Exposure to High-dose Neutron Irradiation in the Criticality Accident occurred in Tokaimura

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Since 1966, when the first nuclear reactor started operation in Japan, we fortunately have not had any nuclear accidents that required medical care for the people involved. However, a criticality accident occurred on September 30 1999 at the uranium conversion facility in Tokai-mura, Ibaraki Prefecture, Japan. This “Nuclear Village” is located at 120 km northwest of Tokyo and there are many nuclear facilities including The Japan Atomic Energy Research and The Japan Nuclear Cycle Development Institute in Tokaimura. The criticality event occurred when a worker (B) was pouring a solution of enriched $^{235}$U into a precipitation tank directly and the other worker (A) was assisting him. At the accident, three workers including their supervisor (C) saw “blue-white glow”, and heard the alarm of the radiation monitor. They were severely exposed to neutron and $\gamma$-ray irradiation and developed the acute radiation syndrome (ARS). Anorexia, nausea, vomiting, and diarrhea are typical prodromal symptoms observed in ARS. Worker A reported vomiting within minutes and loss of consciousness for 10-20 seconds, indicating significant concomitant total body exposure. Therefore, Worker C asked to make emergency call to the Tokai Fire Department. Worker A also had diarrhea an hour after exposure. Worker B started to vomit an hour after the initial exposure. Three workers were brought to the National Mito Hospital (NMH) by the ambulance. Their hematological data at NMH 2-3 hours after the accident showed markedly reduced numbers of lymphocytes; the relative numbers of lymphocytes were 3, 1, and 13 % of whole leukocyte counts, respectively. Because of detection of $\gamma$-ray from body surfaces of these workers by preliminary surveys and possibility of high-dose exposure, it was decided that they should be transferred from NMH to the National Institute of Radiological Sciences (NIRS), Chiba. At the time of admission to NIRS, the body temperature of Worker A rose to 38.5 °C without any evidence of infection whereas these symptoms of nausea, vomiting, and diarrhea were not observed. An analysis by $\gamma$-spectrometry of vomitus from Worker A detected $^{24}$Na, suggesting exposure to neutron. Dose estimation for the three workers was performed at NIRS by onset of prodromal symptoms, lymphocyte counting, chromosomal analysis, and $^{24}$Na activity. The average doses of the whole-body for Workers A, B, and C were 16-20 Gy equivalent to $\gamma$-ray (GyEq), 6-10 GyEq, and 1-4.5 GyEq, respectively. From these results, the severe bone marrow suppression was expected for these workers. Stem cell transplantation was performed from peripheral blood and cord blood for Workers A and B, respectively, and Worker C received the cytokine therapy. Worker A developed a severe radiation-burn involved over than 50 % of total body and gastrointestinal injury. Despite of all medical efforts, Worker A died of multiple organ failure 83 days after the accident. In this presentation, the initial assessment for irradiated workers and their clinical courses more detailed will be described.