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Original Article

Tapping but Not Massage Enhances Vasodilation and Improves Venous Palpation of Cutaneous Veins

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This paper investigated whether tapping on the median cubital vein or massaging the forearm was more effective in obtaining better venous palpation for venipuncture. Forty healthy volunteers in their twenties were subjected to tapping (10 times in 5 sec) or massage (10 strokes in 20 sec from the wrist to the cubital fossa) under tourniquet inflation on the upper arm. Venous palpation was assessed using the venous palpation score (0–6, with 0 being impalpable). Three venous factors—venous depth, cross-sectional area, and elevation—were also measured using ultrasonography. The venous palpation score increased significantly by tapping but not by massage. Moreover, all 3 venous measurements changed significantly by tapping, while only the depth decreased significantly by massage. The three venous measurements correlated significantly with the venous palpation score, indicating that they are useful objective indicators for evaluating vasodilation. We suggest that tapping is an effective vasodilation technique.

Key words: massage, tapping, vasodilation, venipuncture, venous palpation

Obtaining good vasodilation is a prerequisite for safe and easy venipuncture. However, there are subjects whose veins are difficult to palpate even after tourniquet application. For these subjects, additional methods for vasodilation are employed, which include tapping, massage, hot compress or fist-clenching [1–2].

Tapping and massage have been reported to be effective methods of vasodilation [3–6] and are recommended when the target vein is not prominent and/or needs to be made more prominent for venipuncture [3, 7–9]. Notably, tapping and massage seem to meet the demands of busy clinical scenes as they are convenient and quick methods requiring no tools. Our survey showed that about one-third of nurses preferentially use either tapping or massage for vasodilation [1]. However, whether tapping and/or massage actually facilitate venous palpation for venipuncture has not been sufficiently studied.

In an effort to elucidate factors affecting easy venous palpation, Kato and Mori [10] introduced the venous palpation score (VPS) as a subjective indicator for easy venous palpation, and studied the correlation of VPS with various physical measurements. They reported that VPS negatively correlated with the following physical factors: body weight, body mass index (BMI), triceps skinfold thickness (TSF), and upper arm circumference (UAC). However, they did

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not study venous measurements in detail. Recently, we reported that VPS significantly correlated with 3 venous measurements, namely venous depth ($r = -0.542$), cross-section area (0.258), and elevation (0.486) [11]. Thus, these physical and venous measurements may be useful markers for the objective evaluation of vasodilation and venous palpation.

In this paper, we studied the effects of tapping and massage on vasodilation by measuring the VPS as well as the 3 above-mentioned venous factors. Our results showed that tapping was an effective vasodilation methods.

Materials and Methods

Participants. Healthy young men and women in their twenties were recruited for the study; inpatients were excluded. All participants received oral and written information about this study and provided their written consent. The cutaneous vein examined was the median cubital vein on the non-dominant arm of the subject. Data were collected in August and September 2012.

Experimental procedure. The experimental procedure is shown in Fig. 1. All participants were subjected to both a tapping experiment and massage experiment, which were performed on the same day in a randomized order with more than a 2-h interval between them. In each experiment, an appropriate control was taken, in which the tourniquet was applied but no tapping or massage was performed. The order of the control and experiment was also randomized and the interval was 5 min. The subjects were in a comfortable sitting position in a quiet and temperature-controlled room (24–25℃), with their arms on an armrest. The ultrasound images of the vein were recorded as motion pictures after tourniquet inflation at 60 mmHg. After 40 sec had passed, tapping or

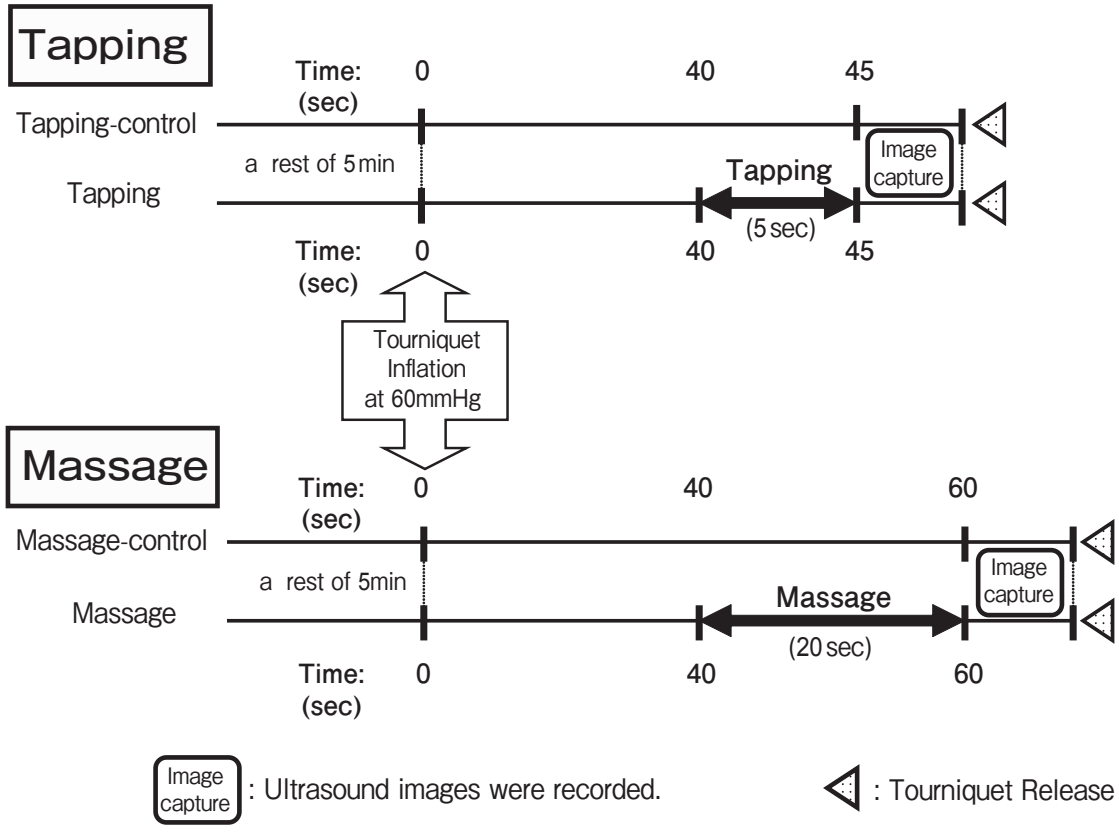

Fig. 1 The experimental procedure is illustrated. All participants were subjected to tapping and massage along with appropriate controls. After 5 min of rest, a tourniquet around the upper arm was inflated to 60 mmHg. Forty sec later, tapping and massage were performed for 5 sec and 20 sec, respectively. Then the ultrasound images of the vein were recorded.

massage was performed as described below and the VPS and venous factors were measured at 45 or 60 sec after the tourniquet inflation, respectively. In addition, we recorded general subjects characteristics and asked subjects about their typical experience with venipuncture.

Methods of tapping and massage. According to the guideline [8] for standard phlebotomy in Japan and our previous investigation [1], tapping and massage were performed as follows: 1) Tapping; the median cubital vein was tapped 10 times in 5 sec (2-tapping/sec) with lightly flexed index and middle fingers. 2) Massage; the forearm was rubbed from the wrist to the cubital fossa on the flexor surface 10 strokes in 20 sec (1-stroke/2 sec). To minimize technical error, one researcher (K.O.) carried out these procedures throughout this study.

Method of tourniquet application To obtain accurate compression pressure, an adult-use sphygmomanometer with a 13.6-cm- wide pneumatic tourniquet was used to dilate the target vein instead of the rubber-tube tourniquet commonly used during venipuncture in Japan. The pneumatic tourniquet was applied around the upper arm and inflated to 60 mmHg for the times indicated above [12].

Subcutaneous vein imaging. An ultrasound system (Prosound 2, ALOKA, with 7.5 MHz linear scan probe, Tokyo, Japan) was used to image the target vein. After applying an excessive amount of ultrasonic transmission gel to the skin of the target area, the probe was carefully placed on the transmission gel so that the probe did not directly compress the skin. Video capture software (GV-MDVD3, I-O DATA, Kanazawa, Japan) was used to continuously record the ultrasound images onto a computer.

Assessment of vasodilation using the palpation scale. Vasodilation was assessed by palpation using Kato and Mori's scale [10] with modification (venous palpation score (VPS)) as follows: "impalpable", 0; "slightly palpable", 1 ("less") or 2 ("more"); "palpable" 3-4 and "well palpable" 5-6. One researcher (M.I.) assessed the VPS throughout this study without being informed as to whether tapping/massage had been performed or not.

Measurements. Measurements included six general characteristics and 3 venous factors. The 6 general characteristics were sex, age, BMI, blood pressure, UAC at about 7 cm proximal from the cubital fossa, and TSF. The 3 venous factors were: (1) depth of the vein (Depth), defined as the distance from skin surface to the top of the vein, (2) venous cross-section area (VCS), and (3) the height of elevation of skin covering the vein (Elevation), which was from the level of the adjacent bilateral skin 1 cm from the center of the vein (Fig. 2). These 3 venous factors have been shown to correlate significantly with

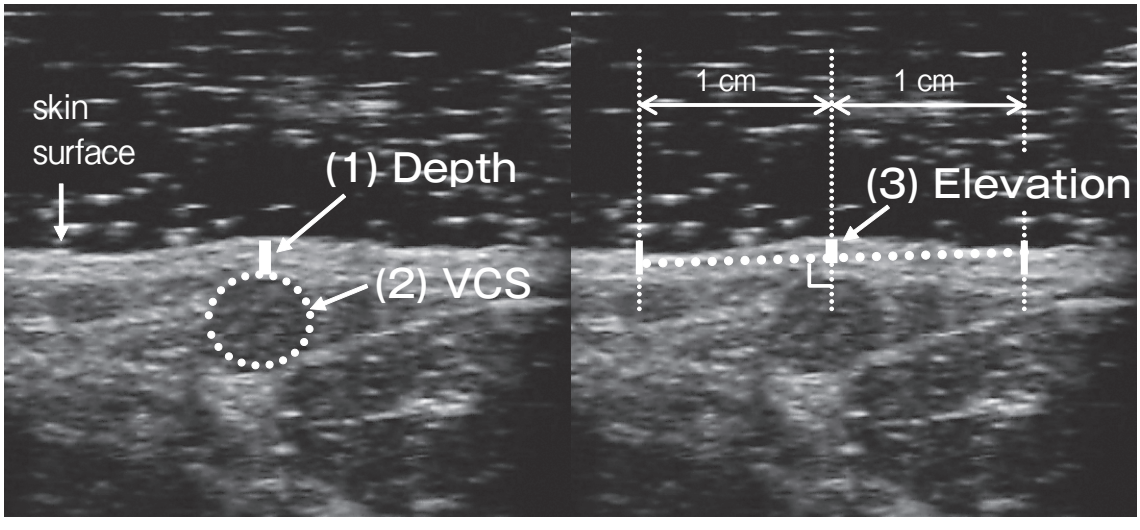

Fig. 2 Venous factors were measured using cross-sectional ultrasonography as follows: (1) Depth (mm): distance from the skin surface to the top of the vein. (2) VCS (mm^2): venous outline was approximated by an ellipse and the area was calculated. (3) Elevation: height from the level of the adjacent bilateral skin 1 cm from the center of the vein.

VPS [11], an indicator for the ease of venous palpation. Thus, they are suitable for the objective assessment of vasodilation.

Frequency of venipuncture failure. We also asked how often the subjects experienced failure of venipuncture. The assessment scale was "never", "rarely", "sometimes" and "often", assigned scores of 0, 1, 2, and 3, respectively.

Ethical issues and approval. This study was approved by the Okayama Prefectural University Ethics Committee. Written informed consent was obtained from all volunteers before the study.

Statistical analysis. Data were analyzed using SPSS 20 (IBM SPSS Advanced Statistics, IBM, Tokyo, Japan). The VCS (tapping/massage vs. control) was compared using a paired *t*-test, while the VPS, Depth, and Elevation were compared using the Wilcoxon signed-ranks test. Correlation between VPS and the 3 venous measurements was studied using Spearman's test. *P* values smaller than 0.05 were considered statistically significant.

Results

Subject characteristics. Forty healthy volunteers, 20 men and 20 women, in their twenties were enrolled. The subjects' characteristics are shown in Table 1. In this study, a few subjects reported experiencing failure at venipuncture. Among 40 subjects, 31 reported "never", 3 reported "rarely", 4 reported "sometimes" and 2 reported "often". Thus, most subjects typically experienced successful venipuncture.

The differences of VPS and 3 venous factors on tapping and massage. The effects of tapping and massage on VPS, Depth, VCS, and Elevation are shown in Fig. 3 and Table 2. Tapping induced a significant increase in VPS (Fig. 3). The number of subjects with VPS = 5 or 6 (well palpable) was increased by tapping (29 persons, 72.5%) from the control (22 persons, 55%). In addition, the 3 venous measurements also showed significant changes, namely, Depth was decreased and VCS and Elevation were increased significantly (Table 2).

In contrast, massage did not result in a significant increase in VPS. Among the 3 venous measurements, only Depth decreased significantly, whereas VCS and

Table 1 Subject characteristics (N = 40: 20 women, 20 men)

Characteristics Items	Mean ± SD
Age (yrs)	21.8 ± 0.8
Height (cm)	165.0 ± 11.3
Weight (kg)	56.1 ± 9.2
Body mass index (BMI) (kg/m^2)	20.5 ± 2.3
Systolic blood pressure (mmHg)	110.7 ± 11.3
Diastolic blood pressure (mmHg)	68.4 ± 10.3
Upper arm circumference (UAC) (cm)	23.8 ± 1.8
Triceps skinfold thickness (TSF) (mm)	9.1 ± 4.4

Table 2 Effects of tapping and massage on depth, VCS and elevation (N = 40)

Measurement	Depth (mm)		Venous cross-section area (VCS) (mm^2)		Elevation (mm)	
	median (mean)	min-max	median (mean)	min-max	median (mean)	min-max
Tapping-control	1.80 (1.95)	1.27–5.50	16.4 (17.8)	7.26–31.0	0.74 (0.92)	0.25–2.73
tapping	1.60*** (1.78)	1.00–4.80	18.0 (18.5)*	7.90–32.7	0.83** (1.00)	0.25–2.90
Massage-control	1.79 (2.00)	1.20–5.50	16.4 (17.6)	6.19–32.0	0.80 (0.94)	0.25–2.64
massage	1.70** (1.90)	1.20–6.10	16.4 (17.6)	7.32–30.3	0.79 (0.96)	0.25–2.73

The Depth, VCS and Elevation were compared between the experimental groups and the corresponding controls for tapping and massage. Median, mean and minimum as well as maximum values (min-max) are shown. The VCS was compared using a paired *t*-test, whereas the Depth and Elevation were compared using the Wilcoxon signed-ranks test. ***, **, and * indicate significant differences at $p < 0.001$, $p < 0.01$, and $p < 0.05$, respectively.

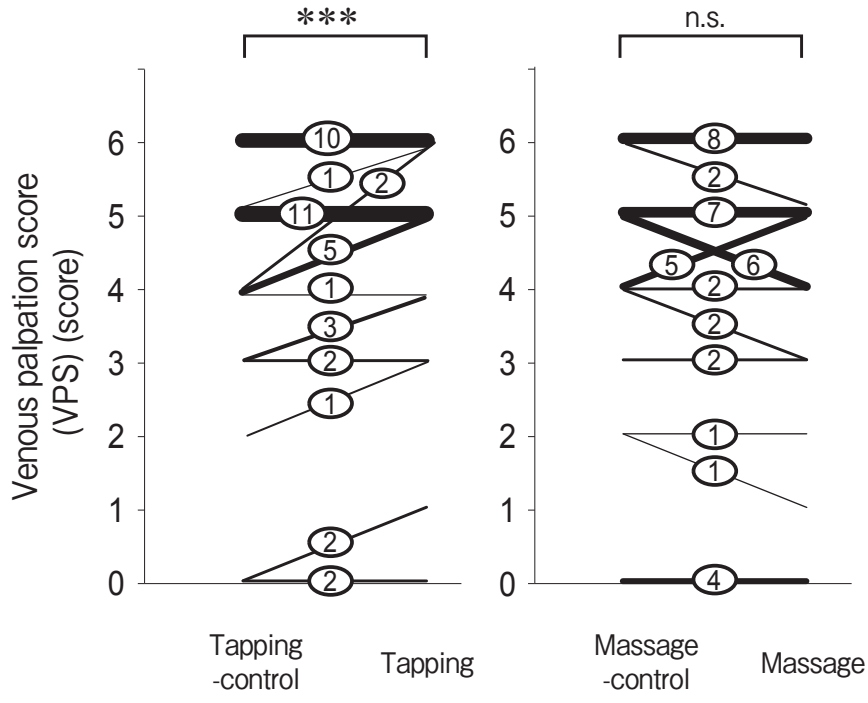

Fig. 3 Effects of tapping and massage on VPS (n = 40). The control and experimental VPS for each subject are shown individually as line graphs. VPS values were compared using the Wilcoxon signed-ranks test. *** indicates significant difference at $p < 0.001$. Numbers of subjects are shown in the circles.

Elevation did not change significantly.

Correlation between VPS and venous factors. The correlations between VPS and the three venous factors were studied using Spearman's test, and the results are shown in Table 3. Consistent with our previous result [11], VCS and Elevation showed positive correlations, whereas Depth showed a negative correlation.

Effect of VPS on tapping and massage. We compared the VPS after tapping and massage in each individual and the results are shown in Table 4. In all subjects, the VPS after tapping was better than (17 cases) or equal to (23 cases) that after massage.

Table 3 Correlation between venous palpation score (VPS) and three venous factors (N = 40)

Measurement	Depth	Venous cross-section area (VCS)	Elevation
Tapping-control	−0.618***	0.460**	0.667***
Tapping	−0.526***	0.496**	0.683***
Massage-control	−0.597***	0.470**	0.632***
Massage	−0.579***	0.538***	0.649***

Spearman's correlation coefficients and statistical significances (***$p < 0.001$, **$p < 0.01$) are shown.

Table 4 Comparison of venous palpation score (VPS) between tapping and massage (N = 40)

	Subjects' number	Ratio (%)
Tapping VPS = massage VPS	23	57.5
Tapping VPS > massage VPS	17	42.5
Tapping VPS < massage VPS	0	0

Discussion

In this paper we studied whether tapping on the cutaneous vein or massaging the forearm was effective in obtaining better venous palpation for venipuncture. The VPS indicated that tapping but not massage was an effective vasodilation technique. This result was also substantiated by the measurements of three venous factors, *i.e.*, Depth, VCS, and Elevation. The findings provide evidence that our tapping procedure was effective in dilating the target vein for venipuncture.

In the case of tapping, 3 venous factors are likely to contribute to making venous palpation easier. Mechanical stress, such as shear stress, stimulates release of nitric oxide (NO) and other vasoactive substances from the endothelium [13–14]. Pain is also known to induce vasodilation through the axon reflex [15]. Actually, flare was observed around the tapping site, which indicated that the tapping resulted in the axon reflex. These factors may have increased the VCS by tapping. When VCS increases, the tissue above the vein is pushed up, which decreases the Depth and increases the Elevation. In contrast, both tapping and massage compressed the tissue above the vein mechanically, which may also have contributed to the decrease in the Depth as shown in Table 2. In contrast, while massage decreased the Depth, it did not increase VCS or Elevation, which meant no significant increase in VPS.

Massage did not induce vasodilation, despite the fact that many nurses employ this method [1]. It has been reported that massage dilates superficial blood vessels and increases the rate of blood flow [6]; however, this may require a longer massage time. Our result showed that gentle rubbing of the forearm for only 20 sec was not suitable for obtaining instant vasodilation. Moreover, there was no subject in whom VPS after massage was higher than that after tapping (Table 4). Thus, massage proved to be an ineffective vasodilation technique under this experimental setting.

Tapping is a quick and cost-free method which requires no tools. Nevertheless, when compared with more elaborate vasodilation techniques, such as a hot compress, the effect of tapping may be small. Specifically, our tapping procedure increased VCS by about 4%, *i.e.* from tapping-control VCS = 17.8 mm^2 to tapping VCS = 18.5 mm^2. On the other hand, Sasaki *et al.* [16] reported that a hot compress for 15 min increased VCS by about 17%, which was substantially higher than our tapping procedure. In actual practice, a larger VCS is often helpful for easier venipuncture because a smaller vein may be difficult to puncture even if it is palpable. Therefore, if the equipment is available and the time is sufficient, a hot compress may be preferable. The most appropriate method should be selected depending on the circumstances.

In this study, only young adults were included. Further study must determine whether similar effects of tapping can be observed in older subjects, as vascular responses may differ in different age groups [17]. It has been reported that vascular responses to nitroprusside (NO donor) and acetylcholine were age-dependent [18], whereas the responses to serotonin and isoprenaline were not [18–19]. Thus, older people may respond to tapping or massage differently from younger people, which needs to be clarified.

In our previous experiment (n = 110, mean age = 43.9 yrs), we found that VPS correlated significantly with the 3 venous factors, *i.e.*, Depth, VCS, and Elevation [11]. In the present study (n = 40, mean age = 21.8 yrs), these correlations were again observed, confirming that Depth, VCS, and Elevation are useful objective indicators for the evaluation of vasodilation, regardless of subject age. Therefore, we recommend that Depth, VCS, and Elevation as well as VPS should be included in future studies for evaluating vasodilation techniques.

The potential limitations of our study are as follows. First, the number of subjects with VPS = 0 to 2 (impalpable and slightly palpable) was only 15% (6/40) in this study. Second, the methods of tapping and massage may not be optimal. Third, older subjects need to be included in a future study to determine whether similar effects can be observed. Fourth, we applied a pneumatic tourniquet at 60 mmHg for 45–60 sec, which was an optimal condition for vasodilation [12]. If we used a different tourniquet pressure such as 40 mmHg or 100 mmHg, which is not rare clinically [20], the results would be different because of the difference in hemodynamics. Lastly, a pneumatic tourniquet is not a common tool for venipuncture at clinical settings. The reason why we employed one is that we had to use an appropriate and reproducible condition to study techniques for vasodilation. If we used a rubber tube tourniquet, as most Japanese nurses do, it would be very difficult to obtain a reproducible pressure.

In a future study, it will be necessary to increase the number of subjects with hardly palpable veins and subjects of various age groups. Moreover, procedures other than tapping and massage should be tried under various settings to establish effective techniques for vasodilation.

In conclusion, tapping but not massage induced a significant increase in VPS. In addition, tapping increased VCS and Elevation, but decreased Depth

significantly. In contrast, massage did not induce significant changes except for a decrease in Depth. Consistent with a previous report, the 3 venous measurements correlated significantly with the venous palpation score, indicating that they are useful objective indicators for the evaluation of vasodilation. The results indicated that tapping is an effective vasodilation technique.

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