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Beyond Ultra-high Frequency: Clinical Feasibility of 10–12 MHz and Portable Ultrasound in Lymphatic Imaging

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Summary: Lymphatic ultrasound has recently emerged as a noninvasive, contrast-free modality for evaluating lymphatic vessels, particularly as a preoperative tool for lymphaticovenous anastomosis. Although high-frequency linear probes (18–20 MHz) are commonly used, their availability may be limited, and ultra-high-frequency probes (≥30 MHz) are limited by poor tissue penetration. This study investigated the feasibility of using lower frequency linear probes (10–12 MHz), including a portable 10-MHz device, to visualize lymphatic vessels in patients with extremity lymphedema. A total of 24 limbs from 13 female patients were examined. Dilated lymphatic vessels were first identified using an 18-MHz probe, then reevaluated with either a 12- or 10-MHz probe. Among 44 sites, 86.4% of lymphatic vessels detected with the 18-MHz probe were also visible with lower frequency probes. Identification was more successful in the lower extremities (89.5%) than in the upper extremities (66.7%). Visualization rates were comparable between the 12- (87.0%) and 10-MHz (85.7%) probes. These findings suggest that lower frequency probes, including portable devices, can adequately visualize lymphatic vessels in most cases. This may facilitate wider adoption of lymphatic ultrasound in general clinical settings and resource-limited environments. However, further studies are needed to evaluate their standalone diagnostic performance and ability to assess lymphatic degeneration, and their limitations in de novo identification should also be acknowledged. Addressing these issues may help optimize probe selection and further expand the clinical utility of lymphatic ultrasound. *(Plast Reconstr Surg Glob Open 2025;13:e7357; doi: 10.1097/GOX.0000000000007357; Published online 16 December 2025.)*

INTRODUCTION

Recently, lymphatic ultrasound has emerged as a noninvasive, contrast-free modality for visualizing lymphatic vessels, especially as a preoperative evaluation tool for lymphaticovenous anastomosis (LVA).[1–4] We previously proposed the NECST classification (normal, ectasis, contraction, and sclerosis type) to describe degenerative changes based on intraoperative findings.[5] These morphological patterns can be detected using lymphatic ultrasound, allowing the modality to serve for functional assessment.[6–8]

We usually perform lymphatic ultrasound using high-frequency linear probes, often in the range of 18–20 MHz.[6–8] Some investigators have reported the use of ultra-high-frequency probes (≥30 MHz), which provide superior resolution for visualizing submillimeter structures.[9,10] However, due to the physics of ultrasound attenuation, ultra-high-frequency probes have limited penetration and may fail to visualize lymphatic vessels located deeper than 1 cm beneath the skin surface, especially in lower extremity lymphedema.

In this study, we explored the feasibility of visualizing lymphatic vessels using lower frequency linear probes (10–12 MHz) in both upper and lower limbs affected by lymphedema. The aim of this study was to demonstrate the feasibility of lymphatic vessel detection using lower frequency probes.

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METHOD AND RESULT

We analyzed 24 limbs from 13 female patients with extremity lymphedema who underwent LVA under local anesthesia and provided informed consent. The mean age was 64.2 years (range, 43–82 y), and the mean body mass index was 23.7 kg/m² (range, 19.5–30.9 kg/m²). Eleven patients had lower extremity lymphedema, and 2 had upper extremity lymphedema. The underlying causes were uterine cancer in 11 patients and breast cancer in 2 patients. All patients had undergone lymph node dissection; 8 (61.5%) received chemotherapy, and 6 (46.2%) received radiation therapy. The mean duration of lymphedema was 8.1 years (range, 1–21 y). According to the International Society of Lymphology staging system, 3 limbs were stage I, 3 were stage IIa, 14 were stage IIb, and 4 were stage III.

First, an 18-MHz linear probe (model: L64, Noblus; Fujifilm Healthcare, Tokyo, Japan) was used to identify dilated lymphatic vessels in each lymphosome. Based on the proximity of a suitable recipient vein for LVA, the optimal site for skin incision was selected. At the same site, lymphatic vessels were then examined using a lower frequency linear probe—a 12-MHz probe (Linear 441, Noblus; Fujifilm Healthcare) in 7 patients and a 10-MHz portable probe (Smart eCHO, Viewfii 64; Toray Medical Co., Ltd., Tokyo, Japan) in 6 patients. The images were compared with those obtained using the 18-MHz probe. Lymphatic vessels were differentiated from veins using the D-CUPS (doppler, crossing, uncollapsible, parallel, and superficial fascia) criteria, as previously described.[6–8] Gain was adjusted to allow clear visualization of superficial veins, and imaging depth was set at 2–3 cm. A single focal zone was placed at approximately 1 cm or at the subfascial layer. Because vessel depth varied with body habitus and subcutaneous fat thickness, and image quality was also affected by skin and adipose condition, settings were adjusted for each patient. All examinations were performed by a single operator.

Takeaways

Question: Can lower frequency linear ultrasound probes (10–12 MHz), including portable devices, adequately visualize lymphatic vessels in lymphedematous extremities and serve as practical alternatives to higher frequency probes?

Findings: In 24 limbs from 13 patients with lymphedema, 86.4% of lymphatic vessels identified using an 18-MHz probe were also detected by 12- or 10-MHz probes, with higher success in lower limbs (89.5%) than in upper limbs (66.7%). Lower frequency probes provided sufficient resolution and depth for clinical visualization.

Meaning: Lower frequency probes, including portable devices, can reliably visualize lymphatic vessels, broadening clinical accessibility of lymphatic ultrasound.

Of the 44 lymphatic vessel sites identified with the 18-MHz probe, 38 (86.4%) were also visualized with the lower frequency probes. In all cases, the intraoperative findings confirmed the presence of the lymphatic vessels as identified on preoperative ultrasound. In lower extremities, 34 of 38 sites (89.5%) were identifiable, whereas in upper extremities, 4 of 6 sites (66.7%) were identified. By probe type, 20 of 23 sites (87.0%) were successfully visualized using the 12-MHz probe, and 18 of 21 sites (85.7%) with the 10-MHz portable device.

Figure 1 shows lymphatic ultrasound images of the right lower leg in a 75-year-old patient with secondary lower limb lymphedema, obtained using 18- and 12-MHz probes. (**See Video [online]**, which displays comparison of lymphatic ultrasound using 18-MHz, 12-MHz and portable 10-MHz linear probes.) Figure 2 presents images of the left lower leg in a 69-year-old patient with secondary lower limb lymphedema, captured with an 18-MHz probe and a portable 10-MHz probe. In both cases, the 18-MHz probe provided higher resolution and smoother delineation of lymphatic vessels and veins; however, the lymphatic vessels were also clearly visualized with the 12- and 10-MHz probes.

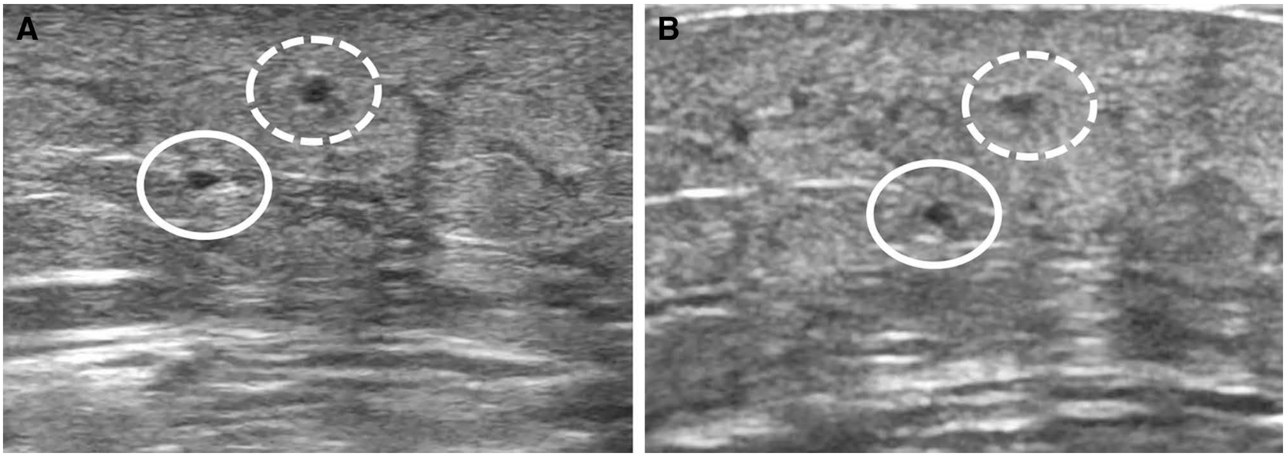

Fig. 1. Lymphatic ultrasound images of the lower leg in a 75-year-old patient with secondary lower limb lymphedema obtained using an 18-MHz (A) and a 12-MHz (B) linear probe; the 18-MHz probe provided higher resolution and smoother delineation of lymphatic vessels and veins, whereas the 12-MHz probe also enabled clear visualization. White circles: lymphatic vessels; white dashed lines: veins.

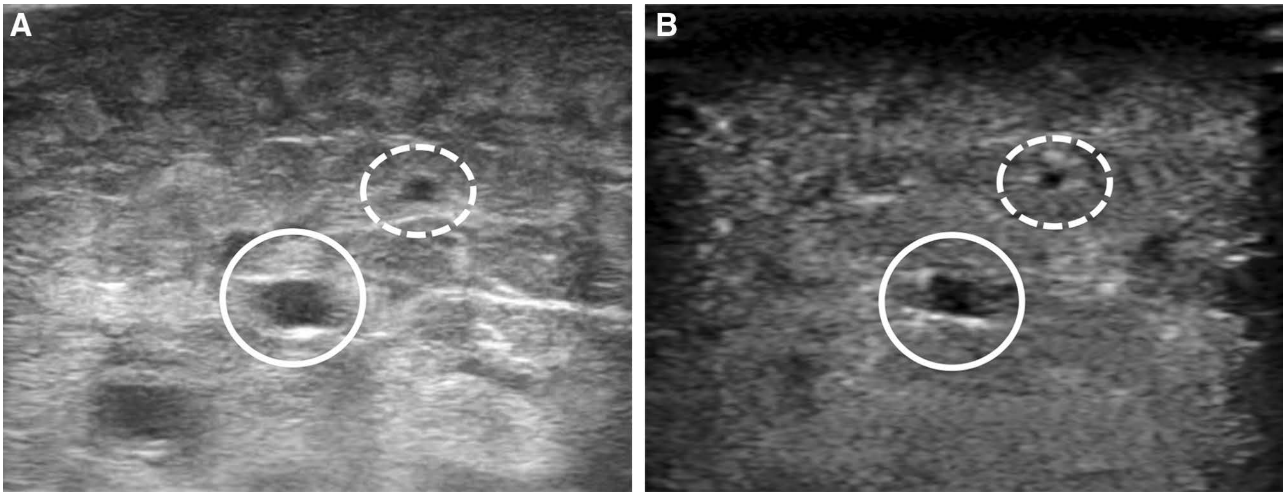

Fig. 2. Lymphatic ultrasound images of the lower leg in a 69-year-old patient with secondary lower limb lymphedema obtained using an 18-MHz (A) and a 10-MHz portable (B) linear probe; the 18-MHz probe provided higher resolution and smoother delineation, whereas the 10-MHz probe produced slightly more image noise or graininess yet still allowed clear visualization of lymphatic vessels. White circles: lymphatic vessels; white dashed lines: veins.

DISCUSSION

In this study, we demonstrated that lymphatic vessels could be visualized in 86.4% of cases using lower frequency linear probes. The identification rate was higher in the lower extremities (89.5%) than in the upper extremities (66.7%). In the upper extremities, lymphatic vessels are often located approximately 5 mm beneath the skin surface. Higher frequency probes are generally more suitable for superficial imaging, making ultra-high-frequency devices (≥30 MHz) potentially advantageous.[10] In contrast, in lower extremity lymphedema, the subcutaneous tissue can be 2–3 cm thick, and lymphatic vessels are often located around 1 cm beneath the skin. In these settings, standard probes in the 10- to 18-MHz range can offer sufficient depth and resolution for clinical use, making them more practical in everyday settings.

Although the 10-MHz probe provides lower resolution than the 12-MHz probe, it still achieved successful visualization of lymphatic vessels in most cases. This suggests that, despite its relative inferiority, the 10-MHz probe remains a practical and accessible option for lymphatic ultrasound, particularly in settings where higher frequency probes are not available. Such devices may be particularly beneficial in resource-limited environments, including home care settings and low- and middle-income countries, because they are relatively low cost. These findings underscore the importance of selecting probes based on anatomical context and clinical objectives.

In this study, the target lymphatic vessels were preidentified using an 18-MHz probe before being reexamined with lower frequency probes. Therefore, the performance of low-frequency probes in detecting lymphatic vessels de novo remains uncertain. Additionally, whether lower frequency probes can accurately classify lymphatic degeneration using the NECST criteria remains to be explored. Future studies are needed to clarify how each type of degenerative lymphatic morphology appears across different probe frequencies.

In conclusion, we found that 10- to 12-MHz probes—including portable devices—can adequately visualize lymphatic vessels in both upper and lower extremity lymphedema. This suggests that lymphatic ultrasound may be feasible even in resource-constrained environments, supporting the need for flexible probe selection tailored to clinical circumstances.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

ETHICAL APPROVAL

This study was approved by the institutional ethics committee (no. R06-10).

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