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Clinical application of vein visualization apparatus AccuVein®500 in breast cancer surgery: a case report

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Abstract

Background AccuVein® can help visualize superficial veins and is generally used as an auxiliary device to identify patterns of veins that are difficult to locate for collecting blood and securing venous lines. Even when venous patterns are obscure via visual inspection and/or palpation, the clear projection/delineation of superficial veins using this apparatus facilitates safe venous puncture and helps secure venous lines. Therefore, this apparatus is widely used in clinical settings. AccuVein® can easily visualize not only superficial veins in the limbs but also the ones located throughout the body surface.

Case presentation We report three cases of 68-year-old, 41-year-old, and 56-year-old Japanese women in whom superficial veins in the breasts were visualized using AccuVein®, and mastectomy and partial mastectomy were performed. All patients were of Japanese ethnicity. AccuVein® can enable the examiner to observe superficial veins in the breasts, irrespective of their skills. The examiner can, thus, secure detailed visualization of subcutaneous veins in the breasts. Furthermore, AccuVein® ensures reproducibility and subjectivity regardless of the examiners' experience. During a mastectomy, the perforating branches of the internal thoracic vein originating from the greater pectoral muscle are identified, ligated, and separated. The preoperative use of AccuVein® makes it possible to instantaneously identify their position. Visualizing the perforating branches to their root in patients with thin subcutaneous breast fat and their roots' proximity in patients with thick subcutaneous breast fat is possible. While the position and/or range of a breast cancer lesion may sometimes be unclear in ultrasonography, marking subcutaneous mammary veins around the lesion as the benchmark helps identify the lesion position. In this study, we inspected the patterns of subcutaneous mammary veins using AccuVein®. This manuscript reports the clinical application of this apparatus in breast cancer surgeries.

Conclusion Understanding the vascular construction of subcutaneous mammary veins using the vein visualization apparatus AccuVein® may serve as an auxiliary technique for safely and securely identifying breast cancer lesions.

Keywords Vein visualization apparatus, AccuVein®, Subcutaneous mammary veins, Breast cancer, Surgery

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Background

AccuVein® is a battery-powered and hand-held device that can be used to reveal patient vasculature information to aid venipuncture processes. It comprises two laser-emitting diodes: the first one emits infrared light (approximately 830 nm) and the second one emits only visible wavelengths (approximately 520 nm). The vasculature absorbs a portion of the infrared light, causing the reflection of a contrasted infrared image. A silicon photodiode, responsive to the contrasted infrared image, generates the transmission of a corresponding signal. The signal is processed through the circuitry to amplify, sum, and filter the outgoing signals. With the use of an image processing algorithm, the contrasted image is projected onto the patient's skin surface using the second laser diode (Fig. 1).

When light is projected, fixing the apparatus approximately 150–250 mm away from the skin and minutely adjusting the distance and angle relative to the skin may improve the display quality. Moreover, the display quality may be improved, and other veins may become visible when the apparatus is held close to or away from the skin, depending on room lighting and vein depth. The visualization of veins is dependent on various factors in the patient. If the patient has thick body hair, wounds, tattoos, scars, undulated skin surface, and thick fat layers, it may become difficult to visualize superficial veins using the apparatus. In addition, the apparatus is unable to quantify vein depth. This apparatus should only be regarded as an auxiliary device for observing superficial veins. Accordingly, ensuring that veins are confirmed by visual inspection and palpation before performing venous puncture for blood collection and securing infusion routes is essential.

The reported clinical applications of AccuVein® include assisting in identifying peripheral veins and securing infusion lines [1–9], anastomosing blood vessels during flap surgery [10], identifying veins during lymphatic vessel anastomosis for lymphatic edemas in upper/lower limbs [11–14], identifying veins around an ulcer during sclerotherapy injection for venous leg ulcer [15], diagnosing congenital hemangioma [16], and identifying vascular construction in the palate [17]. Furthermore, the apparatus has other uses that include prevention/alleviation of vascular damage by identifying superficial veins.

This manuscript reports the first case of breast cancer surgery where AccuVein® was utilized to identify subcutaneous veins in the breasts before mastectomy.

Case presentation

Application for identifying the position of the perforating branches of the internal thoracic vein during mastectomy

During a mastectomy, the perforating branches of the internal thoracic vein originating from the greater pectoral muscle are identified, ligated, and then separated. Normally, the positions of blood vessels are identified via ultrasonography before surgery. Through AccuVein®, the examiner can instantaneously observe the localization of these vessels; thus, we anticipated that this would be conducive to a safe/secure surgical procedure, not dependent on the examiner's experience. We present the case of a 68-year-old Japanese woman (height, 155 cm; weight, 53 kg; and body mass index [BMI], 22.2 kg/m^2). An expansive ductal carcinoma in situ (DCIS) lesion (clinical stage 0) was observed in section BD of her right breast (Fig. 2a). Although surgeons, including the authors, tend to focus on breast cancer lesions, the patterns of subcutaneous mammary veins and the positions

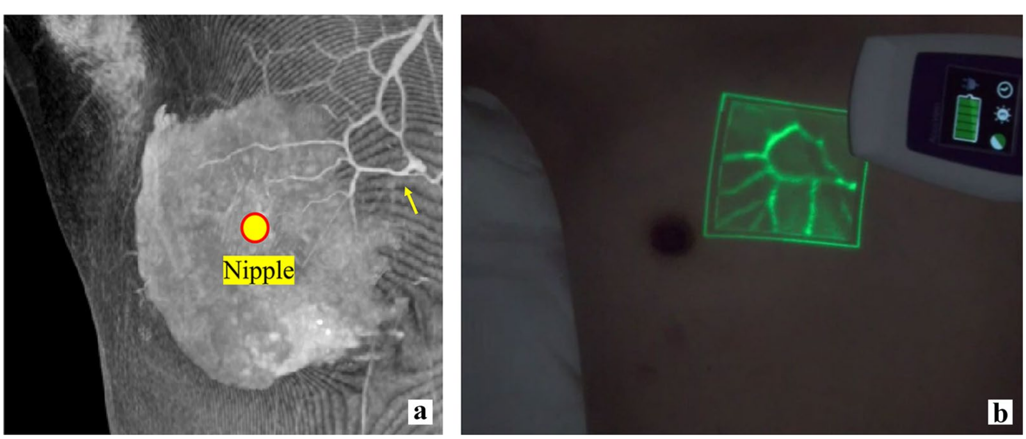

Fig. 1 Consistency between contrast-enhanced computed tomography maximum intensity projection image and superficial mammary vein construction visualized via AccuVein®. **a** The contrast-enhanced computed tomography maximum intensity projection image shows the perforating branches of the internal thoracic vein (yellow arrow). **b** AccuVein® clearly visualizes the subcutaneous mammary veins. This is completely identical to the vascular construction shown in the contrast-enhanced computed tomography maximum intensity projection image

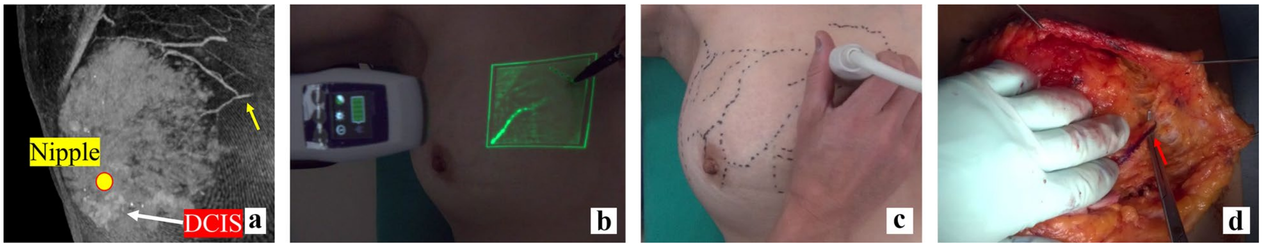

Fig. 2 Consistency between superficial mammary veins visualized via AccuVein® and the corresponding blood vessels during surgery. **a** The contrast-enhanced computed tomography maximum intensity projection image shows the perforating branches of the internal thoracic vein (yellow arrow). **b** AccuVein® clearly visualized the subcutaneous mammary veins. **c** The marking of the vascular construction on the skin and the ultrasonography of the position of the perforating branches of the internal thoracic vein. **d** Safe ligation treatment of the perforating branches of the internal thoracic vein (red arrow); *DCIS* ductal carcinoma in situ

of the perforating branches of the internal thoracic artery deserve more attention. AccuVein® makes it possible to visualize the perforating branches of the internal thoracic vein through the subcutaneous veins in section A of the breast (Fig. 2b) such as maximum intensity projection (MIP) images of contrast-enhanced computed tomography (CT; captured for staging at our institution using GE Revolution®, taking 1.25 mm slices). Moreover, superficial vein structures can be marked on the breast skin to create a map (Fig. 2c). The position of the perforating branches of the internal thoracic vein identified by AccuVein® was confirmed to be consistent by ultrasonography (Fig. 2c). Before surgery, adrenaline saline diluent was subcutaneously injected into the site where a skin flap was planned to be constructed. By marking the patterns of subcutaneous veins on the skin, it is possible to avoid vascular damage by a syringe needle or intravascular administration of drugs. In addition, vascular damage can be minimized when visualizing venous patterns before skin flap construction during surgery. In the present case, no vascular damage was noted because the position of the perforating branches of the internal thoracic vein was identified in advance, and it was possible to ligate and separate this vein (Fig. 2d). Normally, a vein runs in proximity to an artery. Accordingly, identifying the perforating branches of the internal thoracic vein helps identify the corresponding artery, which can then be treated safely.

Marking of a breast cancer lesion using subcutaneous mammary veins as the benchmark

Identifying a breast cancer lesion and its scope with ultrasonography can be difficult. Thus, various techniques have been reported, including projecting a breast cancer lesion on the skin [18–20] and fusing echographic images with magnetic resonance (MR)/CT/ultrasound images [21–36]. This paragraph explains a more simplified novel identification technique for breast cancer lesions using subcutaneous mammary veins as the benchmark. The case concerned a 41-year-old Japanese woman (height, 158 cm; weight, 74 kg; and BMI, 29.8 kg/m^2) who had an expansive DCIS lesion (clinical stage 0) in section AC of her right breast. In a MIP image of contrast-enhanced CT (Fig. 3a), the green portion signifies the DCIS lesion, which was expanded distortedly. Thus, it was extremely difficult to mark the shape of this lesion using ultrasonography in the same way as contrast-enhanced CT. Here, it is important to focus on not only the breast cancer lesion but also the construction of subcutaneous mammary veins (Fig. 3a). Since subcutaneous mammary veins can be identified with AccuVein®, it is possible to visualize the identified breast cancer lesion using the MIP image of contrast-enhanced CT on the skin by collating the positional relationships between the vascular construction and the lesion in the MIP image of contrast-enhanced CT after subcutaneous veins are marked on the skin (Fig. 3b). The pathological findings of the removed breast indicated the lesion to be DCIS, and the lesion range (Fig. 3c) was almost comparable to the MIP image of contrast-enhanced CT (Fig. 3a); moreover, the breast cancer lesion marked using the subcutaneous vessels served as the benchmark (Fig. 3b). This result suggested the effectiveness of this novel marking technique using AccuVein®.

Next, we present an auxiliary technique using AccuVein® to identify a cancer lesion left unclear by preoperative pharmacotherapy. This case was of a 56-year-old Japanese woman (height, 154 cm; weight, 50 kg; and BMI, 23.4 kg/m^2) who had invasive ductal carcinoma (luminal A type) and underwent preoperative endocrine therapy (using an aromatase inhibitor) for 3 months. Following the treatment, the lesion shrunk and became nearly undetectable via ultrasonography. In contrast, the subcutaneous mammary veins were not affected by the treatment, with their shape remaining unchanged before and after the treatment.

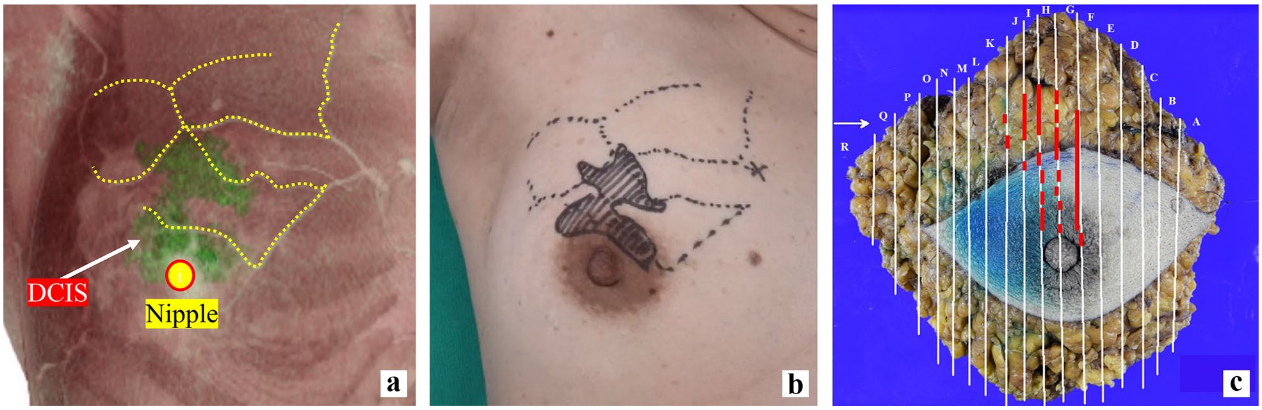

Fig. 3 Marking of the breast cancer lesion using the subcutaneous mammary veins as the benchmark. **a** The positional relationship between the breast cancer lesion (green) in the contrast-enhance computed tomography maximum intensity projection image and the construction of the superficial mammary veins (yellow dotted line) is shown. **b** Using AccuVein®, the subcutaneous mammary veins were marked on the skin, and the positional relationship between the vascular construction and the breast cancer lesion in the contrast-enhanced computed tomography maximum intensity projection image was collated. This allowed us to visualize the breast cancer lesion in the contrast-enhanced computed tomography maximum intensity projection image on the skin. **c** In the removed specimen, the breast cancer lesion (red line) expanded as much as the lesion shown in **a**, **b**; *DCIS* ductal carcinoma in situ

We then attempted to visualize the subcutaneous veins using AccuVein® on the assumption that it would serve as the benchmark for identifying the breast cancer lesion. In the MIP image of contrast-enhanced CT (Fig. 4a), the breast cancer lesion was observed in section A of the breast, and a bell-shaped subcutaneous vein was present on its superior side. After the shrunk lesion site was marked by ultrasonography following the preoperative endocrine therapy, the subcutaneous mammary veins were visualized using AccuVein® (Fig. 4b). The positional relationship of these veins and the tumor was confirmed to be consistent with the positional relationship between the subcutaneous veins and tumor in the MIP image of contrast-enhanced CT (Fig. 4a, b). This demonstrates that it is possible to predict the site of a lesion before ultrasonography by benchmarking superficial blood vessels. In this patient, a negative pathological result was obtained for the resection stump after partial mastectomy. All patients were of Japanese ethnicity.

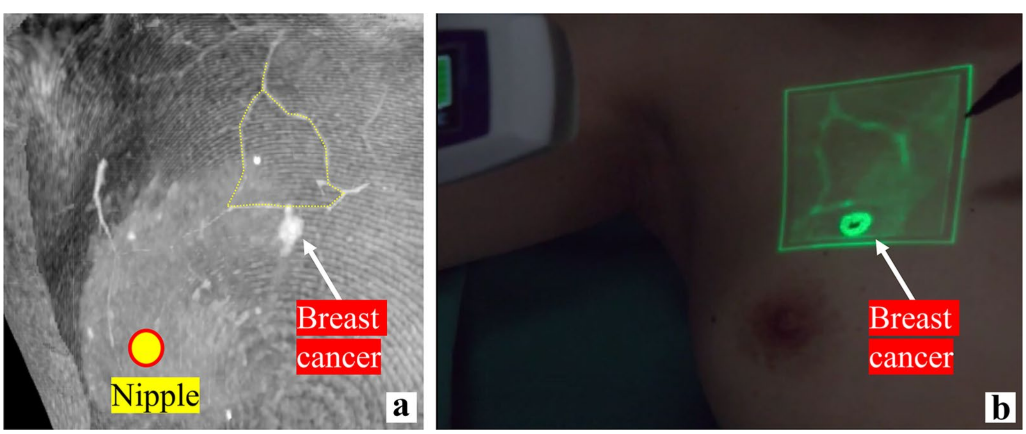

Fig. 4 Estimation of the breast cancer lesion using subcutaneous mammary veins as the benchmark (partial mastectomy). **a** The positional relationship between the breast cancer lesion in the contrast-enhanced computed tomography maximum intensity projection image (white arrow) and the bell-shaped construction of the superficial mammary veins (yellow dotted line) are shown. **b** The positional relationship between the subcutaneous veins visualized by AccuVein® and the ultrasonography-marked lesion after preoperative endocrine therapy was identical to that between the vascular construction and the lesion in the contrast-enhanced computed tomography maximum intensity projection image. This means that a breast cancer lesion can be estimated from vascular construction

Discussion and conclusion

In principle, breast cancer lesions should be identified using an ultrasound device during breast cancer tissue biopsy or surgery. In this study, we mapped the subcutaneous veins in the breast skin using AccuVein® with the hope of applying the apparatus to breast cancer biopsy or surgery. We then filed the first case report related to surgery. During tissue biopsy, tumors are punctured under ultrasonic guidance. Then, a puncture needle is inserted while thick blood vessels near the tumor are observed and avoided using ultrasound to minimize hemorrhage. Meanwhile, superficial blood vessels cannot be observed because the probe of the ultrasound device needs to be pressed against the skin, causing the compression of vascular lumens. Using AccuVein®, it becomes possible to avoid superficial blood vessels during a tissue biopsy puncture and prevent needless hemorrhage (Fig. 5). Normally, AccuVein® is used to secure venous lines for blood collection and infusion. Conversely, it can also avoid superficial blood veins [37, 38]. At our hospital, adrenaline saline diluent is subcutaneously injected before mastectomy for hemostasis purposes. When using AccuVein® to visualize superficial veins and mark the skin, the surgeon can avoid superficial blood vessels while giving a subcutaneous injection, reducing vascular damage. Moreover, during skin incision and skin flap construction in mastectomy, the surgeon can check the patterns of blood vessels point by point during the operation, thus reducing vascular damage. As mentioned above, it is also possible to visualize the root area of the perforating branches of the internal thoracic vein originating from the greater pectoral muscle, hence making it possible to ligate/separate blood vessels while ensuring safety and security. In general, an artery often runs along or near a vein; therefore, identifying the position of the perforating branches of the internal thoracic vein can serve as the benchmark for arteries.

AccuVein® is highly precise in visualizing superficial veins, with an error range of ≤ 0.05 mm from the center of a vein. However, it depends on various factors related to the patient. Specifically, it may fail to detect veins in deep parts (more than approximately 10 mm from the body surface), under certain skin conditions, in parts with thick body hair, in wounded sites, in tattooed sites, and under a thick fat layer. Therefore, detecting all superficial veins is impossible. Visualizing the perforating branches of the internal thoracic vein was possible in a thin patient with little subcutaneous fat. However, visualizing the root area was difficult in an obese patient with much subcutaneous fat. The proximity was clearly visualized on the skin even when the root area was not visualized. Therefore, the root area of the perforating branches could be identified by performing ultrasonography in the extended line of the visualized vein.

In principle, ultrasound devices should be used to identify a breast cancer lesion during breast conservation surgery. However, it may be difficult to identify the lesion in the case of non-mass lesions, where the lesion site and range are unclear via ultrasonography or when preoperative drug therapy is performed. This poses a problem in the clinical setting. As a novel approach to resolving the issue of unclear lesion imaging, the clear blood vessel construction of superficial veins around the lesion may serve as a benchmark. Although this approach may not be applied to patients with certain skin conditions or patients with obesity with high fat content, the use of AccuVein® as an auxiliary device is anticipated in future medical practice for identifying breast cancer lesions. As a future direction, it is hoped that a device will be developed that can easily project not only the subcutaneous vein visualization of the breast using AccuVein® but also tumors depicted in MIP images of contrast-enhanced CT onto the skin of the breast.

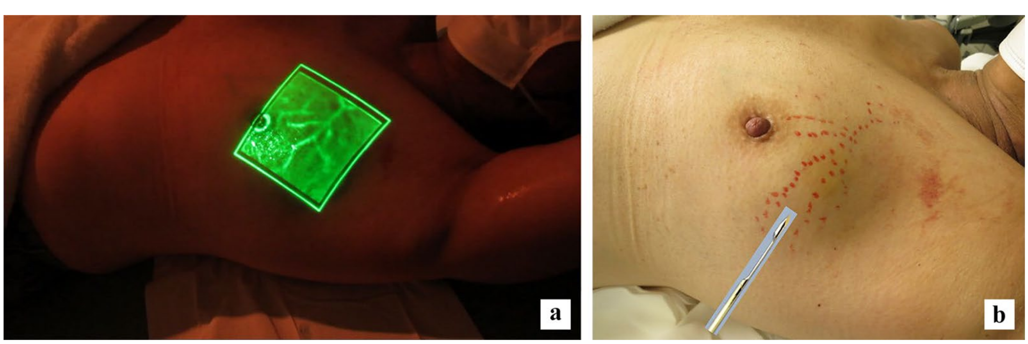

Fig. 5 Detailed visualization of subcutaneous mammary veins and avoidance of vascular damage during tissue biopsy. **a** Prior to tissue biopsy, the mammary subcutaneous veins are visualized using AccuVein®. **b** Visualization of the mammary subcutaneous veins makes it possible to avoid vascular damage caused by the biopsy needle

The vein visualization apparatus AccuVein® can help understand the vascular construction of subcutaneous mammary veins, thereby serving as an auxiliary technique for safely and securely identifying breast cancer lesions.

Abbreviations

BMI	Body mass index
MIP	Maximum intensity projection
CT	Computed tomography
DCIS	Ductal carcinoma in situ

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Author contributions
JS mainly performed surgery and perioperative management of the three cases. JS drafted the manuscript. JS, THS, JY, HF, MT, TN, and MO were involved in the management of the patients. KN provided imaging diagnosis and JI provided pathological diagnosis. All authors read and approved the final manuscript.

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Availability of data and materials
Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Declarations

Ethics approval and consent to participate
All procedures adhered to the Helsinki Declaration of 1964 and later versions. Informed consent was obtained from all patients for being included in the study.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors do not have any competing interests.

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