psychoactive substance use), 202 (33.1%) in F2 (schizophrenia, schizotypal, and delusional disorders), 145 (23.8%) in F3 (mood [affective] disorders), 53 (8.7%) in F4 (neurotic, stress-related, and somatoform disorders), four (0.7%) in F5 (behavioral syndromes associated with physiological disturbances and physical factors), 15 (2.5%) in F6 (adult personality and behavioral disorders), 20 (3.3%) in F7 (mental retardation), nine (1.5%) in F8 (disorders of psychological development), and nine (1.5%) in others including epilepsy.

The types of admission were as follows: 341 (56.0%) were voluntary, 253 (41.5%) for medical protection, four (0.7%) emergency, 10 (1.6%) involuntary, and two (0.3%) unknown. Figure 2 shows the period from the earthquake to the date of new patient admissions. The number of patients whose admissions

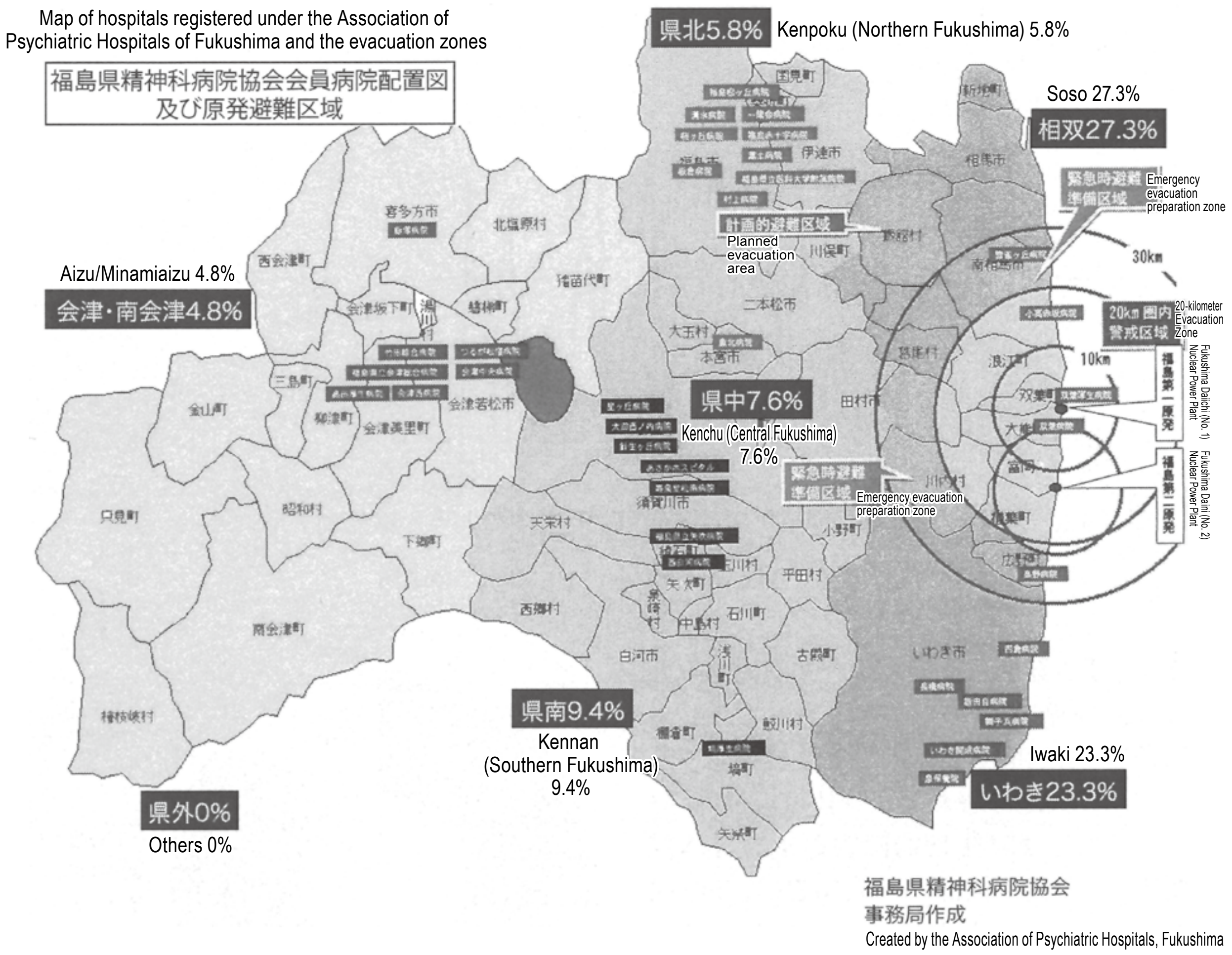

Figure 4. Ratio of Patients whose Admission was Associated with the Fear of Radiation Exposure to All Patients Admitted by Each Area.
(Number of patients in each area whose admission was associated with the fear of radiation exposure/the number of patients admitted in the area)

were associated with radiation exposure was as follows: 74 (12.1%) had an association and 75 (12.3%) a possible association, which accounted for 24.4% of total admissions (Figure 3). Regarding admissions in each region, the ratio of patients in each region whose admissions were associated with radiation exposure was as follows: 5.8% in northern Fukushima (Kenpoku) including Fukushima City; 7.6% in central Fukushima (Kenchu) including Koriyama; 9.4% in southern Fukushima (Kennan); 27.3% in Soso including Futaba, where the Fukushima Daiichi and Daiini nuclear power plants are located; 23.3% in Iwaki; 4.8% in Minamiaizu, Aizu; and 0% from other prefectures (Figure 4).

2) Of the patients who were admitted during the study period, following are the survey results of 74 patients whose admissions were associated with radiation exposure.

The age distribution of the patients were as follows: six (8.1%) were aged 10–19, 12 (16.2%) aged 20–29, nine (12.2%) aged 30–39, 16 (21.6%) aged 40–49, 18 (24.3%) aged 50–59, six (8.1%) aged 60–69, four (5.4%) aged 70–79, two (2.7%) aged 80–89, and one (1.4%) aged over 90 years. The gender breakdown was 31 males (41.9%) and 43 females (58.1%).

The housing condition was as follows: 16 patients (21.6%) had damaged houses and 58 patients' (78.4%) houses suffered no damage. The living conditions prior to admission were as follows: 43 patients (58.1%) lived in their own houses, 25 (33.8%) in evacuation centers, and six (8.1%) in other places such as their relative's houses.

Psychiatric diagnoses prior to the earthquake by ICD-10 classification were as follows: six (8.1%) were in F0 (organic including symptomatic and mental disorders), one (1.4%) in F1 (mental and behavioral disorders due to psychoactive substance use), 32 (43.2%) in F2 (schizophrenia and schizotypal and delusional disorders), 16 (21.6%) in F3 (mood [affective] disorders), seven (9.5%) in F4 (neurotic, stress-related, and somatoform disorders), three (4.1%) in others, and nine

(12.2%) had no history of psychiatric diagnosis.

The conditions on admission were as follows: 28 (37.8%) were hallucinating or delusional, eight (10.8%) confused, eight (10.8%) manic, eight (10.8%) depressed, seven (9.5%) had a nervous breakdown, one (1.4%) catatonic, three (4.1%) delirious, five (6.8%) had dementia, and six (8.1%) were others.

Admission diagnoses by ICD-10 classification were as follows: 10 (13.5%) were in F0 (organic including symptomatic, mental disorders), two (2.7%) in F1 (mental and behavioral disorders due to psychoactive substance use), 36 (48.6%) in F2 (schizophrenia and schizotypal and delusional disorders), 15 (20.3%) in F3 (mood [affective] disorders), eight (10.8%) in F4 (neurotic, stress-related, and somatoform disorders), and three (4.1%) in others.

The types of admission were as follows: 41 (55.4%) were voluntary admissions, 30 (40.5%) for medical protection, and three (4.1%) involuntary admissions. Figure 5 shows the period from the earthquake to the admission.

4. Discussion

Since this study does not include all patients admitted in Fukushima Prefecture, we are unable to compare the results with those of patients admitted under normal circumstances. In addition, since this is a preliminary survey not strictly controlled for statistical processing and a simple review of the trend of newly admitted patients after the earthquake and nuclear accident, a detailed discussion will be challenging. However, there is no previous report of newly admitted patients to a psychiatric ward after a major disaster including a nuclear incident. Thus, this study serves the important role of providing fundamental data for future studies.

The characteristics of newly admitted patients with psychiatric disorders after the catastrophes are discussed as follows: First, 33.1% were in F2 (schizophrenia spectrum), the most diagnosed condition on admission; 23.8% in F3 (mood disorder spectrum); and 7.4% in F4 (neurotic, stress-related, and somatoform disorders, including Post Traumatic Stress Disorder [PTSD]), which was relatively rare. Second, 11.6% of all admitted patients were in a manic state on admission, which is relatively high. Third, among all newly admitted patients, 12.1% were associated with the fear of radiation exposure after the nuclear power plant accident. We focus on reviewing statistics from outpatient psychiatric wards in Fukushima Prefecture after the earthquake and excluded data on PTSD since it is beyond the scope of

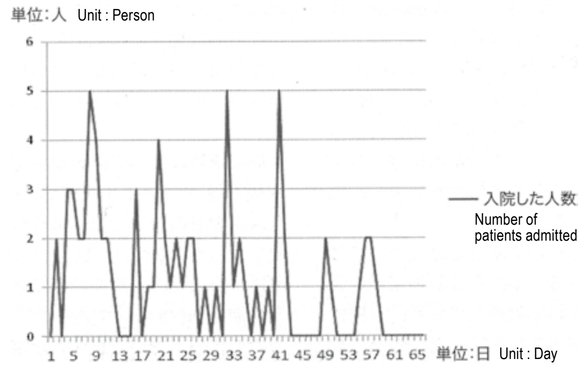

Figure 5. Period from the Earthquake to the Date of Admission of Patients whose Admissions are Associated with Radiation Exposure

our study.

1) There was an increase in the admission of patients in a manic state after the earthquake.

There were 71 patients (11.6% of all admissions) who were in a manic state on admission. Considering that mood disorder symptoms seasonally fluctuate, comparative data of the same season under normal circumstance is required; however, there was no such data available. Therefore, we decided to compare new admission data at Fukushima Medical University Hospital, Department of Psychosomatic Medicine between March 12 and May 11 from 2007 to 2010. There were 112 new admissions over a period of four years, of which four (3.6%) were admitted in a manic state. Our data shows that the admissions of patients in a manic state were approximately three times higher at 11.6%, illustrating a higher trend after the earthquake. In addition, this study shows the statistics of admission applications submitted for medical protection by type of disorder in Fukushima in 2009. The necessary approval has been provided by the Welfare division, Fukushima Prefecture. The admission rate for medical protection for F3 disorders, such as manic and depressive states, was a total of 14.5%. Admissions of patients in both depressive and manic states were 14.5% under normal circumstances, while those only in a manic state were 11.6% of all admissions after the earthquake. Although we cannot compare manic and depressive states because data available shows admission for medical protection only, and considering that depression is far more common than manic cases, the rate of manic cases is higher than that under ordinary circumstances.

There have been several reports about the increase in manic state after major disasters. Yamaguchi et al. reported that there were numerous admission cases of patients with bipolar disorder who had a relapse of the manic phase after the Great Hanshin-Awaji Earthquake[12].

Shinpuku et al. reported that many victims were found to be talkative and cheerful and that depressive patients developed manic conditions after the Great Hanshin-Awaji Earthquake[10]. This phenomenon of symptomatic exacerbation in bipolar patients after catastrophic disasters has been reported overseas[1], and attention should be paid to worsening symptoms, even if the patient has been stable for years. Furthermore, if there is even a slight deterioration of symptoms, patients may benefit from early-stage treatment, such as mood stabilizers, or admission.

2) The fear of radiation exposure as a possible cause of psychiatric admission

Of the patients who were admitted during the study period, the number of patients whose admissions were associated with the fear of radiation exposure was 74 (12.1%), and those whose admission was possibly associated with the fear of radiation exposure was 75 (12.3%), which accounted for 24.4% of total admissions. In this case, whether the fear of radiation was a cause for deterioration in clinical status leading to admission was subjectively evaluated by the doctor in charge. Thus, the analysis of this phenomenon lacked objectivity, which should be taken into account when drawing a conclusion.

The radiation dose rate in Fukushima Prefecture largely varies depending by each area. As shown in Figure 4, the ratio of patients whose admissions were associated with the fear of radiation exposure was higher in Soso and Iwaki. However, the areas with high radiation dose rates are not Iwaki, but rather Fukushima City, Nihonmatsu, Kenpoku (Northern Fukushima) including Koriyama, and Kenchu (Central Fukushima). Thus, the degree of fear of radiation exposure may not be correlated with actual radiation dose rates.

In comparison to the trend of all admitted patients, the most common condition of patients whose admissions were associated with the fear of radiation exposure was hallucinations or delusions (37.8%), while depression (10.8%) was the least. The most common diagnosis of patients whose admissions were associated with the fear of radiation exposure was schizophrenia spectrum (48.6%). The fear of radiation exposure may have acted as an exacerbating factor for various disorders, particularly schizophrenia spectrum. A repercussion of a nuclear disaster is the continuous exposure to vague but strong stresses due to the lack of information and uncertain outcomes. The so-called "radiophobia" (radiation phobia) was first recognized around 1950 in relation to the atomic bombings in Hiroshima and Nagasaki[9], and became more widely known after the Chernobyl nuclear disaster[8]. Some patients whose admissions were associated with the fear of radiation exposure may have developed a condition of radiophobia. However, over-diagnosing radiophobia should be carefully avoided as it may distort the reality of the effects of radiation exposure.

It was suspected that those with schizophrenia spectrum or who were vulnerable to stress, a negative factor inducing schizophrenia, developed excessive fear toward the health hazards of radiation exposure. This places them under continuous stress leading to the exacerbation of symptoms. Further follow-up study is required to investigate the degree of association of the fear of radiation exposure with patient admission.

5. Conclusion

This study discussed the status of new psychiatric admissions after the Fukushima nuclear accident. It showed that compared with admissions under normal circumstances, there were higher numbers of admissions in a manic state and admissions associated with the fear of radiation exposure. Despite various methodological limitations, this data serves as an important foundation for future follow-up studies.

Acknowledgments

We greatly appreciate contributions by all doctors at Fukushima Medical University, Department of Neuropsychiatry and the hospitals registered under of the Association of Psychiatric Hospitals of Fukushima. They diligently supported our study while working hard under strenuous conditions after the earthquake. We also sincerely thank those at the Association of Psychiatric Hospitals of Fukushima, Welfare Division, Fukushima Prefecture, for their assistance in compiling this report.

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Fukushima Daiichi Nuclear Power Plant Accident and Emergency Medical Response at Fukushima Medical University Hospital

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Summary. Fukushima Medical University Hospital has unexpectedly experienced the most difficult situation during the Fukushima Nuclear Disaster just after the combined disaster of the biggest earthquake and tsunami in Japan. Through our own activities at the unit of radiation emergency medicine, we have learnt that there is much room for improvement. However, even under such unpredicted conditions, we also gained a valuable experience thanks to our wonderful colleagues who were dispatched to our area from all over Japan. We have the responsibility to provide the radiation emergency medical service, the physical-mental-radiological health care, and risk communication with considerable information, to plant workers, emergency responders, and residents in Fukushima in turn.

Key words : *Fukushima NPP accident; combined disaster; radiation emergency medicine; risk communication*

1. Introduction

The Fukushima nuclear power plant accident on March 11, 2011 followed the magnitude 9 great earthquake and the up to 38.9 meters tsunami, and resulted in the massive release into the atmosphere of radionuclides, put at Level 7 in International Nuclear Event Scale (INES). The deposition of artificial radionuclides in a particular area occurred due to the rain and snow mainly on March 15 and it has dramatically changed our conventional safe life in Fukushima from the beginning with unpredictable fear and anxiety [1,2]. Reviewing our experience, we are trying to understand what we should have done, what we have learned, and what we should do from now on.

2. Results and Discussion

Fukushima Medical University Hospital is located 56 km north east from Fukushima Daiichi nuclear power plant. We have an Emergency and Critical Care Center with a Level 1 trauma center; also, we have an emergency medical helicopter system.

Fortunately, we did not suffer a building collapse, but did lose both our water and petrol supply. In the initial phase of the disaster, we did our best to examine the patients of trauma and submersion due to the tsunami and earthquake. Because of the lack of water we could not perform enough medical procedures including major operations and renal replacement therapy. The combined disaster taxed us to the limits.

To our regret, we had not had enough engagement in Radiation Emergency Medicine (REM) nor had we had any communication with the nuclear power plant Company previous to that. Therefore, leading up to the nuclear power plant accident, we ER physicians did not have enough preparation for a nuclear accident, nor had enough information for the plant accident. Also, the only information we could get was from television reports, not from the disaster site or the government. At first immediately after the accident, we had to resort to making our way by looking at a textbook as we examined a contaminated patient. At first, the situation overwhelmed us, and our mood became dark and depressed, like a patient who has been told they have cancer for the first time. However, soon, Radiological

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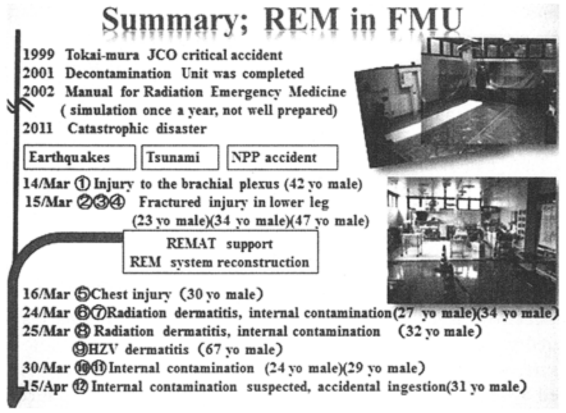

Figure 1. Summary of the Radiation Emergency Medical Service in Fukushima Medical University Hospital.
We have examined twelve radiation-exposed and contaminated patients. REM; Radiation Emergency Medicine, FMU; Fukushima Medical University, yo; years old, REMAT; Radiation Emergency Medical Assistance Team.

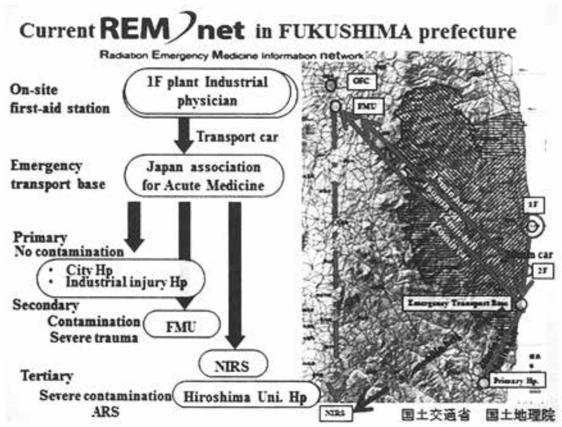

Figure 2. Current Radiation Emergency Medicine Network in Fukushima Prefecture.
Off-site center manages the patient information and controls the transport. Patients with radiation contamination cannot be accepted in the Primary Radiation Emergency Hospital at this point. Emergency medical helicopter can approach to 20 km radius to contact the non-contaminated patients at this point. Doctors can enter into the 20 km radius at their own risk. 1F; Fukushima Daiichi Nuclear Power Plant, FMU; Fukushima Medical University Hospital, NIRS; National Institute of Radiological Sciences.

Emergency Medical Assistance Team (REMAT) in Japan, came to help our hospital. They let us know the severity of the plant's status despite the scarcity of accurate information and the prevailing confusion.

During this time, REMAT was always in our side. Finally, they resuscitated us; they braced us up to take on facing the accident.

When setting up our own REMAT against the nuclear disaster at our hospital, we had to share the recognition and role of our jobs, such as risky crisis intervention, focusing on the assistance of people who had been evacuated from the disaster site. We tried to share the scanty information to calm our anxiety, and to focus on the health problems of the plant workers. To prepare for some kind of adequate treatment of the radiation-exposed patients, we set up the daily morning conferences, web meetings, night lectures and simulations to brush up our skills and knowledge with the volunteer doctors, and also together with the Japan Self-defense Force NBC protective unit. We treated twelve patients in our unit from March 14 to April 15. Six of them were whole body contaminated, four were locally contaminated, and two only locally externally exposed (Figure 1).

Fortunately, there were no radiation-exposed and contaminated patients in the nuclear power plant, in those days. At that point, we did not have an adequate Radiation Emergency Medical hospital, nor had enough local community medical hospitals, especially near the nuclear power plant because of the evacuation direction and hospital damage there. We had to reconstruct the Radiation Emergency Medical System nearly from the beginning and in short possible time (Figure 2).

Very quickly, we became aware of another important problem of the emergency responders such as firefighters and ambulance crew in the disaster site. They were not only crisis responders but also disaster-associated victims as they began to suffer from post-disaster stress-induced psycho-somatic illness. They had not only exhausted themselves but also felt uncertain feelings about their own radiation consequences during the crisis. We, therefore, introduced them to the mental health care psychologist, and also set up a consultation clinic by ourselves for treating them.

Simultaneously, we calculated the internal and external exposure dose by the data from whole-body counter and personal dosimeter in turn. Using the dose date evaluated, we were able to counsel them to relieve their mental stress over radiation related anxieties and their future. Two hundred and seventy-five persons were examined by September 11 as an acute internal exposure cohort. After 9.11, we are planning to examine them again to either deny or estimate the chronic internal exposure which may be from food consumption.

Based on our own experience just after the accident, the established support system from the network related with radiation emergency medicine in Japan worked relatively effectively and efficiently. However, still the general citizens residing in the contaminated area of Fukushima have more unexplained fears about low dose radiation exposure, such as food contamination and 20 mSv topics. These fears may be exaggerated by misinformation; unreliable comments and rumors about radiation and its effects on human health. The lack of

Table 1. Outstanding Issue and Solution for Nuclear Power Plant Accident

1. Radiation Emergency Medicine for Plant workers
◆Reconstruction of Radiation Emergency Medical network
⇒Devastation of the local community medicine prevent the reconstruction of the Radiation Emergency Medical network
◆Deficient of the information transport system about plant status
⇒Web meeting, FAX, base on trust relationship with nuclear power plant company.
2. Health care management for emergency responder
◆Lack of the legal safeguard
⇒Development of legal system both economically and medically
◆Needs for long span follow up
⇒Denying the chronic internal contamination using whole body counter
3. Intervention for resident in Fukushima
1) Emergency situation procedure
◆No review for the thyroid protection yet
◆When and how to take the stable iodine if disaster would relapse
◆Lack of information transmission tool about nucleotide release, evacuation direction
2) Decrease the chronic external exposure
⇒Increase the dosimetory measurement points
⇒Draw the local deposition map
⇒Organize the way of decontamination in the soil
3) Decrease the chronic internal exposure
⇒Information provision about the food contamination to the community resident
⇒Careful analysis and restriction for local food shipment (Example. Wild mushroom open-field vegetable)
⇒Adjust the compartmentalized public administration (Example. Ministry of Health, Labor and Welfare: meat dosimetory. Ministry of Agriculture, Forestry and Fisheries : fodder risk management, meat shipment)
⇒Decrease the anxiety about the low dose exposure and contamination
4) Dose assessment and explanation
⇒Unify the way of dose assessment and explanation
⇒Prefectural People's Health Management Survey
⇒External exposure; film badge for students
⇒Internal dose management; how to apply the whole body counter
5) Risk communication
⇒Notably with public office workers, public health nurses and physicians
⇒Public announcement with one voice as much as reasonably achievable
⇒Awareness-raising to the specialist who does not know the impact of their comment to the resident
⇒Put press reporting into resident's shoes

coordination of specialist's comments does nothing to help the situation. All this creates a new wrinkle in risk management: the management of information. We need to cooperate with domestic and international experts in one platform, and speak about the situation with one voice as much as reasonably possible. To begin with, we have had dialogues with public office workers and public health nurses who are also risk communicators with residents. Also, the Prefectural people's health management survey is now beginning from this September, primarily to address health care needs not only for medical research. It will continue for at least 30 years [3].

The recent outstanding issues are listed up as Table 1.

In summary, we very much regret our insufficient preparation. We at the disaster site capital hospital recognize our three main responsibilities. First, we have to provide the Radiation Emergency Medical Service for nuclear power plant workers over the course of several decades. Secondly, we must continue to examine the total health for emergency responders in the long term. Third, we should continue dialogues with citizens about the risk they may and may not face. After all, we, too are citizens living in Fukushima. We wish to share the above with all the staff in Fukushima Medical University.

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Fukushima J. Med. Sci.,Vol. 57, № 2, 2011

An American Hibakusha in Fukushima

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(Received July 21, 2011, accepted August 31, 2011)

Abstract : A magnitude 9.0 earthquake and tsunami originating off the east coast of Japan triggered the explosive release of radioactive isotopes from one of four nuclear power plants in the affected area. This event has been compared with the 1986 nuclear accident at Chernobyl, the 1945 atomic bombing of Hiroshima and Nagasaki, and the intervening era of atmospheric nuclear weapons testing. The credibility of any comparison depends on the source, for which reason various specialists were invited to address an audience of media, healthcare, and disaster response professionals on July 18, 2011 in Fukushima City, Fukushima Prefecture. This article is based on a presentation given July 18, and interprets the Fukushima nuclear crisis from the perspective of an American doctor who grew up downwind of an atomic bomb test site, and who now works at Fukushima Medical University.

Key words : *hibakusha, radiation exposure*

WORDS ON WORDS

1. Hibakusha

Hibakusha has entered the English lexicon, particularly in reference to survivors of the 1945 atomic bombing of Hiroshima and Nagasaki[1]. It may surprise English speakers to hear the same word applied to people exposed to radiation from the Fukushima Daiichi nuclear power plant. An important distinction is lost when *hi-baku-sha* is rendered in Roman letters rather than the ideographic kanji characters that Japan adopted, and adapted, from Chinese. 被爆者 (subjected to - explode - person)[2] refers specifically to victims of an A-bomb or H-bomb blast[3]. 被曝者 (subjected to - expose - person) can be anyone exposed to radiation[2,3]. Nuclear power plant accidents are typically cited in this definition, but laboratory mishaps and medical radiation can also make people 被曝者. The middle kanji of each word can be understood as a composite of two simpler elements : either 火 (fire) or 日 (sun, day) on the left, and 暴 (violent) on the right[2]. Thus, A- or H-bomb exposure to radiation is connoted by violent fire, and other exposures to radiation are connoted by violent light. More rigorous analyses are available, but inordinate attention to linguistics can interfere with practical understanding of language. In everyday Japanese, the distinction between 被爆者 and 被曝者 is often blurred by rendering the baku of *hi-baku-sha* with two *hiragana* characters that represent the syllables *ba* (ば) and *ku* (く) without imposing a specific meaning : 被ばく者. Early language learners, Japanese or foreign, might render the entire word in *hiragana* : ひばくしゃ.

2. Fukushima

Fukushima, too, has entered the general English lexicon as a name associated with detrimental effects of ionizing radiation. In a specialized English lexicon, Fukushima had previously been associated with a beneficial effect. In 1988, Fukushima Medical University was the first institution worldwide to treat all allogeneic donor blood cell products with ionizing radiation to prevent transfusion-associated graft-versus-host disease[4]. Modern authors continue to cite pioneering articles on graft-versus-host disease from Fukushima Medical University[5,6].

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General public knowledge about Fukushima is another matter. The prefecture was renowned as a tourist destination and agricultural center, but most people did not know that two nuclear power plants on Fukushima's Pacific coast were dedicated exclusively to Tokyo's massive demand for electricity. These are the Fukushima 1 and 2 Nuclear Power Plants, now known around the world by their Japanese designations, *Fukushima Daiichi* and *Fukushima Daini*.

THE PRICE OF POWER

Per kilowatt-hour, nuclear power plants have been promoted as being less expensive than other sources of electricity, but indirect, human costs are once again earning some attention. Recent investigations have suggested that from 2003 through 2008, on the basis of workplace radiation exposure, Fukushima Daiichi was among the world's five highest-risk nuclear power plants, the other four being in the United States, Spain, India, and Mexico[7]. Through various safety initiatives by TEPCO, the Tokyo Electric Power Company, working conditions seemed to be improving at Fukushima Daiichi in the years just prior to March 11, 2011[7].

THE GREAT EAST JAPAN EARTHQUAKE "3.11"

On March 11, 2011, a magnitude 9.0 earthquake originated off the Pacific coast of Japan's Tohoku district. Nuclear power stations Onagawa (Miyagi Prefecture, est. 1984), Fukushima Daiichi and Daini (Fukushima Prefecture, est. 1971 and 1982), and Tokai Daini (Ibaraki Prefecture, est. 1978) went into automatic shutdown[8]. The earthquake and related tsunami have been implicated in subsequent failures, radiation release, and core meltdowns at the oldest of these power stations, Fukushima Daiichi. Remote video images of gas-releasing explosions at Fukushima Daiichi were promptly and repeatedly aired on commercial and public television.

At Fukushima Medical University, 57 kilometers from Fukushima Daiichi, the leading edge of a spike in background radiation was observed on the evening of March 15. In a physics professor's office, a peak value of 9.3 times average was recorded in the early hours of March 16. As of October 11, 2011, the decay curve of this increased background radiation could be resolved into a short harf-life of 3.74 days and a long half-life of 242 days. These half-lives do not refer to specific radioactive isotopes, but are calculated by non-linear regression analysis from actual data to forecast further decreases in radioactivity. As of October 11, background radiation at the office where the March 15-16 spike was detected was down to 1.50 times the average background observed prior to the spike. Although radioactive isotopes of cesium and strontium have half-lives around 30 years, background radiation decreases faster as isotopes are progressively dispersed into the environment. For example, the aforementioned decay curve includes a noticeable dip in background radiation on July 28, corresponding to a day of heavy rain.

AMERICAN PERSPECTIVES

1. Americans in Japan

On March 17, the US Department of State announced online and by email that US citizens within 50 miles (80 km) of Fukushima Daiichi should evacuate the area or take shelter indoors if safe evacuation is not possible. This recommendation was attributed to the US Nuclear Regulatory Commission, and said to be in accord with directives that would be issued for a comparable event in the United States. Other governments issued similar advice.

This author, an American citizen employed by Fukushima Medical University since January 2008, subscribes to an advisory service of the United States Embassy in Tokyo. The embassy made a health and welfare inquiry by telephone on March 16, and sent an email with evacuation advice on March 17. Subsequent emails in March included information about travel assistance available to US citizens and their dependents. Through September 18, 2011, the United States Embassy in Tokyo continued to advise, "out of an abundance of caution," that citizens living within 80 km of Fukushima Daiichi "evacuate or shelter in place." The March 17 recommendation was modified on May 16 to say that the risk of travel through the area by bullet train or expressway was low. A July 19 travel alert added that it was deemed a low risk to travel to, from, and through Sendai Airport.

Fully aware of official US recommendations, this author continued working at Fukushima Medical University and living about 2 km away. No coercion was involved; in fact, neighbors and colleagues were rather surprised by what seemed to be an act of defiance against the US government by one of its citizens. However, my advice to others, including an American journalist and a Congolese graduate student, was for them to heed the advice of their respective governments, both of which recommended being outside of Japan's post-3.11 risk areas.

It is the opinion of this author that one motivation for the US Embassy's evacuation advice and assistance was to prevent American citizens from burdening Japan, and cordial Japanese hosts, where infrastructure was damaged and resources were limited. Americans with emergency response, medical, and/or nuclear safety expertise have, along with other nationals, freely traveled and worked in Japan's disaster-affected areas.

2. American Hibakusha

In the early 1970s, a guest speaker visited Hibbing High School in the City of Hibbing, capital of St. Louis County in the State of Minnesota. Students assembled in the Hibbing High School Auditorium to learn about nuclear power and radiation. The guest speaker sought a volunteer. From those in the audience who raised their hands, he invited a high school girl onto the stage and asked her to assist with some task. After the task, the speaker offered her a drink of cola as a small reward. The student politely accepted. A conversation along the following lines ensued :

Speaker : "Refreshing?"
Student : "Yes."
Speaker : "Suppose I said your cola was radioactive?"
Student : [Surprised silence.]
Speaker : "Watch."

The speaker turned on a Geiger counter and started to wand our volunteer. As the detector approached her throat, the occasional clicks became much more frequent. This got everyone's attention.

Speaker : "No, I did not give you radioactive cola. Radioactive substances are tightly regulated, and I am not a medical doctor. Your thyroid gland, at the front of your throat, naturally attracts iodine, some of which is radioactive."

To the best of my recollection, the speaker gave no particular details about the extent to which radioactive iodine might be found in nature. However, St. Louis County was downwind of an unnatural source of radioactive iodine: the Nevada Test Site, where 100 of America's 210 atmospheric tests of nuclear weapons were conducted between January 1951 and July 1962[9].

The exposure of Americans to radioactive iodine from the Nevada Test Site was not comprehensively investigated until Public Law 97-414 was enacted in 1993, although smaller investigations had been previously reported[10]. As directed by Public Law 97-414, the US National Cancer Institute published results in 1997[11]. In the 1950s, about 150 million curies — in modern terms 5.6×10^{18} becquerels — of I-131 entered the atmosphere from atomic bombs detonated at the Nevada Test Site. The average thyroid dose to 160 million Americans during the 1950s was 20 millisieverts. St. Louis County residents, 2,200 km from the Nevada Test Site, received an average thyroid dose of 60-90 millisieverts. Not only location, but also milk consumption and thyroid size were significant factors in an individual's exposure. Children 3 months to 5 years old exceeded the average thyroid dose by 3-7 times[11].

What were citizens told about radiation in the era of atmospheric testing of nuclear weapons? A woman who grew up in southern Utah, just east of Nevada, recalled that when visitors with Geiger counters came to her primary school, she was told that dental X-rays were the cause of elevated readings when a Geiger counter was aimed at her face[12]. A transfusion medicine colleague who grew up in North Dakota, just west of northern Minnesota, said that as a child she was told not to chew on grass outdoors, because it was tainted with strontium (Anne Kaldun, personal communication). Cows are more frequent consumers of grass than well-fed children, but American literature (e.g., *The Adventures of Huckleberry Finn* by Mark Twain) and art (e.g., illustrations by Norman Rockwell) conjure up images of rural children chewing on straws of hay as they work or play outdoors. In the same decade that Anne Kaldun was admonished not to chew on strontium-tainted grass in North Dakota, Japanese investigators were systematically measuring and reporting strontium-90, cesium-137, and plutonium-239 fallout in the atmosphere, rainwater, soil, and food supply in Japan.[13]

DISCUSSION

This author, born in 1958, and Americans of similar age were hibakusha as a result of growing up in the era of atmospheric nuclear weapons testing. What we were told about this was limited, perhaps misleading, or at least inconsistent with what is now in the public domain. Retrospectively, the spread of radioactive iodine across the continental United States was the main health consequence of atom bomb detonations at the Nevada Test Site, although other isotopes, such as radioactive cesium, were released as well. Hydrogen bomb detonations around the world fueled a global spread of radioactive strontium[10], so people of every nationality can be counted as hibakusha[9,10]. Saying so should never diminish the significance of this word as it applies to people of Hiroshima and Nagasaki. Rather, this statement of fact should be a touchstone, through which citizens of the world might empathize with the unique history of Japan: a World War II target of two atomic bombs, a Cold War recipient of radioactive fallout that contaminated the food supply, and the most recent nation to deal with a nuclear power plant meltdown.

ACKNOWLEDGMENTS

Background radiation data at Fukushima Medical University came from Professor Tsuneo Kobayashi, Chair of the Department of Natural Sciences (Physics) at Fukushima Medical University. Professor Kobayashi is one among many in Fukushima who make factual data about our current nuclear crisis freely available to scholars and to the general public. Various members of FMU's academic community, and residents of the Hourai neighborhood of Fukushima City, continue to inconvenience themselves for the American among them (just as the US Embassy predicted). Personal narratives and photographs related to life and work in post-3.11 Fukushima have been posted at www.cbbstoday.org, courtesy of Eileen Selogie and the California Blood Bank Society. Melissa Abrams composed an elegant synopsis of these narratives for Mayo Alumni Magazine, Fall 2011 edition, available at www.mayo.edu/alumni/publications.html.

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