High Prevalence of Deep Vein Thrombosis in Tsunami-Flooded Shelters Established after the Great East-Japan Earthquake

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High prevalence of deep vein thrombosis (DVT) in disaster shelters has been reported in the aftermath of earthquakes in Japan. Calf DVT was examined using sonography in the shelters after the Great East Japan earthquake on March 11, 2011. By the end of July 2011, 701 out of 8,630 evacuees suspected with calf DVT, judged by inspections or medical interviews, were examined in 32 shelters, and 190 evacuees were confirmed to have calf DVT. The prevalence of DVT was 2.20%, which was 200 times higher than the usual incidence in Japan. The DVT prevalence seemed to decrease with time. By the end of May, a significantly higher prevalence of DVT was found in tsunami-flooded shelters (109 of 3,871 evacuees; 2.82%) than in non-flooded shelters (53 of 3,155 evacuees; 1.68%). After June, its prevalence was still higher (18/541; 3.33%) in tsunami-flooded shelters than in non-flooded shelters (10/1063; 0.94%). The cause of the high prevalence of DVT was supposed to be dehydration due to the delay in supplying drinking water, vomiting, and diarrhea experienced by the evacuees because of a shortage of clean water to wash their hands. Dehydration was especially noticed in women because they restricted themselves of water intake to avoid using unsanitary toilet facilities. Moreover, crowded shelters restricted the mobility of elderly people, which would exacerbate the prevalence of DVT. Those deteriorated and crowded shelters were observed in tsunami-flooded areas. Therefore, long-term shelters should not be set up in flooded areas after tsunami.

Keywords: deep vein thrombosis; emergency shelter; Great East Japan Earthquake; health hazard; tsunami

echoes in 190 evacuees (137 women; 118 older than 70 years), which indicated the prevalence of DVT as 2.20%, approximately 200 times higher than the usual incidence in Japan (Sakuma et al. 2009). It has been reported that 20% of calf DVTs propagate to proximal veins and can potentially lead to pulmonary embolism (Philbrick and Becker 1988). The usefulness of investigating calf DVT for evaluating the risk of PTE is controversial (Atri et al. 1996), but it was a feasible approach for screening DVT in emergency shelters. In fact, the examination of calf only required the evacuees to roll up their trousers. The accuracy of compression sonography with the addition of Doppler imaging for the diagnosis of calf DVT has been reported (Atri et al. 1996). In some evacuees with multiple or free-floating thrombi, blood D-dimer levels were measured, and 6 of them with levels > 1.0 µg/mL were further examined by whole body computed tomography at the Japanese Red Cross Ishinomaki Hospital. Finally, 2 female evacuees were hospitalized for anti-coagulant therapy for PTE. Others were advised to wear elastic stockings. No evacuee died from DVT. The DVT prevalence in shelters was found to be high soon after the disaster, and seemed to decrease with time (Fig. 2). From March to the end of May, the DVT prevalence was significantly higher in tsunami-flooded shelters (109 of 3,871 evacuees; 2.82%) than in non-flooded shelters (53 of 3,155 evacuees; 1.68%) ($P = 0.0016$). Even after June, the prevalence of DVT was still higher in tsunami-flooded shelters (18 of 541 evacuees; 3.33%) as compared to that in non-flooded shelters (10 of 1,063 evacuees; 0.94%) ($P < 0.001$) (Table 1).

Although the flooding by the tsunami itself had ceased within a few weeks, tsunami destroyed infrastructure and left huge amounts of sludge, which obstructed ground access for repair and transport for several weeks. Very limited supplies of water and food directly caused dehydration, which was exacerbated by vomiting and diarrhea experienced by the evacuees because of a shortage of clean water to wash their hands polluted by mud. Women appeared to minimize their water intake to avoid frequent use of unsanitary toilet facilities in the shelters. High temperature and humidity in June-July might have exacerbated dehydration in places without air conditioning. The elderly might have been immobile for long periods because of difficulty in walking in crowded shelters in tsunami-flooded areas where most of the evacuees lost their houses and remained in the shelters for months. In the tsunami-flooded areas, shelters were very crowded, i.e., approximately 1,000 evacuees per shelter. The high prevalence of DVT in tsunami-flooded shelters after June was thought to indicate that the effect that tsunami flooding had on the evacuees would sustain for a long time.

According to the guideline of the Federal Emergency Management Agency (FEMA 2008), the recommended minimum square footage per occupant for a tsunami refuge is 10 square feet per person for a short stay, approximately 24 hours. It would not be considered appropriate for a longer stay. This guideline also states that the American Red Cross recommends a minimum of 20 square feet per person.
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for short-term stay (ie, a few days), and 40 square feet for long-term stay (ie, days to weeks). In the Great East Japan earthquake, most of the shelters, especially in the tsunami-flooded areas, provided 10 square feet per person for many weeks and at most 20 square feet per person for several months. Evacuees stayed in the crowded shelters for a long time, which would restrict their physical activity and facilitate stagnation of blood in their lower extremities. A similar mechanism that leads to DVT and PTE in occupants of shelters was described for casualties of the night air-attacks in London (Simpson 1940).

Our survey revealed a high prevalence of DVT in the shelters, especially in tsunami-flooded shelters, which has never been reported in the literature. In addition, evacuees in widely devastated and less accessible areas have multiple, serious risks for DVT. Therefore, we recommend not setting up long-term shelters in flooded areas after disasters.

Table 1. Prevalence of deep vein thrombosis (DVT) in flooded and non-flooded shelters.

<table>
<thead>
<tr>
<th>Prevalence of DVT</th>
<th>March-May</th>
<th>June-July</th>
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<tbody>
<tr>
<td>Flooded shelters</td>
<td>2.82% (109/3,871)</td>
<td>3.33% (18/541)</td>
</tr>
<tr>
<td>Non-flooded shelters</td>
<td>1.68% (53/3,155)</td>
<td>0.94% (10/1,063)</td>
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</table>

The prevalence of DVT (top) and actual number of patients per population of shelters (bottom) in the flooded and non-flooded shelters in the early phase (from March to May) and late phase (from June to July), respectively, are shown in each column. The prevalence of DVT in tsunami-flooded shelters is noticeably high in each phase. The statistical analysis was performed by using chi-square test.

Conflict of Interest

We declare that there are no conflicts of interest with this manuscript.

References


