



# Current Awareness and Status of Venous Ultrasonography in Kumamoto Prefecture

## — A Report of the Kumamoto Cardiovascular Echocardiography Standardization Project —

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**Background:** There are few reports on the current awareness and status of venous ultrasonography, including the number of specialists who perform this procedure, in a specific regional area in Japan.

**Methods and Results:** This cross-sectional survey study was conducted in Kumamoto Prefecture from October 2018 to March 2019. Of the 366 medical institutions providing cardiology services in Kumamoto Prefecture, 259 (101 general hospitals, 158 small clinics) responded to our questionnaire. In 2017, 21,773 venous ultrasound tests were performed, 21,101 (97%) of which were performed in hospitals and only 672 (3%) were performed in clinics. Both the number of institutions performing venous ultrasounds and the number of tests performed increased over time. Although 317 medical staff in Kumamoto Prefecture were performing transthoracic echocardiography (TTE) when the questionnaires were collected, only 210 performed venous ultrasounds. Although 91% (61/67) of medical institutions could perform TTE within 30 min, only 77% (53/69) performed venous ultrasounds within 30 min. The number of venous ultrasounds per population $\times$ 100 was largest in the Kumamoto and Kamimashiki areas (1.67) and smallest in the Kamoto area (0.05).

**Conclusions:** This is the first report to reveal the current awareness and status of venous ultrasonography in a specific region in Japan. There are several problems to be overcome, such as a lack of venous ultrasound specialists and the regional disparity in venous ultrasounds in Kumamoto Prefecture.

**Key Words:** Cross-sectional survey study; Kumamoto Prefecture; Venous ultrasonography

Kumamoto Prefecture in Japan was struck by a series of earthquakes (2016 Kumamoto earthquakes<sup>1</sup>), including tremors of moment magnitude ( $M_w$ ) 6.5 on April 14, 2016, and  $M_w$  7.3 on April 16, 2016. After this sequence of earthquakes, more than 180,000 people were evacuated to evacuation centers or private

vehicles. More than 3,000 aftershocks prevented vast numbers of evacuees from returning home, forcing many to stay for prolonged periods in cramped conditions to avoid returning to homes that could potentially collapse.

The incidence of cardiovascular diseases, including hypertension,<sup>2</sup> acute myocardial infarction,<sup>3</sup> heart failure,<sup>3</sup>

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pulmonary thromboembolism (PTE),<sup>4</sup> and deep vein thrombosis (DVT),<sup>4</sup> among others,<sup>2</sup> increases in evacuees after disasters, as does the incidence of stroke and respiratory infections.<sup>5</sup> DVT is defined as an interruption of blood flow through the deep veins because of the formation of a thrombus or clot. A high incidence of DVT in earthquake evacuees has been reported after previous earthquakes in Japan.<sup>6</sup> For this reason, the Kumamoto Earthquakes Thrombosis and Embolism Protection (KEEP) Project was established with the cooperation of local medical institutions. Many participants in the KEEP Project came from medical institutions advocating cardiology. Mobile venous ultrasound screening for DVT was conducted at evacuation centers in Kumamoto Prefecture throughout this project.<sup>1</sup> However, initially, DVT screening had to be performed on a small scale due to a lack of information on sonographers and the inability to recruit sufficient numbers of volunteer venous ultrasound specialists to screen for DVT. This experience made us recognize the need to keep track of venous ultrasound specialists, even in normal times.

Yet, even in ordinary times, PTE is a serious complication after major orthopedic surgery, especially in hospitalized patients and those with cancer,<sup>7,8</sup> and its prevention is important. Acute PTE is the most serious clinical presentation and, in most cases, is a consequence of DVT.<sup>9</sup> Therefore, it is important that thrombosis in deep veins is found to help prevent PTE. Venous ultrasound is recommended as an initial test for the diagnosis of DVT because it is non-invasive and highly sensitive.<sup>10–12</sup> Although we previously reported on the current awareness and status of transthoracic echocardiography (TTE) in Kumamoto Prefecture,<sup>13</sup> as yet there are no data on the actual number of venous ultrasounds performed in a specific area or region because it is difficult to obtain information on venous ultrasound tests performed in medical centers ranging from small clinics to large general hospitals. In 2018, we established the Kumamoto Cardiovascular Echocardiography Standardization Project (K-CHAP) with the aim of standardizing cardiovascular ultrasound techniques and the expertise of sonographers, as well as understanding the status of sonographers during an emergency in Kumamoto Prefecture. Throughout this project, we have communicated with various sonographers, physicians, and medical institutions, which has enabled us to undertake cross-sectional survey studies in Kumamoto Prefecture.<sup>13</sup>

The aim of this study was to clarify the current awareness and status of venous ultrasound, including the number of specialists who perform this procedure, in a specific area of Japan.

## Methods

### Study Design

This cross-sectional survey study was conducted in Kumamoto Prefecture, which is located in the southwestern part of Japan, from October 2018 to March 2019. According to the Kumamoto Prefectural Government, the population of Kumamoto Prefecture in 2017 was 1,765,518 (<https://www.pref.kumamoto.jp/uploaded/attachment/12618.pdf>);

according to the Geospatial Information Authority of Japan, the area of Kumamoto Prefecture is 7,409 km<sup>2</sup> (<https://www.gsi.go.jp/index.html>).

Questionnaires were sent to medical institutions (hospitals and clinics) advocating cardiology on the Kumamoto Prefectural Government homepage (<https://www.pref.kumamoto.jp/soshiki/42/5965.html>), and information was obtained from these institutions regarding venous ultrasound and TTE. In this study we defined a hospital as a medical institution with  $\geq 20$  beds and a clinic as a medical institution focusing on the care of outpatients with  $< 20$  beds, as per the Ministry of Health, Labour and Welfare (<https://www.mhlw.go.jp/toukei/saikin/hw/iryosd/08/dl/02.pdf>).

The study protocol conformed to the principles of the Declaration of Helsinki and was approved by the Institutional Review Board of Kumamoto University (Reference no. 1540). This was a cross-sectional study conducted according to the opt-out method. The study protocol was extensively publicized at Kumamoto University and on our website (<http://www2.kuh.kumamoto-u.ac.jp/tyuokensabu/custom12.html>), and allowed patients and medical institutions the opportunity to withdraw from the study.

### Questionnaires

Two types of questionnaires were constructed. The first, designed for hospitals, was a detailed questionnaire comprising 4 sections investigating: (1) the number of venous ultrasounds or TTE performed from 2013 to 2017; (2) the main profession of those performing venous ultrasounds or TTE; (3) the number of medical staff performing venous ultrasounds or TTE; and (4) the time required to perform venous ultrasounds or TTE. The second questionnaire, for clinics, comprised 2 sections and collected information regarding the number of venous ultrasounds and TTE performed in 2017, as well as the main professions engaged in performing venous ultrasounds.

### Kumamoto Community Medicine Design

The “Kumamoto Community Medicine Design” was devised in Kumamoto Prefecture to establish a system that allows the effective provision of high-level medical care to local people, even if health resources, such as human resources or facilities, are limited. According to this design, Kumamoto Prefecture is divided into 10 subareas: Kumamoto and Kamimashiki, Uki, Ariake, Kamoto, Kikuchi, Aso, Yatsushiro, Ashikita, Kuma, and Amakusa (**Supplementary Figure 1**). In the present study, these 10 areas were reintegrated into 3 areas: Central (Kumamoto and Kamimashiki and Uki), North (Ariake, Kamoto, Kikuchi, and Aso), and South (Yatsushiro, Ashikita, Kuma, and Amakusa).

### Kumamoto Cardiovascular Echocardiography Standardization Project

This questionnaire survey was included as part of the K-CHAP, which involves ultrasounds being performed by various types of medical staff affiliated with Kumamoto University Hospital, Kumamoto Association of Medical Technologists, the Kumamoto branch of the Japan Primary Care Association, and other cardiology hospitals,

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including Saiseikai Kumamoto Hospital, Japanese Red Cross Kumamoto Hospital, Kumamoto Chuo Hospital, Kumamoto City Hospital, National Hospital Organization Kumamoto Medical Center, Kumamoto Rosai Hospital, Kumamoto General Hospital, Hitoyoshi Medical Center, Arao Municipal Hospital, Tamana Central Hospital, Minamata City General Hospital and Medical Center, Yamaga Medical Center, Aso Medical Center, Miyuki Hospital, Sakura Juuji Hospital, and Saiseikai Misumi Hospital.

### Statistical Analysis

Several factors related to venous ultrasounds and TTE were compared among hospitals; comparisons were made using the pairwise Wilcoxon test. Statistical analyses were conducted using SPSS for Windows version 24.0 (IBM, Armonk, NY, USA). Statistical significance was set at 2-sided  $P < 0.05$ .

## Results

### Number of Venous Ultrasounds Performed, and Professions Performing Venous Ultrasounds

In Kumamoto Prefecture there were 366 medical institutions (113 hospitals and 253 clinics) advocating cardiology on the Kumamoto Prefectural Government homepage ([https://www.pref.kumamoto.jp/kiji\\_27800.html](https://www.pref.kumamoto.jp/kiji_27800.html)). Questionnaires were sent to all 366 institutions asking about venous ultrasounds and TTE. Although responses were received from 259 medical institutions (71%; 101 hospitals, 158 clinics), 158 of these (32 hospitals, 126 clinics) did not perform venous ultrasounds. Therefore, 101 medical institutions (69 hospitals, 32 clinics) were enrolled in the present study.

The number of venous ultrasounds performed and the professions engaged in performing these tests are given in **Table 1**. In 2017, 21,773 venous ultrasounds were performed in Kumamoto Prefecture, 21,101 (97%) of which were performed in hospitals and only 672 (3%) were performed in clinics. Sonographers and physicians performed venous ultrasounds in 74% and 27% of medical institutions, respectively (both sonographers and physicians performed

**Table 1. Number of Venous Ultrasounds Performed, and the Profession of Those Performing the Venous Ultrasounds**

Venous ultrasounds performed in 2017	
Total no. ultrasounds performed	21,773
No. performed in hospitals (%)	21,101 (97)
No. performed in clinics (%)	672 (3)
No. medical institutions in which listed professions performed venous ultrasounds (%)	
Physician	25 (27)
Sonographer	70 (74)
Radiologist	5 (5)
Nurse	1 (1)

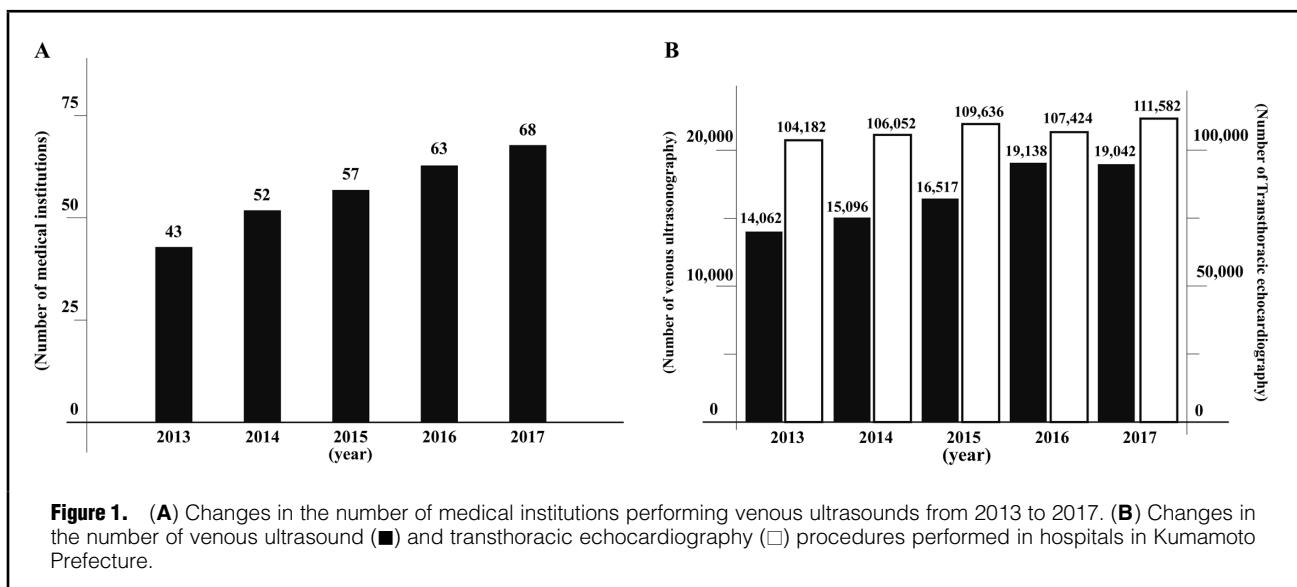
venous ultrasounds in 5% of medical institutions).

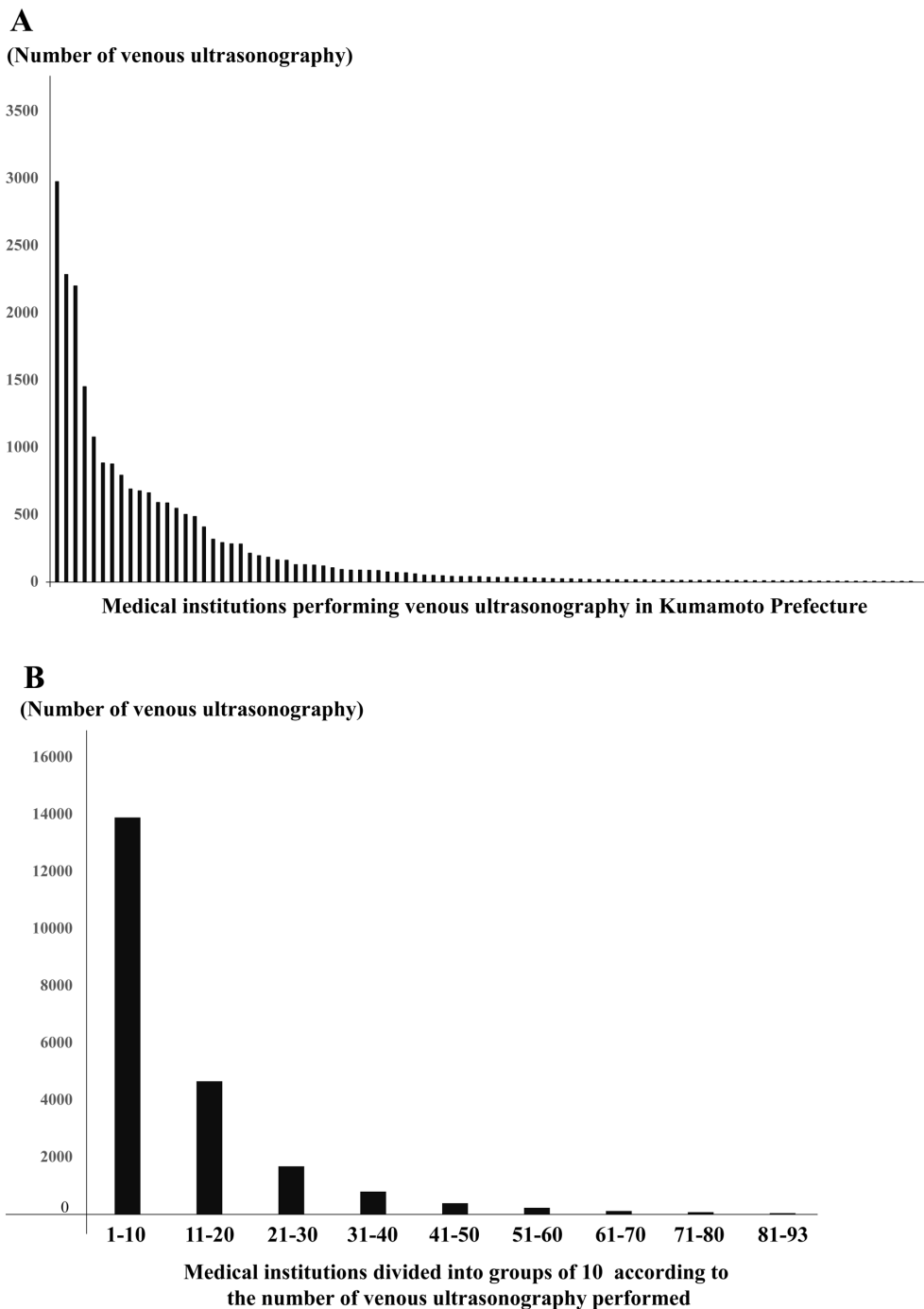
### Changes Over Time in the Number of Medical Institutions and Venous Ultrasounds and TTEs Performed

**Figure 1A** shows changes over time in the number of medical institutions performing venous ultrasounds from 2013 to 2017. The number of medical institutions performing venous ultrasounds increased gradually. Forty-nine hospitals performed both venous ultrasounds and TTE between 2013 and 2017. Changes in the number of venous ultrasounds and TTEs performed in these hospitals over time were evaluated (**Figure 1B**). The number of TTEs increased gradually, except in 2016. In contrast, the number of venous ultrasounds increased markedly especially from 2016.

### Number of Venous Ultrasounds Performed in Each Medical Institution

**Figure 2A** shows that there were large differences in the number of venous ultrasounds performed at different medical institutions. Institutions were divided into 10 groups according to the number of venous ultrasounds performed in descending order (i.e., the top 10 institutions were in the first group, the next 11–20 institutions were in the second





**Figure 2.** (A) Number of venous ultrasounds performed by each medical institution in Kumamoto Prefecture, arranged in descending order from left to right. (B) Medical institutions were divided into groups of 10 according to the number of venous ultrasounds performed and are shown in descending order from left to right.

group etc.). As shown in **Figure 2B**, as many as 64% of venous ultrasounds were performed by the top 10 medical institutions in Kumamoto Prefecture.

**Comparison of Venous Ultrasounds With TTE**

In the 259 medical institutions in Kumamoto Prefecture enrolled in this study, 317 medical staff (physicians, sonog-

rappers, radiologists, and nurses) evaluated TTE, but only 210 evaluated venous ultrasounds. We compared venous ultrasounds and TTE in the 69 hospitals in which both venous ultrasonography and TTE were performed in 2017 (**Table 2**). The number of medical staff performing venous ultrasounds in each hospital was significantly smaller than the number of personnel performing TTE (mean±SD

Table 2. Comparisons Between Venous Ultrasound and Transthoracic Echocardiography			
	Venous ultrasound	TEE	P value
No. medical staff who can perform the procedure in each hospital	3.3±3.4	4.1±3.7	<0.01
Actual no. medical staff performing the procedure in a day in each hospital	2.0±1.7	2.4±1.7	<0.05
Time to perform the procedure for a single patient (min)	30.0±11.6	27.3±7.7	0.08

Data are the mean±SD. P values were obtained using pairwise Wilcoxon tests. TEE, transthoracic echocardiography.

3.3±3.4 vs. 4.1±3.7, respectively;  $P<0.01$ ). In addition, the actual number of medical staff who performed venous ultrasounds daily in each hospital was significantly smaller than the number performing TTE (mean±SD 2.0±1.7 vs. 2.4±1.7, respectively;  $P<0.05$ ). There was no significant difference in the average time to perform venous ultrasound or TTE in a single patient. **Figure 3** shows the distribution of time taken to perform a venous ultrasound (**Figure 3A**) and TTE (**Figure 3B**) in a single patient. Although 91% (61/67) of medical institutions performed TTE within 30 min, only 77% (53/69) of institutions performed venous ultrasounds within the same time frame.

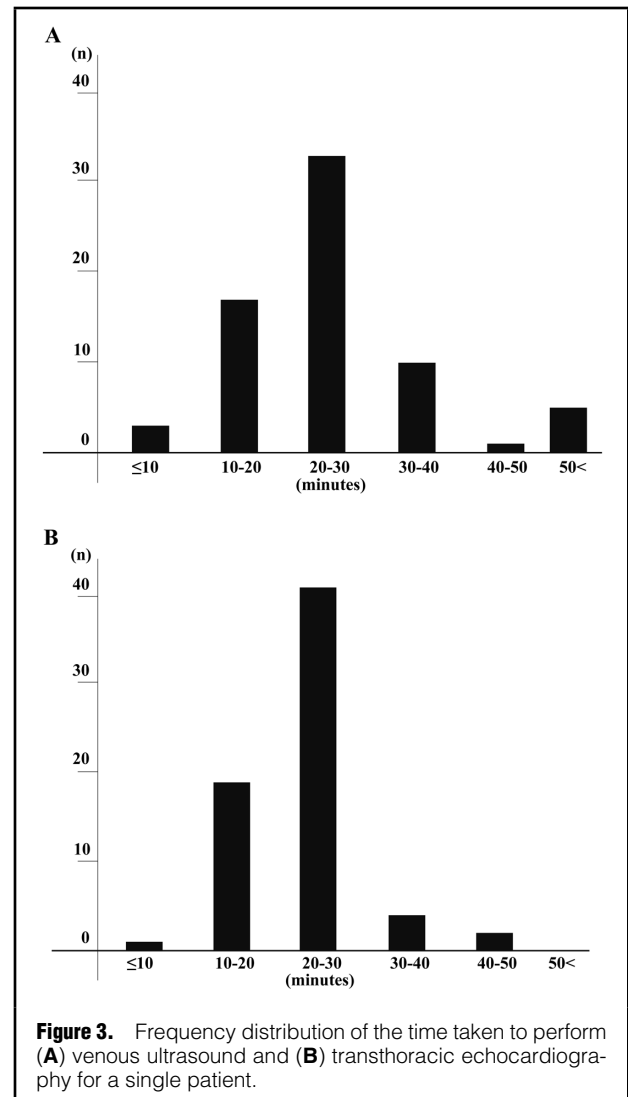
#### Number of Venous Ultrasounds Performed in Different Subareas

Because there was a large difference in the population of different subareas, we compared the ratio of the number of venous ultrasounds performed/population×100 for each subarea (**Figure 4A**). The number of venous ultrasounds/population was largest in the Kumamoto and Kamimashiki areas (1.67) and lowest in the Kamoto area (0.05). The number of sonographers/population×10,000 for each subarea was also highest in the Kumamoto and Kamimashiki areas (**Figure 4B**). However, there were no significant differences in the number of sonographers/population×10,000 among the other subareas.

When Kumamoto Prefecture was reintegrated into 3 areas (Central, North, and South; **Table 3**), the number of venous ultrasounds per population was largest in the Central area. There number of venous ultrasounds per population was considerably lower in the North than South areas (0.63 vs. 1.27, respectively). In contrast, the number of large medical institutions (>200 beds; 8 vs. 6), medium-sized medical institutions (100–200 beds; 5 vs. 3), and medical institutions performing venous ultrasounds (20 vs. 15) was larger in the North than South areas. However, there was little difference between North and South areas in the total number of medical institutions, the total number of sonographers, and the number of sonographers performing venous ultrasounds in hospitals.

## Discussion

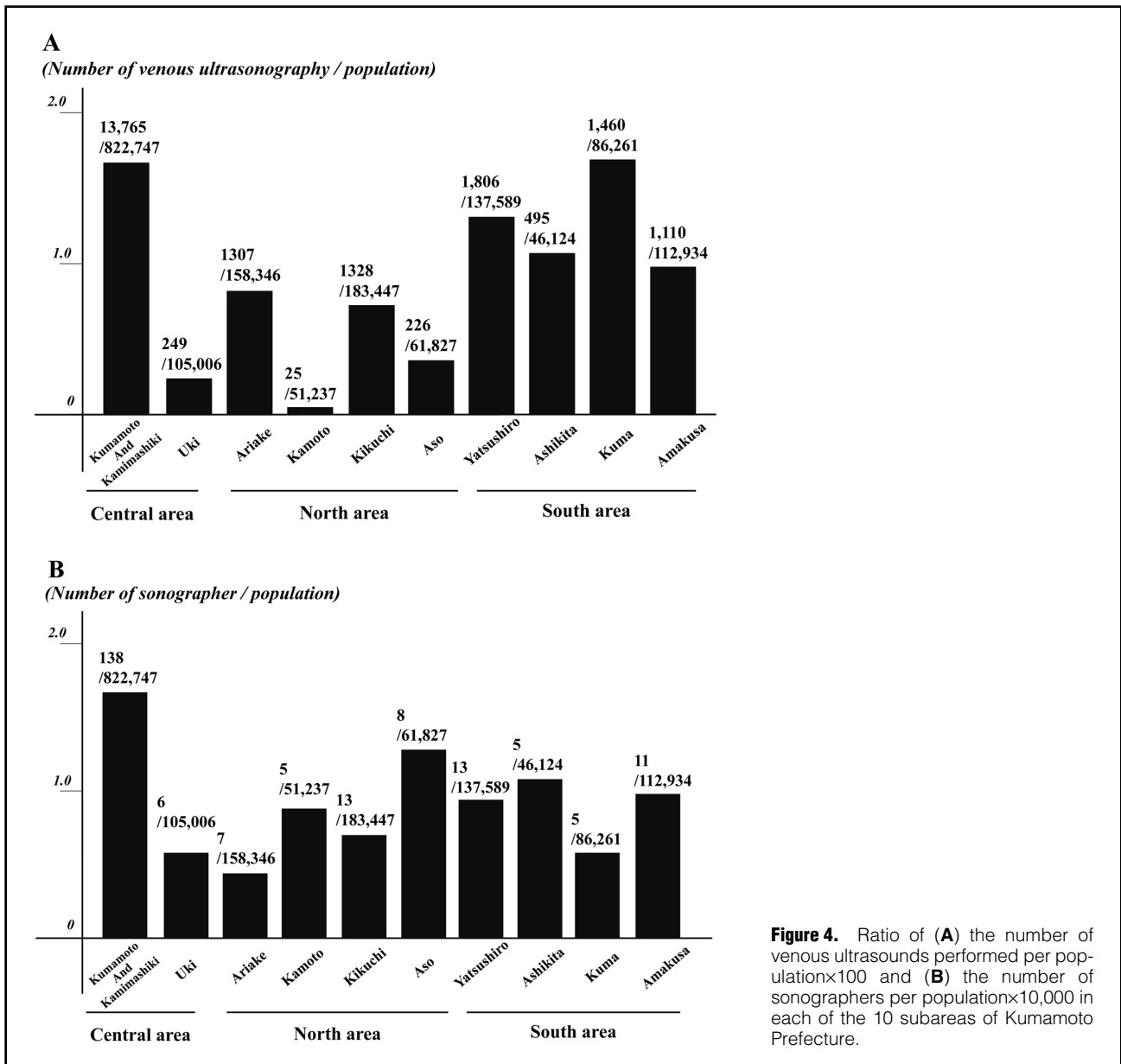
This study reports several findings regarding venous ultrasonography in Kumamoto Prefecture: (1) most venous ultrasounds were performed in hospitals; (2) the number of medical institutions performing venous ultrasounds and the number of venous ultrasounds performed increased over time, especially after the Kumamoto earthquakes; (3) significantly fewer medical staff performed venous ultrasounds than TTE; (4) there was considerable discrepancy in the number of venous ultrasounds among subareas; and



**Figure 3.** Frequency distribution of the time taken to perform (A) venous ultrasound and (B) transthoracic echocardiography for a single patient.

(5) the number of venous ultrasounds was smaller in the North than South area.

Because PTE is a serious complication following major surgery,<sup>7</sup> optimal prophylaxis is needed to reduce perioperative PTE. Malignancy is also known to be a strong risk factor for PTE.<sup>14</sup> Cancer patients have a 4- to 7-fold increased risk of PTE and a 2-fold increased risk of major hemorrhage on anticoagulation than patients without cancer;<sup>15</sup> thus, PTE is the second leading cause of death in the cancer population, directly behind cancer itself.<sup>16</sup> There-



**Figure 4.** Ratio of (A) the number of venous ultrasounds performed per population $\times$ 100 and (B) the number of sonographers per population $\times$ 10,000 in each of the 10 subareas of Kumamoto Prefecture.

Table 3. Comparison Among the North, Central, and South Areas			
	North	Central	South
No. venous ultrasounds performed	2,886	14,014	4,873
Total population (n)	454,857	927,753	382,908
Elderly population (>65 years)/total population (%)	30	25	35
Venous ultrasounds/population $\times$ 100 (n)	0.63	1.51	1.27
No. medical institutions	83	202	81
Large medical institutions	8	16	6
Medium-sized medical institutions	5	19	3
No. medical institutions performing venous ultrasounds	20	59	15
No. sonographers	66	214	52
No. sonographers who can perform venous ultrasounds in hospital	32	144	34

Large medical institutions were defined as those with >200 beds; medium-sized institutions were defined as those with 100–200 beds. Central, Kumamoto and Kamimashiki and Uki; North, Ariake, Kamoto, Kikuchi, and Aso; South, Yatsushiro, Ashikita, Kuma, and Amakusa.

fore, even in cancer patients, optimal prophylaxis is needed to prevent PTE. Our results showed that most venous ultrasounds were performed in hospitals, with very few being performed in clinics. Therefore, it is possible that many venous ultrasound procedures were performed for perioperative screening or for patients with complex illnesses, such as malignancy, in hospitals but not in outpatient screening in clinics.

In the present study, we found an increase over time in the number of medical institutions performing venous ultrasounds and the total number of venous ultrasounds performed in Kumamoto Prefecture. Although one explanation could be that many centers now recognize the risk of PTE during the perioperative period and in patients with malignancy, another explanation could be the Kumamoto earthquakes in Kumamoto Prefecture. From 2015 to 2017, 11 medical institutions started performing venous ultrasounds and the number of venous ultrasounds increased markedly, especially from 2016. Through the KEEP Project and other projects, the risks of PTE and DVT following the Kumamoto earthquakes were widely recognized by the public and medical staff.<sup>1</sup> The activities of these projects increased awareness of the importance of venous ultrasound in Kumamoto Prefecture, increasing the number of medical institutions performing venous ultrasound, as well as the total number of venous ultrasounds performed, after the earthquakes.

Although the number of venous ultrasounds in Kumamoto Prefecture has been increasing with time, the number of venous ultrasound specialists remains insufficient, with the total number of specialists performing venous ultrasounds amounting to only two-thirds of those of performing TTE. In addition, the need for venous ultrasound increases markedly during times of emergency. Therefore, we should maintain an adequate number of specialists who perform venous ultrasounds even in normal times to be able to deal with emergencies as they arise.

In the present study there was no significant difference between venous ultrasound and TTE in the mean time taken to perform the procedure for a single patient. However, venous ultrasounds were performed within 30 min in only 77% of medical institutions. In contrast, TTE was performed for a single patient within 30 min in 91% of institutions. Several types of venous ultrasound have been recommended for DVT diagnosis, such as compression ultrasound, proximal ultrasound, point-of-care compression ultrasound, and whole-leg ultrasound.<sup>10,17-19</sup> Differences in venous ultrasound equipment may be one reason for the variations in the time taken to perform the procedure among medical institutions. However, a more pertinent reason may be delayed standardization of venous ultrasound procedures among medical institutions. Therefore, we should aim to standardize venous ultrasound procedures across all hospitals and clinics.

Another important issue was the major discrepancy in the number of venous ultrasound performed among subareas of Kumamoto Prefecture. The number of venous ultrasounds was largest in the Central area, perhaps because of the greater number of large-sized medical institutions and sonographers. However, fewer venous ultrasound tests were performed in the North than South area. Although the reason for the difference between these 2 areas in the number of venous ultrasounds performed is unclear, there was only a small difference in the number of sonographers who perform venous ultrasounds between the North and

South areas, indicating that the number of sonographers has a small effect on the number of venous ultrasounds performed, especially in rural areas. In contrast, the number of large-sized medical institutions, medium-sized medical institutions, and medical institutions performing venous ultrasounds was smaller in the South than North area, even though a greater number of venous ultrasounds were performed in the South than North area. These results may suggest that centralization of hospitals performing venous ultrasounds is important to increase the number of venous ultrasounds performed, especially in rural areas.

To construct an education system for venous ultrasonography is an important issue in these rural areas. To help overcome this issue, we organized hands-on seminars in these areas to standardize cardiovascular echocardiographic techniques and increase the expertise of sonographers and physicians in these areas. Unfortunately, the current situation of the COVID-19 pandemic<sup>20</sup> has made it impossible for us to conduct these hands-on seminars. Therefore, we are now conducting online multicenter cardiovascular meetings. As of July 2020, more than 40 medical institutions and many cardiologists who are Fellows of the Japan Society of Ultrasonics in Medicine in Kumamoto Prefecture have taken part in these cardiovascular meetings. Because all the major medical institutions in each subarea participate in these sessions (**Supplementary Figure 2**), we expect that we will be able to achieve standardization of venous ultrasound procedures in the near future.

### Study Limitations

This study has several limitations. First, it was a cross-sectional survey study and the data were self-reported. Therefore, there may have been respondent bias. Second, this study was conducted in Kumamoto Prefecture, which is a relatively small area of Japan. Therefore, the study may have been affected by regional characteristics. However, because the present study is the first report to include 70% of various types of medical institutions providing cardiology services, from small clinics to large general hospitals, we believe the results of the study well reflect current awareness of venous ultrasound in Kumamoto Prefecture, and may be close to the current awareness of venous ultrasound in Japan. Validation using a similar cross-sectional survey study in other areas would be useful to evaluate and confirm the universality of the findings of the present study. However, conceiving similar studies will be difficult because it is not easy to obtain ultrasound information from many medical institutions in a specific area. Third, we sent questionnaires to medical institutions providing cardiology services and excluded those not providing such services, even if they performed venous ultrasound. In addition to cardiologists and laboratory technicians, vascular surgeons perform venous ultrasounds. In Kumamoto Prefecture, 18 medical institutions perform cardiovascular surgery, including vascular surgery, of which 89% (16/18) not only perform cardiovascular surgery, but also provide cardiology services (<https://www.pref.kumamoto.jp/soshiki/42/5965.html>). Therefore, we did not enroll 2 medical institutions performing only cardiovascular surgery in the present study.

Given the importance of PTE even for non-cardiovascular hospitals, the lack of information regarding venous ultrasound in non-cardiovascular hospitals may represent an important limitation of the present study. However, after the Kumamoto earthquakes, many participants in the KEEP Project came from medical institutions providing cardiol-

ogy services. Therefore, we believe that our study is valuable in assessing the current status of venous ultrasounds and sonographers to prepare for times of emergency. Because a high response rate to questionnaire surveys is important to understand the real-world situation, we had to make a relatively simple questionnaire to avoid overburdening each medical institution. Therefore, we excluded patients' clinical characteristics from our questionnaire. As a result, the response rate to our questionnaire was relatively high (259/366; 71%) and clarified the real situation of venous ultrasound in Kumamoto Prefecture. However, we could not evaluate patients' clinical characteristics, such as a history of DVT, PTE, or malignancy, in the survey. This point is an important limitation of the present study.

However, despite the limitations described above, we believe that the results of this study are meaningful because they reflect the true current status of venous ultrasound in Japan.

## Conclusions

This is the first report to reveal the current awareness and status of venous ultrasound in a specific area of Japan. The number of venous ultrasounds increased over time in Kumamoto Prefecture. However, several problems were encountered, such as a lack of specialists to perform venous ultrasounds and regional disparities in the status of this procedure. We hope to overcome these issues by conducting multicenter cardiovascular meetings.

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## Disclosures

K.T. is a member of Circulation Reports' Editorial Team. The remaining authors have no conflicts of interest to declare.

## IRB Information

This study was approved by the Ethics Review Committee of Kumamoto University (Approval no. 1540).

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## Supplementary Files

Please find supplementary file(s);  
<http://dx.doi.org/10.1253/circrep.CR-21-0028>