Introduction

The prevalence of deep venous thrombosis (DVT) increased in the Ishinomaki area (a population of 220,000), where the tsunami brought devastating damages following the Great East Japan Earthquake in 2011.1,2 The causes of high prevalence of DVT were supposed to be the following: (1) dehydration induced by limited water supply, aggravated by vomiting and diarrhea because of a shortage of clean water to wash dirty hands (mud) and by minimizing water intake to avoid frequent use of unsanitary toilet facilities in the shelters; (2) prolonged immobility of the elderly in the crowded shelters.2 Under these conditions, pulmonary thromboembolism (PTE) occurred. The poor conditions of these shelters were gradually improved by relief supplies and by moving to unaffected areas. However, approximately a thousand of evacuees still remained in the shelters until August, 2011. High prevalence of DVT was expected to cause PTE soon after the earthquake. In the chronic phase of the disaster, the prevalence of DVT was supposed to reduce both in shelters and in temporary emergency housings due to improvement of the disaster area. Moreover, the present illness of the evacuees was also considered to facilitate DVT generation.
**Materials and Methods**

Patients admitted to the Japanese Red Cross Ishinomaki Hospital (Ishinomaki, Miyagi, Japan) and diagnosed with PTE, a month after the earthquake, were investigated for DVT.

From March to August 2011, the evacuees in the shelters in Ishinomaki City were questioned about swelling, injury, or pain of their lower extremities, physical inactivity, limb palsy, and dehydration due to vomiting or diarrhea. Then, the evacuees suspected with calf DVT were examined using portable ultrasonography (Viamo with a 7.5 MHz linear probe; Toshiba Co, Tokyo, MyLabFive with a 4–9 MHz linear probe; Hitachi-Aloka Medical, Ltd, Tokyo, and MicroMaxx with a 5–10 MHz linear probe; SonoSite Japan, Tokyo). Prior to sonography, examinees were questioned about their present illnesses including hypertension, diabetes mellitus, and hyperlipidemia, as well as trauma in their lower extremities.

From August to December 2011, the residents in temporary emergency housings in Ishinomaki City were examined for calf DVT as described above.

In disaster shelters, examinations were performed by the disaster medical care after the oral consent of the evacuees, whereas, examinations were performed in temporary emergency housings, after a signed consent form. This study was performed with the approval of IRB in the Japanese Red Cross Ishinomaki Hospital.

Statistical analysis was performed using the Chi-square test.

**Results**

Twelve patients were diagnosed with PTE a month after the earthquake, a frequency that is three times higher than the same period of the previous year. Ten patients had calf DVT and there were no lethal cases.

Calf DVT echo was identified in 190 (137 women, mean age = 70.1 years) out of 701 evacuees (474 women, mean age = 67.7 years) in 32 shelters. DVT was identified not only in the soleal vein, but also in the peroneal vein, posterior tibial vein, and popliteal vein. The femoral vein of the evacuees was not examined because we found it difficult to expose their thighs and groins in those circumstances.

The DVT prevalence rate was a maximum of 45.6% in March and decreased to 23.0% in April. It increased again to 37.0% in May, and decreased to 12.8% in June and 18.6% in July (Fig. 1). In tsunami-flooded shelters, DVT prevalence rate was 34.2% (127 out of 371 evacuees), whereas it was 19.1% (63 out of 330 evacuees) in non-flooded shelters (significantly different at P < 0.001) (Fig. 2). The relationship between DVT prevalence and hypertension (systolic pressure > 140 mmHg), diabetes mellitus or hyperlipidemia was not significant, whereas evacuees with untreated hypertension had a significantly high prevalence of DVT (P < 0.001) (Fig. 3). Four out of eight evacuees with trauma in their lower extremities...
appeared to have calf DVT, although the difference was not significant because of a few cases with trauma. We found calf DVT in 33 (8.9%) out of 360 residents (262 women, mean age = 68.0 years) in 17 areas of temporary emergency housings (Fig. 4).

Discussion

DVT prevalence in the Ishinomaki area after the Great East Japan earthquake was found to be the highest ever observed in Japan.\(^4\) The increase in PTE patients admitted to the Japanese Red Cross Ishinomaki Hospital was supposed to reflect the high prevalence of DVT in the Ishinomaki area.

The calf DVT is thought to cause PTE.\(^5,6\) Therefore, investigation of calf DVT was performed to evaluate the risk of PTE. DVT prevalence in shelters was found to be high soon after the disaster, and, except for May, seemed to decrease with time, probably because the water supply to the disaster area improved dehydration in evacuees and because many of the evacuees moved back home or to unaffected areas, thus reducing the number of evacuees in overcrowded shelters.\(^2\) In May, several schools that were used as shelters for evacuees started class again. Therefore, shelters were consolidated and crowded again by the remaining evacuees, probably causing the increase in DVT in May.
Near the seashore, tsunami flooded into the shelters where victims of the earthquake evacuated prior to the tsunami. These shelters had bad sanitation and hygiene problems due to contamination by sea soil due to tsunami flooding. The tsunami also brought great amounts of sludge that obstructed the transport of relief supplies and evacuees moving back home. Therefore, thousands of evacuees lived in poor hygiene shelters for months with a maximum of 1.6 m² per person. These shelters were smaller than the shelter recommended by the US Federal Emergency Management Agency and the American Red Cross (approximately 3 m²–6 m² per person). The narrow space in the shelters would restrict the physical activity of the evacuees, particularly among the elderly, and facilitate the stagnation of blood in lower extremities. The crowded condition and the delay in water and food supply may have contributed to DVT generation in people living in tsunami-flooded shelters.

It had been suggested that present illnesses such as hypertension, diabetes mellitus, and hyperlipidemia would contribute to DVT generation in the victims after disasters. However, no relationship between those diseases and DVT generation in evacuees was found. The untreated evacuees with hypertension showed a high prevalence of DVT. It was reported that the victims showed high blood pressure induced by psychogenic stress after earthquake. Therefore, untreated hypertension in the evacuees was supposed to develop in shelters after the earthquake. Psychogenic stress could have reduced physical activity in evacuees, and DVT might have developed in their lower extremities.

DVT prevalence in residents of temporary emergency housings was found to be lower than that in evacuees living in shelters. However, it was still higher than that examined in Yokohama City in 2012 (2.2%) far from the disaster area (Fig. 4). It was reported that victims of the Niigata-Chuetsu Earthquake (2004) reduced their physical activity in temporary emergency housings. DVT observed in temporary emergency housings was supposed to cause residual blood clots not only in shelters but also in temporary emergency housings due to immobility. Therefore, the residents of the housings were required to be physically active in order to avoid calf DVT generation.

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Disclosure Statement
We declare that there is no conflict of interest with this manuscript.

References