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*Original Article*

# Venous Screening Activities at the Site of Hokkaido East Iburi Earthquake: Report from the Result of Venous Screening in Preventive Awareness Activities

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After previous earthquakes, high prevalence of cardiovascular diseases including venous thromboembolism (VTE) has been reported. We performed venous screening at the site of Hokkaido East Iburi Earthquake which happened at 6th September 2018. VTE screening using ultrasound sonography was performed for total 7 days at Atsuma town, Mukawa town and Abira town (total 9 shelters). Deep vein thrombosis (DVT) was found in 19 of 195 evacuees (9.7%), including 8 fresh thrombus cases (4.1%). On multivariable analysis of evacuees and shelter environment factors, systolic blood pressure, use of cardboard bed and toilet environment were significant predictor of DVT. Introduction and setting-up of cardboard beds were found as an important shelter environment factor. (This is secondary publication from Jpn J Phlebol 2021; 32(1): 5–10.)

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***Keywords:*** deep vein thrombosis, emergency shelter, Hokkaido East Iburi Earthquake, ultrasound examination, cardboard bed

## Introduction

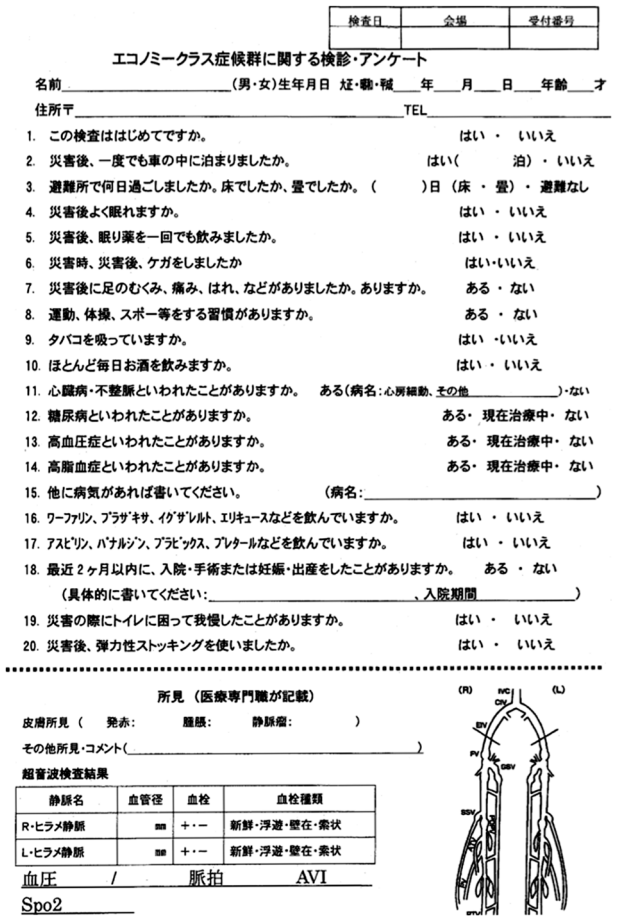
On September 6, 2018, the central-eastern portion of the Iburi region in Hokkaido was struck by an earthquake with a magnitude of 6.7 and a maximum seismic intensity of 7 (Atsuma town), which resulted in a large-scale disaster that claimed the lives of 42 people and seriously injured 31 others.

After natural catastrophes such as earthquakes, cardiovascular diseases such as acute myocardial infarction,[1] heart failure,[2] pulmonary thromboembolism (PTE),[3] and deep vein thrombosis (DVT),[3] are known to increase. DVT is a condition typically caused by blood stasis, endothelial injury, and hypercoagulability, which are the three factors of Virchow's triad. DVT frequently occurs after a disaster—particularly in emergency shelters—because of dehydration from decreased water intake and a reduced physical activity level, combined with trauma from the disaster, which greatly contributes to these three factors, thereby increasing the rate of positive DVT.[4] Additionally, there is a correlation between sleeping in vehicles and DVT and PTE.[5]

In collaboration with the team led by Dr. Hanzawa from Niigata University and under the direction of the Japanese Society of Phlebology Disaster Response Committee, we conducted venous thromboembolism (VTE) screening, with the intention of raising awareness among disaster victims about the prevention of VTE.

## Materials and Methods

We performed screenings at the emergency shelters for a total of 7 days, that is, on September 11–12, 17–18, and



| 検査日 | 会場 | 受付番号 |
|---|---|---|
| | | |

エコノミークラス症候群に関する検診・アンケート

名前＿＿＿＿＿＿＿＿＿＿(男・女)生年月日 妊・戦・報＿＿年＿＿月＿＿日＿＿年齢＿＿才

住所〒＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿TEL＿＿＿＿＿＿＿＿＿＿

1. この検査ははじめてですか。 はい ・ いいえ
2. 災害後、一度でも車の中に泊まりましたか。 はい(　　泊) ・ いいえ
3. 避難所で何日過ごしましたか。床でしたか、畳でしたか。(　　)日 (床 ・ 畳) ・ 避難なし
4. 災害後よく眠れますか。 はい ・ いいえ
5. 災害後、眠り薬を一回でも飲みましたか。 はい ・ いいえ
6. 災害時、災害後、ケガをしましたか はい・いいえ
7. 災害後に足のむくみ、痛み、はれ、などがありましたか。ありますか。 ある ・ ない
8. 運動、体操、スポー等をする習慣がありますか。 ある ・ ない
9. タバコを吸っていますか。 はい ・いいえ
10. ほとんど毎日お酒を飲みますか。 はい ・ いいえ
11. 心臓病・不整脈といわれたことがありますか。 ある(病名：心房細動、その他＿＿＿＿＿＿)・ない
12. 糖尿病といわれたことがありますか。 ある・ 現在治療中・ ない
13. 高血圧症といわれたことがありますか。 ある・ 現在治療中・ ない
14. 高脂血症といわれたことがありますか。 ある・ 現在治療中・ ない
15. 他に病気があれば書いてください。 (病名：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿)
16. ﾜｰﾌｧﾘﾝ、ﾌﾟﾗｻﾞｷｻ、ｲｸﾞｻﾞﾚﾙﾄ、ｴﾘｷｭｰｽなどを飲んでいますか。 はい ・ いいえ
17. ｱｽﾋﾟﾘﾝ、ﾊﾟﾅﾙｼﾞﾝ、ﾌﾟﾗﾋﾞｯｸｽ、ﾌﾟﾚﾀｰﾙなどを飲んでいますか。 はい ・ いいえ
18. 最近２ヶ月以内に、入院・手術または妊娠・出産をしたことがありますか。 ある ・ ない
(具体的に書いてください：＿＿＿＿＿＿＿＿＿＿、入院期間＿＿＿＿＿＿＿＿)
19. 災害の際にトイレに困って我慢したことがありますか。 はい ・ いいえ
20. 災害後、弾力性ストッキングを使いましたか。 はい ・ いいえ

所見 (医療専門職が記載)

皮膚所見 (　発赤:　　腫脹:　　静脈瘤:　　)

その他所見・コメント(＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿)

超音波検査結果

| 静脈名 | 血管径 | 血栓 | 血栓種類 |
|---|---|---|---|
| R・ヒラメ静脈 | mm | +・− | 新鮮・浮遊・壁在・索状 |
| L・ヒラメ静脈 | mm | +・− | 新鮮・浮遊・壁在・索状 |

血圧　/　脈拍　AVI

Spo2



**Fig. 1** Medical interview sheet using at this venous screening activities.

23–24 and November 4. This study included the residents of the three towns, namely, Atsuma, Mukawa, and Abira, who were living at an emergency shelter or in their vehicles. From September 17 to 18, we mainly monitored these evacuees, who were deemed high-risk (elderly, bedridden, injured, having slept in vehicles, etc.[6,7]) by the local Japan Medical Association Team (JMAT) and public health nurses during the screening.

Only volunteer residents who provided consent for an examination after an explanation of its necessity and details were examined.

We asked questions, measured vital signs (blood pressure, heart rate, and saturation of percutaneous oxygen), and performed ultrasonography of the veins of both lower extremities. For DVT-positive examinees, a blood test was added, and D-dimer was measured and recorded for reference. **Figure 1** presents the questionnaire used in the screenings. We mainly examined the soleus veins for venous ultrasound screening because the soleus veins are the site where initial DVT is most frequently found.[8,9] A low-intensity thrombus was considered a fresh thrombus. Pairs of elastic stockings were given to almost all subjects at no cost after the examination while explaining their application. A patient referral document was prepared for evacuees with DVT to be promptly taken to a hospital.

The following types of portable battery-powered ultrasound machines were used for screening: HS-171 (Honda Electronics Co., Ltd., Aichi Prefecture, Japan), LOGIQ eV2 (GE Healthcare Japan Corporation, Tokyo, Japan), MyLab Five (Esaote S.p. A, Genova, Italy), and CX50 (Philips Japan, Ltd., Tokyo, Japan). Cobas h 232 (Roche Diagnostics K.K., Tokyo, Japan) was used for blood testing, and the D-dimer level was measured. The cumulative number of doctors and clinical laboratory technologists who participated in the examinations was 26 and 25, respectively. Examination data were saved as nonlinkable anonymous information, and an analysis was performed after completing all examinations.

This study focused on "introducing cardboard beds (Bed)" and "toilet environment (Toilet)" in the object of the sleeping environment and chance of ambulation to investigate the correlation between DVT onset and environmental factors at the emergency shelter. Bed introduction status was categorized as "introduced within 7 days," "introduced after 8 days," and "no bed introduction," whereas the toilet environment was categorized into "flush toilet," "indoor toilet (not water flushing)," and "outdoor toilet" to assess the incidence rate of DVT and analyze the involvement of environmental factors. The initial examination was conducted 5 or 6 days after the earthquake, and the cardboard bed introduction status was not confirmed at that time; therefore, the 10 evacuees who were not categorized into the above three types were excluded from the bed-related analysis.

Data are shown using the mean ± standard deviation. The t test or the Mann–Whitney U test was used to compare continuous variables, and the chi-square test was used for categorical variables. We performed a multivariate analysis using the binomial logistic regression model for the correlation between the presence of DVT and evacuee or environmental factors. In the three-group multiple comparison test, p values of $<0.016$ were considered statistically significant based on the Bonferroni correction, and in other studies, p values of $<0.05$ were considered statistically significant. For statistical analysis, we used the Statistical Package for the Social Sciences version 23.0 (IBM Corporation, Armonk, NY, USA).

## Results

A total of 195 people (cumulative) were examined during the 7-day screening tests. DVT was observed in 19 (9.7%) people, of whom eight (4.1%) had fresh thrombi based on ultrasound findings. New DVT-positive evacuees were discovered in the September 17–18 examination (11–12 days

after the disaster), although no DVT-positive evacuees were found in the initial examination of September 11–12 (5–6 days after the disaster). The initial positive rate on September 17–18 was 7.7%, which mildly increased in the two subsequent examinations to 8.7% and 9.7% (**Fig. 2**).

**Table 1** shows the comparison of comorbidities, evacuee backgrounds, vital signs, and ultrasound findings between the DVT-positive and DVT-negative groups. Univariate analysis showed a significantly higher ($p<0.01$) number of evacuees who underwent antiplatelet therapy in the DVT-positive group and a significantly lower number of sleep disorder complications, including the use of sleep inducers ($p=0.048$).

**Figure 3** shows the incidence rate of DVT according to cardboard bed introduction status. Emergency shelters that introduced cardboard beds early had a lower incidence rate of DVT, and those that introduced them within 7 days of the disaster had a significantly lower incidence rate of DVT ($p<0.01$) than those that did not introduce them. The incidence rate of DVT for the emergency shelter that introduced the beds after 8 days showed no significant difference compared with the other two statuses. **Figure 4** shows the incidence rate of DVT according to the toilet environment. The better environment and the lower incidence rate of DVT indicated that groups with indoor toilets (not water flushing) ($p<0.01$) and flushing toilets ($p<0.01$) had a significantly lower incidence rate of DVT than the group with outdoor toilets. Multiple comparisons showed no significant differences between the groups with indoor (not water flushing) and flushing toilets. We combined the above two factors (Bed and Toilet) at nine shelters and considered the incidence rate of DVT. The results indicated that the better the environment, the lower the incidence rate of DVT (**Fig. 5**).

Multivariate analysis was performed using the factors of evacuees, cardboard bed introduction status and toilet environment, to determine the risk of developing DVT. In addition to the introduction of cardboard beds within 7 days of a disaster as an important factor that influences the development of DVT, as shown in **Fig. 3**, we determined "no cardboard bed introduction within 7 days" as a risk factor because the guidelines recommend the preparation of portable beds within 7 days.[7] Outdoor

**Table 1** Characteristic of evacuee at Hokkaido East Iburi Earthquake

| | DVT negative | DVT positive | P-value |
|---|---|---|---|
| | n=176 | n=19 | |
| Sex (Female) | 117 (60.0%) | 14 (73.7%) | 0.65 |
| Age | 73±13 | 79±11 | 0.087 |
| Age>80 | 66 (37.7%) | 10 (52.6%) | 0.21 |
| Spent night in vehicle | 21 (10.8%) | 3 (15.8%) | 0.57 |
| Sleep disorder | 105 (50.8%) | 7 (36.8%) | **0.048** |
| Trauma | 41 (21.0%) | 5 (26.3%) | 0.78 |
| Leg edema | 73 (37.4%) | 9 (47.4%) | 0.65 |
| Fitness habit | 89 (45.6%) | 7 (36.8%) | 0.33 |
| Smoking | 24 (12.3%) | 1 (5.3%) | 0.30 |
| Alcohol | 23 (11.8%) | 0 (0.0%) | 0.09 |
| Cardiac disease | 41 (21.0%) | 5 (26.3%) | 0.79 |
| Diabetes mellitus | 26 (13.3%) | 1 (5.3%) | 0.25 |
| Hypertension | 94 (48.2%) | 12 (63.2%) | 0.46 |
| Dyslipidemia | 55 (28.2%) | 7 (36.8%) | 0.64 |
| Malignancy | 9 (4.6%) | 0 (0.0%) | 0.31 |
| Anticoagulant therapy | 18 (9.2%) | 2 (10.5%) | 1.00 |
| Antiplatelet therapy | 17 (8.7%) | 6 (31.6%) | **<0.01** |
| Pregnancy | 8 (4.1%) | 0 (0.0%) | 0.34 |
| Hesitate to urinate | 19 (9.7%) | 4 (21.1%) | 0.20 |
| ELS | 28 (14.4%) | 5 (26.3%) | 0.26 |
| SBP (mmHg) | 137±20 | 145±21 | 0.10 |
| DBP (mmHg) | 76±13 | 80±16 | 0.32 |
| Heart Rate (beats/min) | 73±13 | 79±11 | 0.60 |
| $SpO_2$ (%) | 97±1.4 | 97±2.0 | 0.87 |
| Soleus vein diameter | | | |
| Right (mm) | 5.9±1.8 | 6.8±2.7 | 0.14 |
| Left (mm) | 5.9±1.7 | 6.7±2.8 | 0.29 |

ELS: elastic stocking; SBP: systolic blood pressure; DBP: diastolic blood pressure; $SpO_2$: saturation of percutaneous oxygen

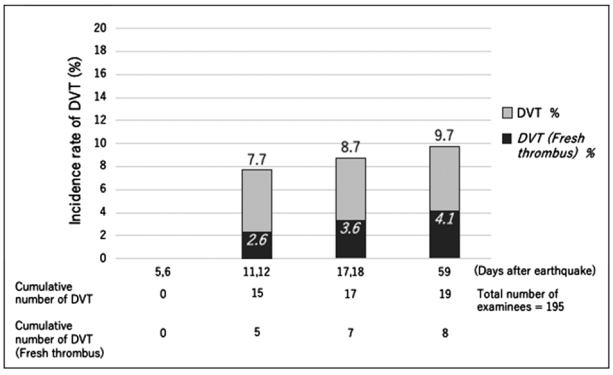



**Fig. 2** Incidence rate of deep vein thrombosis on venous screening from 11 September to 4 November.

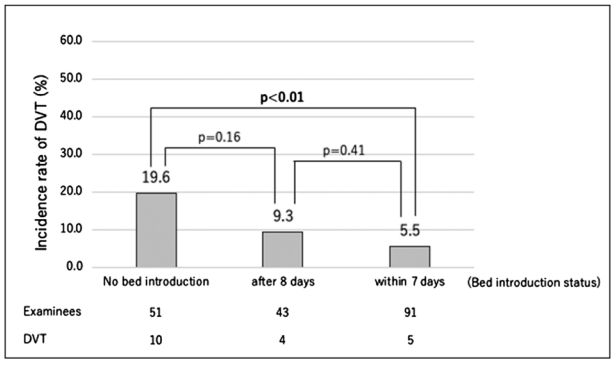



**Fig. 3** Incidence rate of deep vein thrombosis by cardboard bed introduction status.

toilets are another risk factor based on the results in **Fig. 4**. Therefore, independent risk factors for DVT development included no cardboard beds within 7 days (odds ratio [OR]: 5.19; 95% confidence interval [CI]: 1.34–20.1; p = 0.017) and outdoor toilets (OR: 18.6; 95%CI: 1.72–200.2; p = 0.016), besides systolic blood pressure (OR: 1.03; 95%CI: 1.00–1.06; p = 0.047) (**Table 2**).

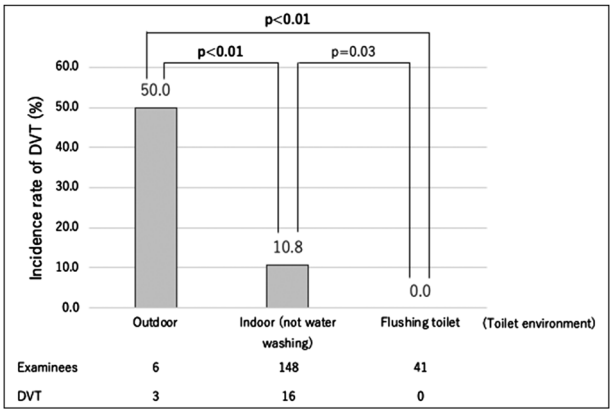



**Fig. 4** Incidence rate of deep vein thrombosis by toilet environment.

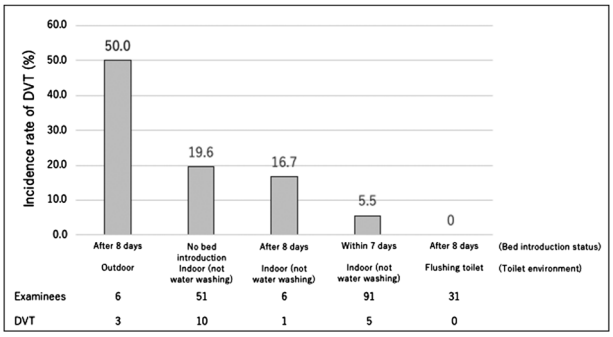



**Fig. 5** Incidence rate of deep vein thrombosis by combined cardboard bed introduction status and toilet environment.

## Discussion

We investigated the situation concerning the development of VTE after the Hokkaido Eastern Iburi Earthquake by conducting screenings while also carrying out public health awareness activities at emergency shelters for approximately 2 months from Day 5 after the earthquake. This study revealed that the incidence rate of DVT was 9.7%. We considered this rate to be higher than normal because, in another study, the incidence rate of DVT for healthy adults was approximately 2.2%.[10] **Table 3** shows the DVT prevalence among those who were affected by recent large-scale earthquakes.[4,6,11–14] The highest was 32% from the Mid Niigata Earthquake in 2004, although the area was inundated by the tsunami accompanying the Great East Japan Earthquake with an even higher rate at 34.2%. The most recent Kumamoto Earthquake in 2016 had a 10.6% rate, making our present study results the same or slightly lower than those of previous earthquakes.

Very few people were sleeping in vehicles after the present disaster, and no significant difference was observed between the DVT-positive and DVT-negative groups, although a well-known evacuee factor for developing DVT during a disaster is sleeping in a vehicle.[5] Other reported risk factors include old age,[6,15] the use of sleep inducers,[6] edema and varicose veins in the lower extremities,[6] and a history of VTE. The present study revealed a smaller proportion of people with sleep disorders, including the current use of sleep inducers and current or past sleep disorder complications, among the DVT-positive group; therefore, the influence of previously recorded sleep inducers could not be analyzed. No significant differences were observed with other factors.

The multivariate analysis revealed that no cardboard bed introduction within 7 days of a disaster and outdoor toilets, besides systolic blood pressure, significantly increased the chance of developing DVT.

We believe that blood pressure status influences the risk of developing DVT because untreated hypertension is reported to be a risk factor for DVT development.[4] Furthermore, we suspect that the stress of living at an

**Table 2** Risk factor of deep vein thrombosis

| Variables | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|
| | Odds ratio (95% CI) | P-value | Odds ratio (95% CI) | P-value |
| Age>80 | 1.80 (0.69–4.67) | 0.23 | NS | |
| Sleep disorder | 0.39 (0.15–1.05) | 0.06 | NS | |
| Antiplatelet therapy | 4.15 (1.39–12.4) | 0.011 | NS | |
| SBP | 1.02 (0.99–1.05) | 0.10 | 1.03 (1.00–1.06) | 0.047 |
| Bed | 3.01 (1.04–8.74) | 0.043 | 5.19 (1.34–20.1) | 0.017 |
| Toilet | 10.2 (1.90–54.7) | <0.01 | 18.6 (1.72–200.2) | 0.016 |

SBP: systolic blood pressure; Bed: Cardboard beds were not introduced within 7 days; Toilet: outdoor toilet

**Table 3** Incidence rate of deep vein thrombosis after earthquakes in Japan of recent years

| Earthquake | Year | Incidence rate of DVT | Author |
|---|---|---|---|
| The Mid Niigata Prefecture | 2004 | 32% (at 2–3 weeks)<br>15% (at 4–8 weeks) | Hanzawa K et al[11] |
| The Noto Peninsula | 2007 | 10.6% | Terakami T et al[12] |
| The Niigataken Chuetsu-oki | 2007 | 6.9% (at 1 week)<br>3.3% (at 2 weeks) | Hanzawa K et al[13] |
| The Iwate-Miyagi Nairiku | 2008 | 15% | Shibata M et al[14] |
| The Great East Japan | 2011 | 34.2% (Tsunami flooded shelters)<br>19.1% (Non-flooded shelters) | Ueda S et al[4] |
| The Kumamoto | 2016 | 10.6% | Sato K et al[6] |
| The Hokkaido East Iburi | 2018 | 9.7% | Kamada K et al |

emergency shelter may influence blood pressure and thrombus formation.[16,17] A univariate analysis showed a significant difference with antiplatelet therapy, suggesting that having a history of cardiovascular disease as a result of arterial sclerosis is a major factor for developing DVT, although the multivariate analysis revealed no significant differences.

The present study focused not only on evacuee factors but also on emergency shelter environmental factors, and relevant analyses were carried out. Dehydration from decreased water intake is one of the causes of thrombus formation,[4] given that supplied drinking water is restricted in emergency shelters and people may refrain from drinking water because of hesitation or reluctance to go to the toilet. A multivariate analysis showed that bad toilet environments increased the risk of DVT, suggesting the importance of organizing toilet environments at emergency shelters, although we observed no significant difference between those who hesitated to go to the toilet and those who did not.

In recent years, the importance of cardboard beds at emergency shelters has gained attention, and the Cabinet Office recommends the early introduction of portable beds and cardboard beds for the prevention of secondary health hazards in their guidelines for managing shelters.[18] During the present disaster, cardboard beds were provided at many shelters. The cardboard bed introduction status impacted the development of DVT, as revealed in multivariate analysis; thus, early introduction is important.

In terms of improving the emergency shelter environment, organizing toilet facilities can take time, as this depends on a water supply, which may be unavailable. Conversely, promptly providing cardboard beds is possible, and the results showed that shelters that had beds at an earlier time had a lower incidence rate of DVT (**Fig. 3**). According to those results, providing cardboard beds as early as possible after a disaster is desirable. However, we observed that the timing in which beds were introduced varied among the shelters, and thus, the improvement of such measures remains a task for the future.

The present study has several limitations. First, it had fewer examinees than in previous studies. The screening tests were conducted during the day when most evacuees had returned to their damaged homes to clean up, meaning that the screening tests were not very effective. Second, we mainly examined high-risk evacuees who were listed in advance by JMAT and public health nurses from September 17 to 18; hence, the incidence rate of DVT was biased. Furthermore, we have no records of such a list of high-risk evacuees, and we were unable to perform a specific analysis regarding high-risk evacuees. Third, the first examination was too early to detect DVT, meaning that the incidence rates may be underestimated if we focus on the screening tests for DVT, since the first examination was performed on days 5 and 6 of the disaster, as shown in **Fig. 2**.

## Conclusion

We provided VTE screening for evacuees at the emergency shelters in response to the Hokkaido East Iburi Earthquake with awareness about the prevention of thrombus formation. Besides evacuee factors, we discovered emergency shelter environmental factors that affect the development of DVT. To prevent DVT, organizing the emergency shelter environment is important. Particularly, predisaster preparation or postdisaster responses including the early introduction of cardboard beds are tasks to be accomplished in the future.

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## Disclosure Statement

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## Author Contributions

Study conception: KK, SK, NA
Data collection: all authors
Analysis: KK, SK, NA
Investigation: all authors
Manuscript preparation: KK, SK, NA
Funding acquisition: MI, KH
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

## Additional Statement

This study was approved by the ethical review board of Asahikawa Medical University (approval number: 20041).

The content of this manuscript was presented at the 39th Annual Meeting of Japanese Society of Phlebology in 2019 in Aichi, Japan.

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