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Original article

Phlebology

Phlebology
2026, Vol. 0(0) 1–9
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DOI: 10.1177/02683555261475099
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Ultrasound criteria for upper extremity lipedema diagnosis

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Abstract

Lipedema is a chronic progressive disease characterized by disproportionate and symmetric adipose tissue accumulation, predominantly affecting women, with upper extremity involvement (Type IV) in approximately 30% of cases. This study aimed to evaluate ultrasound measurements of subcutaneous tissue thickness in the upper extremities of women with lipedema compared with matched controls and to establish diagnostic cutoff values for this region.

Methods: Cross-sectional case-control study including 102 women (51 with clinically diagnosed lipedema and 51 age- and BMI-matched controls). Bilateral ultrasound measurements were obtained at six standardized anatomical points on the upper extremities, and subcutaneous thickness was measured from the dermal-epidermal junction to the deep fascia. Receiver Operating Characteristic (ROC) curves were used to derive diagnostic cutoff values.

Results: Subcutaneous thickness was significantly greater in the lipedema group at all sites, independent of BMI ($p < .05$). The mid-arm region (10 cm distal to the axillary line) showed the best diagnostic performance (AUC 0.74; sensitivity 82.4%; specificity 51.9%; cutoff >11.4 mm), and four of the six points demonstrated good accuracy (AUC 0.73–0.74).

Conclusion: Ultrasound using standardized anatomical points and defined cutoff values provides good discriminatory capacity for diagnosing upper extremity lipedema and represents an accessible and reproducible adjunct to clinical assessment.

Keywords

lipedema, type IV, ultrasonography, upper extremity, subcutaneous tissue, obesity

Introduction

Lipedema is a chronic progressive disease formally described by Wold et al. in 1951, characterized by disproportionate and symmetric accumulation of adipose tissue predominantly affecting the lower extremities of women.[1] Its prevalence may reach up to 11% of the female population,[2] although the actual number is likely higher due to a high rate of underdiagnosis caused by difficulties in clinical recognition and differentiation from obesity and lymphedema.[3–6]

Beyond its physical impact, lipedema exerts profound psychosocial effects, significantly compromising patients' quality of life. Recent data demonstrate that approximately 40% of women with the disease report depressive symptoms, 28% present emotional lability, and 16% report eating disorders—rates substantially higher than those observed in the general population.[7,8] Persistent pain, functional limitation, and resistance to volume reduction through conventional methods contribute to physical and mental health impairment, underscoring the need for early diagnosis and intervention.[4]

Regarding anatomical distribution, lipedema presents five distinct patterns, with approximately 30% of patients also manifesting upper extremity involvement (Type IV).[1,4,9] Despite this, there remains a scarcity of studies dedicated to systematic and standardized assessment of upper extremity lipedema, a region that can present classic symptoms similar to those observed in lower extremities,

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such as pain, spontaneous ecchymosis, and bilateral symmetric fat accumulation sparing the hands.[10,11]

Currently, ultrasonography has emerged as an accessible, cost-effective, and valuable diagnostic tool. The method allows differentiation of specific alterations in lipedematous subcutaneous tissue from other disorders such as lymphedema and can be employed even in patients with severe obesity, extending its utility to populations frequently excluded from advanced imaging modalities such as computed tomography and magnetic resonance imaging.[12–15]

Despite advances in research, there remains a scarcity of studies specifically addressing upper extremity involvement and standardized imaging criteria for lipedema diagnosis in this territory. Systematic utilization of ultrasonography in this segment may enhance disease recognition and provide more reproducible parameters for clinical practice. This study seeks to address this gap by evaluating ultrasound measurements of subcutaneous tissue thickness that are clinically elevated and compatible with lipedema in the arms and forearms, with the aim of proposing cutoff values that assist in screening and diagnosis of upper extremity lipedema.

Objective

To evaluate, through ultrasonography, the subcutaneous tissue thickness in the arms and forearms of women with lipedema compared to control subjects, and to investigate its association with morphological alterations characteristic of the disease, such as disorganization of connective tissue fibers and signs of increased microcirculation, aiming to propose standardized assessment parameters for the upper extremities.

Methods

Study design and patient recruitment

This study was conducted as a cross-sectional observational case-control analysis involving 102 women, of whom 51 presented with clinical diagnosis of lipedema in the upper extremities and 51 were controls. Recruitment was performed between January and June 2025 in medical consultations conducted by plastic surgeons, angiologists, and vascular surgeons in Brazil. The inclusion of a control group aimed to increase the specificity and sensitivity of findings, allowing comparison of alterations observed in lipedema patients relative to a similar healthy population.

Sample size was estimated based on statistical analysis using a case-control model (1:1 ratio), considering an exposure prevalence of 70% in the case group, a minimum odds ratio of 5.4, a confidence level of 99%, and statistical power of 95%. These parameters determined a minimum requirement of 51 participants in each group (lipedema and control). The control group was matched by age range and was selected at random.

The research protocol adhered to the principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of the Center for Health Sciences of the Federal University of Espírito Santo (CCS/UFES) under protocol number 85778424500005060. All participants received detailed information about the study's objectives and procedures, and written informed consent was obtained before inclusion.

Collection of demographic and clinical data

At the time of inclusion, all participants underwent detailed clinical evaluation, with recording of age, weight, height, body mass index (BMI), number of pregnancies, family history of lipedema, and presence of clinical symptoms associated with the disease (edema, pain and hematomas).

Patients were initially evaluated and classified as lipedema or control by plastic surgeons with extensive clinical experience in lipedema, who established the reference clinical diagnosis. This classification was subsequently reviewed and confirmed during the ultrasound assessment by the vascular specialists performing the scans, who were board-certified and accredited by the Brazilian Society of Angiology and Vascular Surgery (SBACV) and the Brazilian College of Radiology and Diagnostic Imaging (CBR).

Imaging protocol

Ultrasound examinations were performed using Philips EPIQ Elite (Philips Healthcare) with a 3–12 MHz linear transducer and GE LOGIQ P7 (GE Healthcare) with a 9 MHz linear transducer. The cohort was prospectively divided between two examiners, and each participant was scanned by a single operator.

To ensure maximum technical alignment and minimize operator-dependent variability before participant enrollment, both examiners conducted collaborative workflow meetings and hands-on calibration sessions. During these meetings, the scanning protocol was thoroughly standardized, focusing on accurate transducer positioning and caliper placement, as well as uniform application techniques to prevent compressing the subcutaneous tissue.

To reduce potential inter-machine variability, technical parameters were standardized across devices, including overall gain, imaging depth, and focal zone position. Both systems used linear transducers within a conventional frequency range for musculoskeletal and subcutaneous tissue assessment, and all measurements were obtained using fixed anatomical landmarks and objective linear distances, in order to enhance reproducibility across different ultrasound devices and operators.

Patients were seated with the upper extremity relaxed and positioned on the lap or elevated to 90°, standardizing tissue tension during each scan.

To ensure precise identification of anatomical interfaces during ultrasonographic assessment, we first referenced the normal anatomical layers of the skin and subcutaneous tissue (Figure 1). This baseline diagram guided accurate localization of the dermal-epidermal junction, superficial fascia, deep fascia, and muscle for all measurements performed in the study.

Subcutaneous thickness measurements were performed perpendicular to the skin surface, from the dermal-epidermal junction to the deep (muscular) fascia, applying only the minimum pressure necessary to maintain acoustic contact and avoid tissue compression. The digital caliper function of the equipment was utilized, with fine adjustments to gain and depth for optimal delineation of anatomical interfaces (Figure 2).

Six standardized measurement points were established on each upper extremity (Figure 3):

Point 1 (P1): Dorsal forearm, 6 cm proximal to the ulnar styloid process.

Point 2 (P2): Dorsal forearm, 6 cm distal to the elbow.

Point 3 (P3): Posterior arm, 10 cm proximal to the olecranon.

Point 4 (P4): Posterior mid-arm, 10 cm distal to the posterior axillary line.

Point 5 (P5): Posterior arm, 6 cm distal to the posterior axillary line.

Point 6 (P6): Anterior arm, 6 cm distal to the anterior axillary line.

Selection of these locations was based on ease of anatomical identification, bilateral symmetry, and clinical relevance for assessment of regions most frequently affected by lipedema. These points were defined by consensus of the research group, considering accumulated clinical experience and areas of greatest involvement observed in practice.[16–18]

In addition to subcutaneous thickness, qualitative alterations were recorded when present, including nodules, disorganization of connective tissue fibers, and heterogeneous patterns of dermis and hypodermis suggestive of the disease.

Statistical analysis

Analyses were conducted using IBM SPSS Statistics, version 24.0 (IBM Corp., Armonk, NY, USA) and MedCalc, version 19.4.1 (MedCalc Software Ltd, Ostend, Belgium). Data distribution was assessed using the Shapiro–Wilk test.

Comparisons between lipedema and control groups, as well as between right and left upper extremities, were performed using Student's t-test, applying the model for independent or paired samples as appropriate for each analysis.

Diagnostic accuracy of ultrasound measurements was determined using the Receiver Operating Characteristic (ROC) curve, which evaluated the discriminatory capacity of variables in correctly identifying individuals with and without lipedema. Sensitivity and specificity were calculated, and interpretation of the area under the curve (AUC) followed the criteria of Hosmer and Lemeshow (2000): excellent (0.9–1.0), very good (0.8–0.9), good (0.7–0.8), poor (0.5–0.6), and not applicable (<0.5).

A significance level of 5% ($p < .05$) was adopted for all analyses. Missing data affected self-reported clinical variables (bruising, edema, pain, family history of lipedema) in 4.9–39.2% of cases (Table 1) and were handled using complete-case analysis; ultrasound measurements were complete across all participants.

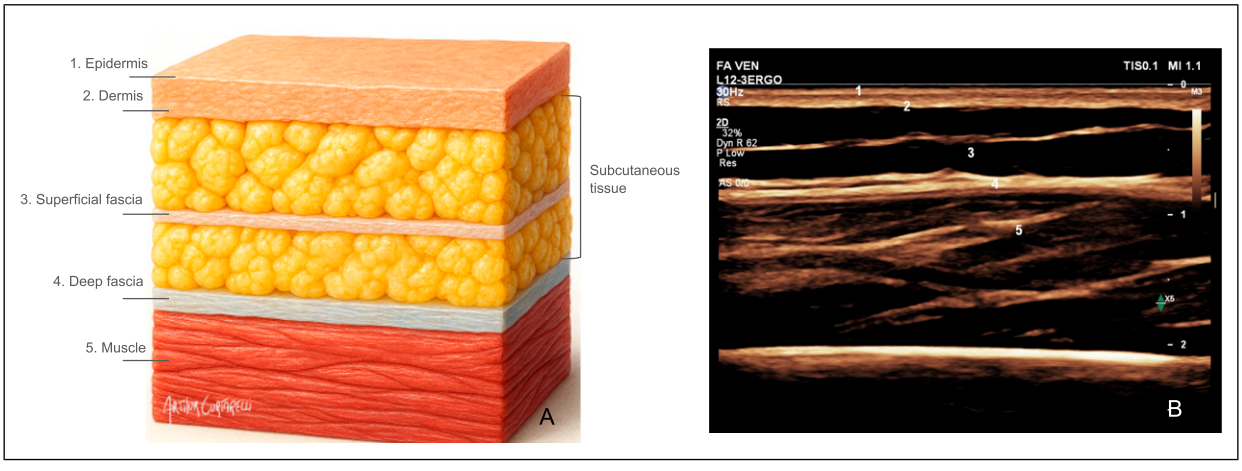

Figure 1. Anatomical layers of normal skin — (a) Schematic diagram; (b) Longitudinal B-mode ultrasound section on the dorsal aspect of the arm, shown from top to bottom: 1. epidermis, 2. dermis, 3. superficial fascia, 4. deep fascia, 5. muscle. Note that the superficial fascia is thin and highly echogenic, while the deep fascia is thicker.

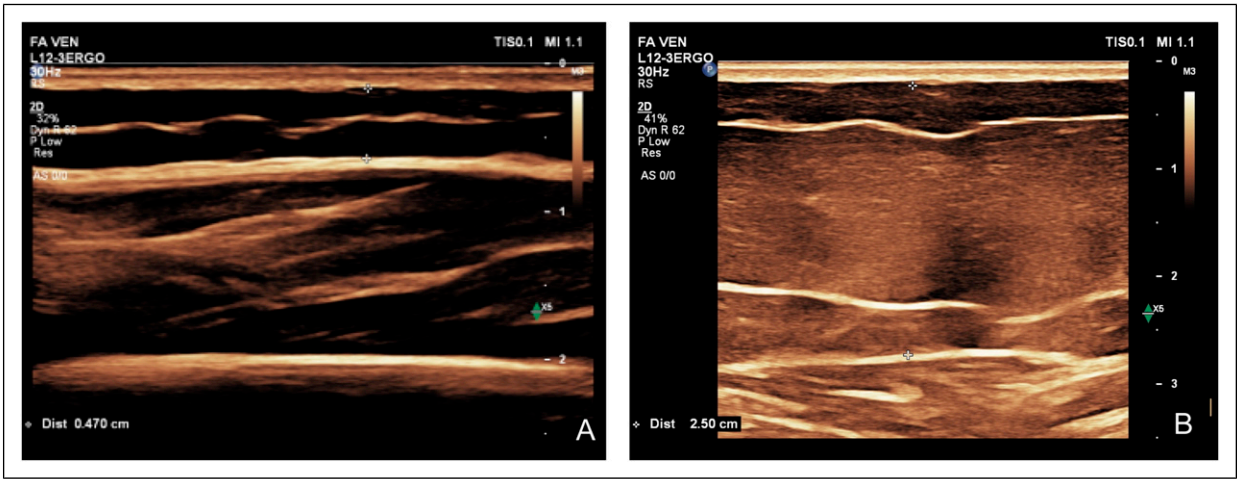

Figure 2. Subcutaneous thickness measurement technique: (a) B-mode ultrasound image demonstrates subcutaneous thickness measurement from the lower dermal border to the deep fascia (transition structure with musculature) in a control patient; (b) Subcutaneous tissue measurement in a patient with lipedema.

Results

A total of 102 women were evaluated, equally distributed between lipedema (n = 51) and controls (n = 51). Groups presented similar anthropometric profiles with no significant differences in age, height, or distribution of BMI categories ($p > .05$). In contrast, clinical findings typical of the disease were markedly more frequent in the lipedema group: recurrent hematomas (58.8% vs 23.5%), edema (56.9% vs 13.7%), and pain (66.7% vs 15.7%), all with

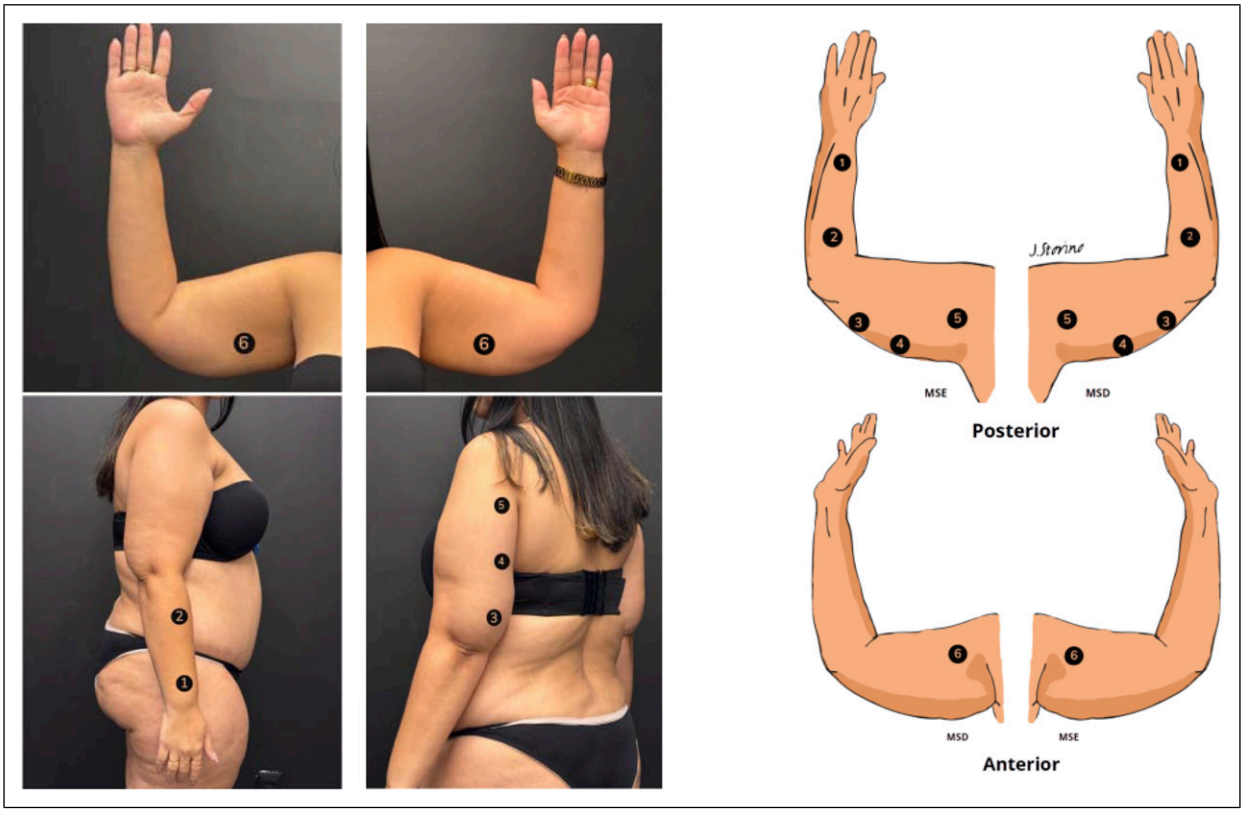

Figure 3. Ultrasound measurement points: P1 dorsal forearm (6 cm proximal ulnar styloid); P2 dorsal forearm (6 cm distal elbow); P3 posterior arm (10 cm proximal olecranon); P4 posterior mid-arm (10 cm distal posterior axillary line); P5 posterior arm (6 cm distal posterior axillary line); P6 anterior arm (6 cm distal anterior axillary line).

Table 1. Demographic and clinical characteristics of participants with lipedema and controls.

Variável	Control (n 51)	Lipedema (n 51)	p-value*
Age (years)	42.5 (23.0–69.0)	41.5 (23.0–64.0)	0.985*
Height (m)	1.60 (1.48–1.77)	1.64 (1.53–1.80)	0.126*
Pregnancies (n)	2 (1–10)	2 (1–4)	0.945*
BMI (n%)			
<18.5 kg/m^2	1 (1.96%)	0 (0%)	0.398**
18.6 - 24.9 kg/m^2	25 (49.02%)	17 (33.33%)	
25 - 29.9 kg/m^2	15 (29.41%)	15 (29.41%)	
>30 kg/m^2	10 (19.61%)	14 (27.45%)	
Missing Information	0 (0%)	5 (9.80%)	
Recurrent bruising (n%)			
No	37 (72.55%)	11 (21.57%)	<0.001**
Yes	12 (23.53%)	30 (58.82%)	
Missing Information	2 (3.92%)	10 (19.61%)	
Edema (n%)			
No	42 (82.35%)	11 (21.57%)	<0.001**
Yes	7 (13.73%)	29 (56.86%)	
Missing Information	2 (3.92%)	11 (21.57%)	
Pain (n%)			
No	41 (80.39%)	8 (15.69%)	<0.001**
Yes	8 (15.69%)	34 (66.67%)	
Missing Information	2 (3.92%)	9 (17.65%)	
Family history of lipedema (n%)			
No	23 (45.10%)	3 (5.88%)	<0.001**
Yes	1 (1.96%)	23 (45.10%)	
Unknown	3 (5.88%)	9 (17.65%)	
Missing Information	24 (47.06%)	16 (31.37%)	

*Mann–Whitney test; ** Pearson's chi-square test or Fisher's exact test; significant if p ≤ .050.
Quantitative variables: median (minimum–maximum).

p < .001. Positive family history was also much more prevalent among lipedema patients (45.1% vs 1.96%; p < .001). Thus, although physically similar, the groups demonstrated differences in clinical phenotype, reinforcing sample validity (Table 1).

In the global analysis, all ultrasound measurements differed significantly between lipedema and control groups, with greater subcutaneous thickness in all regions evaluated in the lipedema group (Table 2). This pattern was maintained in women with BMI <30, in whom all regions showed statistically significant differences. In the group with BMI ≥30, differences were also significant at most sites, except in the anterior arm where no distinction was observed between groups.

Bilateral evaluation of subcutaneous measurements demonstrated symmetry between right and left sides in both groups, with differences within expected variability at most evaluated points (Table 3). In the lipedema group, only two sites showed statistically significant difference between sides—distal dorsal forearm (P1; p = .041) and mid-arm region (P4; p = .018)—although the magnitude of these variations was small and lacked clinical relevance. In the control group, only the mid-arm region showed difference between sides (P4; p = .034).

Analysis of ROC (Receiver Operating Characteristic) curves for the six standardized points (Table 4) identified cutoff values with good clinical applicability. Cutoff values prioritized sensitivity for screening, accepting moderate specificity (~50%). In our study, subcutaneous thickness measurements showed symmetric bilaterality between upper limbs, indicating that small side-to-side variations did not change the diagnostic pattern. Among the regions evaluated, the mid-arm region (P4) demonstrated the best overall performance (AUC 0.74) with a cutoff value of >11.4 mm, followed by the distal dorsal forearm (P1) (>2.5 mm), the distal posterior arm (P3) (>8.7 mm), and Point 2, proximal dorsal forearm (>3.7 mm), all with AUC between 0.73 and 0.74. Measurements at the proximal posterior and anterior arm (P5 and P6) demonstrated lower diagnostic accuracy compared with the other assessed sites.

In addition to increased subcutaneous tissue thickness, ultrasonography revealed morphological alterations characteristic of lipedema. Disorganization of connective tissue fibers, septal disruption, and hyperechoic nodular areas were observed, resulting in heterogeneous echotexture

Table 2. Subcutaneous thickness in lipedema vs. controls.

Grupo	Region	Control (mm)	Lipedema (mm)	p-value*
Total sample	P1 Distal dorsal forearm	2.91 (±1.25)	5.23 (±3.64)	<0.001
	P2 Proximal dorsal forearm	3.86 (±1.36)	6.27 (±3.50)	<0.001
	P3 Distal posterior arm	9.66 (±4.53)	17.60 (±11.15)	<0.001
	P4 Mid posterior arm	11.82 (±4.84)	18.59 (±10.03)	<0.001
	P5 Proximal posterior arm	10.06 (±3.97)	15.72 (±8.97)	<0.001
	P6 Anterior arm	7.09 (±3.99)	9.99 (±6.29)	0.007
BMI <30	P1 Distal dorsal forearm	2.62 (±1.14)	4.43 (±3.40)	0.006
	P2 Proximal dorsal forearm	3.65 (±1.33)	4.73 (±1.65)	0.004
	P3 Distal posterior arm	8.43 (±3.01)	12.90 (±6.16)	<0.001
	P4 Mid posterior arm	10.59 (±3.65)	14.73 (±5.94)	0.001
	P5 Proximal posterior arm	9.24 (±3.10)	12.61 (±5.69)	0.004
	P6 Anterior arm	5.92 (±2.99)	7.71 (±4.07)	0.034
BMI ≥30	P1 Distal dorsal forearm	4.09 (±0,98)	6.41 (±3.27)	0.024
	P2 Proximal dorsal forearm	4.73 (±1.15)	10.11 (±4.20)	0.003
	P3 Distal posterior arm	14.72 (±6.20)	28.31 (±14.20)	0.005
	P4 Mid posterior arm	16.85 (±5.99)	28.47 (±12.49)	0.013
	P5 Proximal posterior arm	13.41 (±5.41)	25.11 (±9.76)	0.002
	P6 Anterior arm	11.87 (±4.14)	15.15 (±8.27)	0.263

*Student's t-test for independent samples; significant if p ≤ .050. Quantitative variable: mean ± standard deviation.

situated between the echogenicity of the dermis and musculature (Figure 4). In contrast, reference images of normal tissue demonstrated sharp anatomical interfaces, continuous linear fasciae, and absence of irregular adipose accumulation (Figure 4). Assessment with high-sensitivity Doppler (Microflow Imaging) identified increased microvascularization in lipedematous subcutaneous tissue, not detectable on conventional color Doppler (Figure 5).[19–22] Spectral analysis demonstrated a low-resistance arterial flow pattern (resistance index: 0.61).

Discussion

Lipedema diagnosis remains a clinical challenge, frequently delayed by overlap with obesity, lipohypertrophy, lymphedema, phlebolymphedema, and other disorders causing limb volume increase. The absence of consensus imaging methods contributes additionally to underdiagnosis. Studies of lower extremities have demonstrated that Doppler ultrasonography can assist in differentiating lipedema from other conditions, particularly through analysis of subcutaneous tissue thickness and echotexture. The findings of this study extend this evidence to the upper extremities, a region still underexplored despite involvement in up to 30% of patients.

Selection of the six standardized anatomical points was based on clinical relevance, reproducibility, and correspondence with regions most frequently affected and symptomatic in upper extremity lipedema. These sites also coincide with regions commonly addressed in aesthetic and surgical procedures, reinforcing their practical applicability and potential for protocol integration into clinical routine.

Subcutaneous thickness proved significantly greater in lipedema across all evaluated regions regardless of BMI, findings consistent with lower extremity studies.[12–22] This reinforces that observed alterations do not result solely from excess weight but reflect a disease-specific tissue phenotype. Bilateral evaluation revealed symmetric subcutaneous thickness in both groups, with only small side-to-side variations that did not change the diagnostic pattern. This

Table 3. Comparison of subcutaneous measurements between right and left sides in each group.

	Lipedema (mm)			Control (mm)		
Region	Right	Left	p-value*	Right	Left	p-value*
P1 Distal dorsal forearm	4.57 ± 3.14	5.83 ± 5.08	0.041	2.92 ± 1.36	2.84 ± 1.27	0.430
P2 Proximal dorsal forearm	6.24 ± 3.65	6.16 ± 3.41	0.865	3.88 ± 1.30	3.78 ± 1.22	0.058
P3 Distal posterior arm	17.37 ± 11.35	17.77 ± 11.25	0.429	9.57 ± 4.59	9.72 ± 4.61	0.501
P4 Mid posterior arm	18.02 ± 10.00	19.10 ± 10.29	0.018	11.56 ± 5.00	12.03 ± 4.80	0.034
P5 Proximal posterior arm	15.54 ± 8.76	15.84 ± 9.50	0.533	9.89 ± 3.94	10.18 ± 4.28	0.354
P6 Anterior arm	9.77 ± 6.09	10.17 ± 6.78	0.304	6.96 ± 4.05	7.17 ± 4.03	0.267

*Student's t-test for paired samples; significant if p ≤ .050. Quantitative variable: mean ± standard deviation.

Table 4. ROC curve results for determining diagnostic cutoff points.

Subcutaneous thickness	Classification	AUC (95%CI)	p-value	Sensitivity (95%CI)	Specificity (95%CI)	Cutoff
P1 Distal dorsal forearm	Good	0.74 (0.65–0.84)	<0.001	82.4 (69.1–91.6)	49.0 (34.8–63.4)	>2.5
P2 Proximal dorsal forearm	Good	0.73 (0.63–0.83)	<0.001	81.4 (66.6–91.6)	50.9 (36.6–65.2)	>3.7
P3 Distal posterior arm	Good	0.74 (0.64–0.84)	<0.001	80.4 (66.9–90.2)	49.1 (34.5–65.2)	>8.7
P4 Mid posterior arm	Good	0.74 (0.64–0.84)	<0.001	82.4 (70.1–92.0)	51.9 (40.3–68.9)	>11.4
P5 Proximal posterior arm	Poor	0.69 (0.59–0.79)	<0.001	80.1 (66.2–91.2)	39.2 (25.8–53.9)	>8.5
P6 Anterior arm	Poor	0.66 (0.55–0.77)	0.003	88.2 (76.1–91.6)	43.1 (29.3–57.8)	>4.9

AUC: area under the curve; 95% CI: 95% confidence interval; significant if p ≤ .050.

pattern of symmetry is consistent with ultrasound findings previously reported in the lower limbs by Amato et al., who also demonstrated that bilateral involvement allows the use of unified cutoff values for clinical application.

Analysis of ROC curves demonstrated good accuracy at four of six points (AUC 0.73–0.74), particularly the mid-arm region. These cutoffs, which prioritized high sensitivity (80–88%) while accepting a moderate specificity (~40–52%), provide valuable objective parameters when combined with clinical assessment. Consequently, these ultrasound parameters should not be interpreted as standalone, definitive diagnostic criteria. Instead, given their high sensitivity, they are particularly valuable as screening tools and adjunctive parameters within a broader multimodal clinical assessment. In clinical practice, integrating these objective tissue measurements with detailed anamnesis and physical examination can significantly enhance diagnostic confidence, preventing underdiagnosis in populations where upper limb involvement is frequently overlooked. This clinical utility is further supported by morphological and microcirculatory findings, which complement thickness measurements and reinforce the characteristic lipedema phenotype.[19–25] Previous studies have shown that increased subcutaneous vascularization, uncommon in individuals without lipedema, is associated with low-resistance arterial flow patterns (RI <0.7), suggesting underlying neovascularization and inflammatory activity.[26]

In clinical practice, ultrasound evaluation should prioritize the four high-performing sites (P1–P4). Proximal anterior and posterior arm sites (P5, P6) with lower accuracy are best reserved as complementary parameters for monitoring progression or treatment response, consistent

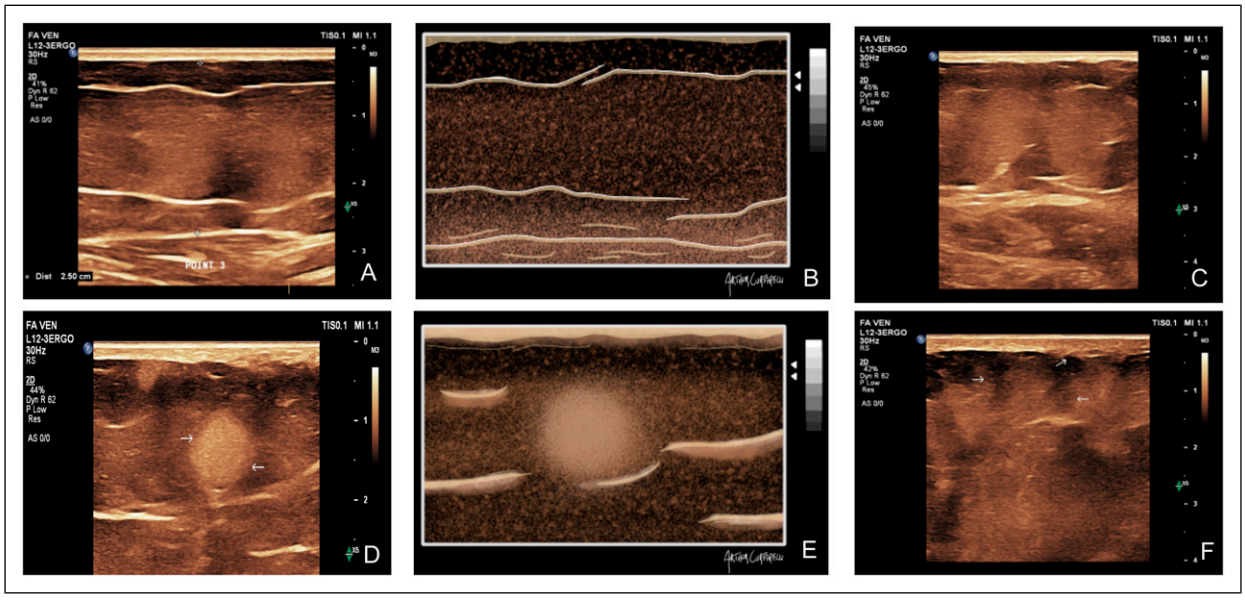

Figure 4. B-mode ultrasound findings in lipedema of the arm: (a) Increased subcutaneous thickness. Note the fat deposition increasing the subcutaneous layer; (b) Schematic diagram illustrating increased subcutaneous thickness; (c) Disorganization of connective tissue fibers with rupture and loss of connective structures due to fat accumulation. The hypodermis (subcutaneous tissue) presents a homogeneous texture, with lower echogenicity than the dermis and similar or higher than muscle, along with a poorly defined nodular appearance; (d) Nodules which may be presente (arrows), but are not pathognomonic of lipedema; (e) Schematic diagram illustrating diffuse nodular image with rupture of connective tissue fibers; (f) More advanced stages showing connective tissue disorganization associated with dermal irregularity and consequent attenuation artifacts (arrows).

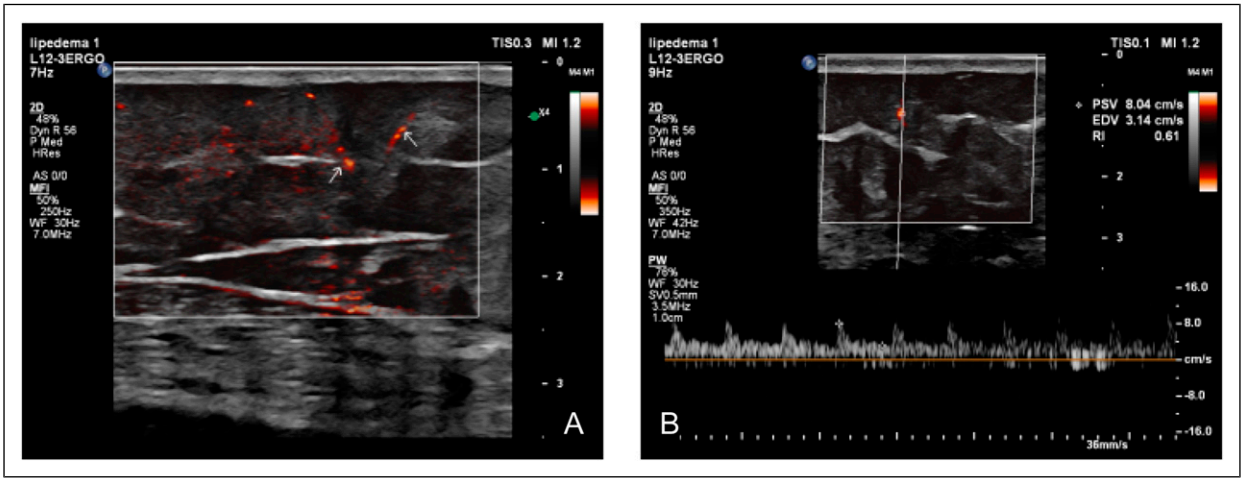

Figure 5. Vascularization: (a). Mapping with Micro Flow Imaging (MFI) demonstrates vascularization in the subcutaneous tissue surrounding connective tissue fibers. (b). Spectral analysis shows a low-resistance blood flow.

with progressive subcutaneous thickening in advancing lipedema.[18]

This study presents limitations, including its cross-sectional design, which does not allow evaluation of evolutionary changes or therapeutic response, and the operator-dependent nature of ultrasonography—although anatomical points and technical parameters were rigorously standardized. Given the limited evidence on upper limb lipedema, further studies are needed to better define disease progression and staging, and to explore the relationship between imaging findings and clinical presentation in this anatomical region. Future multicenter studies incorporating elastography, advanced microvascular analysis, and three-dimensional techniques may complement these findings and deepen understanding of lipedema pathophysiology and progression.

Collectively, these results reinforce the potential of ultrasonography as an accessible, reproducible, and useful tool in upper extremity lipedema evaluation, particularly when integrated with morphological tissue analysis and systematized clinical assessment.[27,28]

Conclusion

Doppler ultrasonography is a reliable and reproducible diagnostic imaging method which has proven to be a valuable adjunctive screening tool that supports clinical diagnosis and enhances the differentiation of patients with and without lipedema in the upper extremities.

Acknowledgements

The authors would like to thank all patients who kindly participated in this study, sharing their personal experiences and making this research possible. The authors also thank Arthur Curtarelli, vascular surgeon, for illustrations that enhanced the ultrasound findings.

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Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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