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The Challenge of a Qualitative Ultrasonographic Classification in Lipedema

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ABSTRACT

Lipedema is characterized by fat accumulation in the limbs, sparing the trunk, hands, and feet. Its etiology remains uncertain, but may be related to genetic and female hormones. Several theories suggest an association with chronic inflammation and fibrosis. Pain, spontaneous bruising, and increased diameter of the affected areas are the most frequent signs and symptoms. Diagnosis is primarily clinical, but frequently supported by imaging techniques, including ultrasound, magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DEXA), and lymphoscintigraphy to differentiate lipedema from other similar conditions. This study retrospectively analyzed ultrasonographic images of 34 female patients, clinically diagnosed with lipedema and correlated structural patterns with different stages of inflammation and fibrosis in the dermis and subcutaneous tissue. The images were obtained in 2024 using high-frequency linear transducers (12 - 15 MHz). The findings enabled the identification of potentially characteristic changes for the development of a classification that may assist in diagnosis, treatment, and monitoring of this condition. However, while ultrasonography has already been incorporated into routine medical practice to investigate lipedema, prospective and comparative multicenter studies that correlate ultrasound findings with the clinical stage of the disease are necessary to validate the applicability of this approach.

1. INTRODUCTION

Lipedema is a chronic condition affecting approximately 12.3% of women in Brazil [1], clinically characterized by symmetrical fat accumulation in the arms and legs, sparing trunk, hands, and feet. Symptoms

include persistent evening pain, heightened sensitivity to touch, easy and spontaneous bruising, a lack of response to weight loss interventions, and painful edema that does not improve with limb elevation (Trendelenburg position) [2]. In contrast to lymphedema, which is a disorder of the lymphatic system, lipedema does not present with pitting edema in its early stages, nor does it show a positive Stemmer's sign.

The exact pathophysiology remains uncertain, though genetic and hormonal factors have been proposed as potential contributors [2, 3]. Obesity, while not considered a direct cause, must be carefully differentiated from lipedema to avoid diagnostic confusion. Clinical parameters, including body mass index (BMI), abdominal circumference, and impedance, are commonly employed to facilitate accurate differentiation [4, 5]. Due to significant overlap with symptoms of lymphedema, accurate clinical diagnosis of lipedema can be challenging.

Accurate differentiation between lipedema and lymphedema is essential for effective patient management. This distinction relies primarily on clinical history and detailed physical examination assessing specific signs. Lymphedema typically presents with painless edema, a positive Stemmer's sign (inability to pinch the skin at the base of second toe or finger), and a positive Godet's sign (persistent indentation upon skin compression). Additionally, lymphoscintigraphy in lymphedema demonstrates altered lymphatic flow, such as reduced or obstructed transport [4, 6].

Existing classifications of lipedema are primarily based on anatomical distribution (**Figure 1**) [2, 6, 7] or functional staging (**Table 1**) [2, 3, 8]. However, these approaches do not sufficiently account for other relevant factors such as disease severity, degree of inflammation, and extent of fibrosis, thus limiting their effectiveness in guiding clinical management. Given these limitations, recent research has aimed at developing a classification system that integrates ultrasonographic findings with clinical features, potentially improving diagnostic accuracy and interobserver reproducibility in the evaluation of lipedema.

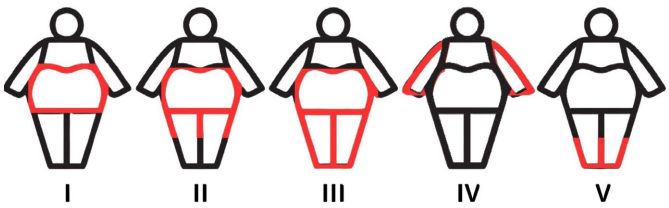


Figure 1. Anatomical Classification of Lipedema: Type I affects only the hips; Type II involves the hips and thighs; Type III involves the hips, thighs, and calves; Type IV extends to the arms up to the wrists; and Type V affects only the calves.

Table 1. Functional classification of lipedema (adapted), based on clinical signs involving the skin, subcutaneous tissue, and lymphatic involvement.

	Stage 1	Stage 2	Stage 3	Stage 4
Skin	Smooth	Irregular	Folds	Folds
Subcutaneous tissue	Increased	Increased, Nodules	Increased, Nodules, Fibrosis	Increased, Nodules, Fibrosis
Lymphatic involvement	Absent	Absent	Absent	Present

Source: Adapted from Herbst, 2012.

This work proposes a new ultrasonographic classification for lipedema that describes radiological findings based on structural changes in dermis and hypodermis.

2. MATERIALS AND METHODS

Ultrasound images of the dermis and hypodermis from 34 female patients, 20 - 47 years old, forwarded for evaluation of lipedema, were retrospectively analyzed. Examinations were performed in 2024, utilizing the ultrasonographic technique described by Amato *et al.* [9] (Table 2). The study was approved by our institutional review board, and all patients gave informed consent. Patients diagnosed with lipedema who presented concomitant obesity were excluded from this analysis. Imaging was performed using high-frequency linear transducers (10 - 15 MHz) on GE Logiq S8, Philips Affiniti 70, and Samsung V6 systems in B-mode, with a minimum depth of four centimeters, in a limb longitudinal orientation, emphasizing the medial proximal leg, lateral mid-proximal thigh and posterior distal thigh.

Table 2. Reference values for the diagnosis of lipedema.

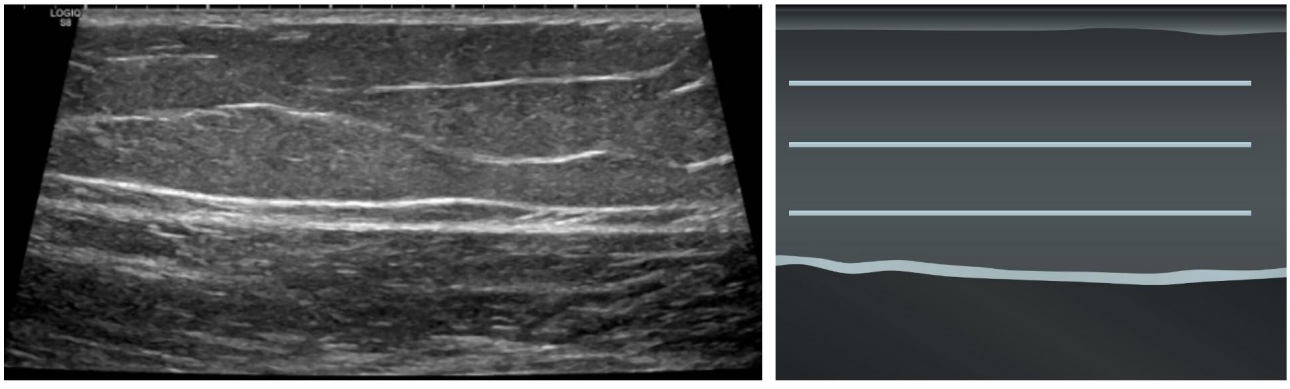
TOPOGRAPHY	THICKNESS (mm)
Pretibial (middle)	Greater than 11.7
Anterior thigh (mid-distal)	Greater than 17.9
Lateral leg (mid-proximal)	Greater than 8.4
Medial leg (supramalleolar)	Greater than 7.0

Source: Amato *et al.* 2021 [9].

A qualitative analysis was conducted to identify morphological changes in the dermis and hypodermis. These patterns were subsequently used to develop a classification system, correlating structural findings with possible disease progression.

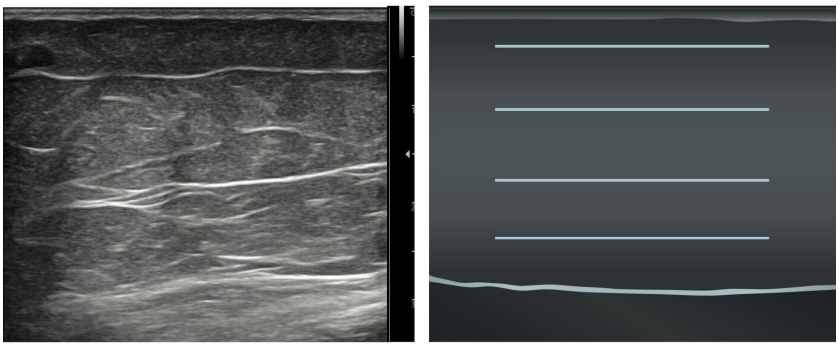
3. RESULTS: FINDINGS AND CLASSIFICATION

Qualitative analysis first characterized the normal ultrasonographic appearance of the dermis and hypodermis, identified as "layered hypodermis pattern", defined by linear hyperechoic septa, regularly interspersed within the subcutaneous tissue (Figure 2). Ultrasonographic images from obese patients, without lipedema, demonstrated thickening of the subcutaneous tissue (SCT), predominantly within the deep hypodermis, while maintaining preserved linear septa and a layered architecture (Figure 3).



(a) (b)

Figure 2. (a) Ultrasonographic image of the medial aspect of the proximal leg, B-mode, showing the usual "layered hypodermis pattern"; (b) Schematic image of the "layered hypodermis pattern".

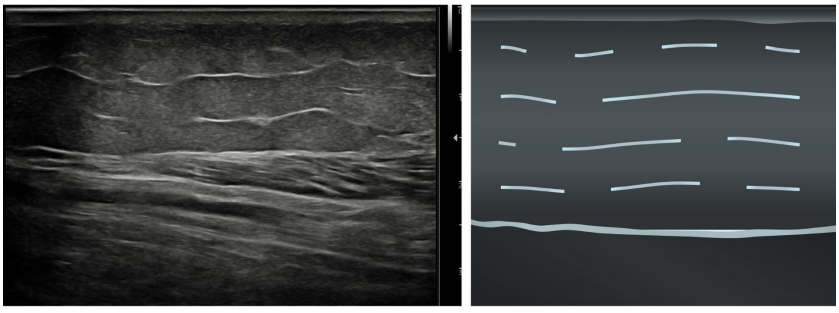


(a) (b)

Figure 3. (a) B-mode ultrasonographic image of the medial aspect of the proximal leg in a patient with obesity (BMI above 30), showing an increased hypodermis, primarily due to thickening in the deep layer compared to the superficial layer. The septa are preserved, horizontal, and linear, resembling "layered hypodermis pattern", indicating maintenance of typical architecture despite the increased thickness. (b) Schematic image representation of the "layered hypodermis pattern" in obese patient.

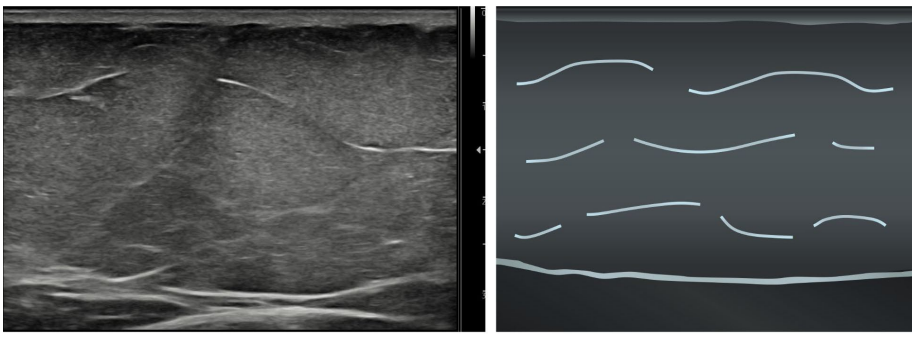
Subsequent analysis of patients with lipedema revealed four distinct ultrasonographic patterns in the dermis and hypodermis. These observed patterns were organized into the Lipedema Dermal and Hypodermal Classification (LDHC), subdivided into LDHC 1 - 4. Hypodermal findings included the evaluation of septa and hyperechoic nodules, whereas dermal assessment primarily focused on the dermis-hypodermis junction and dermis thickening.

The LDHC classifications are based on distinct ultrasonographic findings that describe varying degrees of tissue disruption. LDHC 1 shows a preserved architecture with linear, thin septa and no hyperechoic nodules, indicating minimal disruption (**Figure 4**). In LDHC 2, the architecture appears bulging with irregular septa and around 50% disruption, but hyperechoic nodules remain absent (**Figure 5**). LDHC 3 presents with a bulging deep hypodermis and disorganized superficial hypodermis, irregular septa, and the presence of hyperechoic nodules, along with asymmetric thickening of the dermis and an irregular dermis-hypodermis junction (**Figure 6**). LDHC 4 displays a "marbled" pattern with more than 50% disruption of the septa, branching and verticalization, and asymmetric dermal thickening. Further, hyperechoic nodules are absent, and the dermis-hypodermis junction presents a "serrated" pattern (**Figure 7**). These classifications reflect a spectrum of increasing disruption and structural disorganization in the tissue.



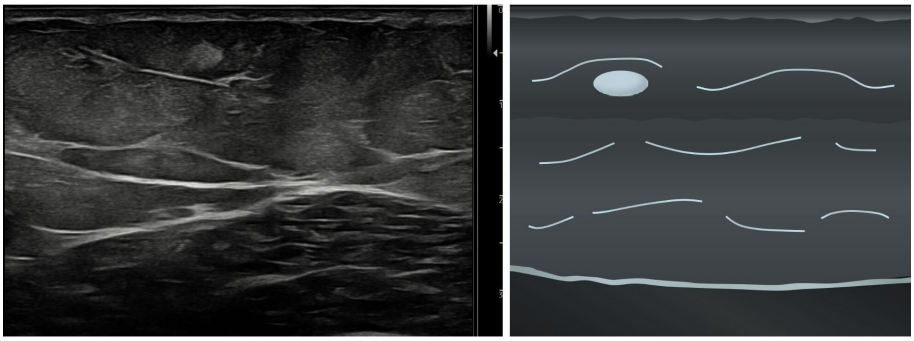
(a) (b)

Figure 4. LDHC 1. (a) Ultrasonographic image of the medial aspect of the proximal leg demonstrating the following features: Architecture: preserved; Septa: linear and thin, with less than 50% disruption; Hyperechoic nodules: absent; Dermis: preserved; Dermis-hypodermis junction: preserved. (b) Illustration of LDHC 1 in schematic form.



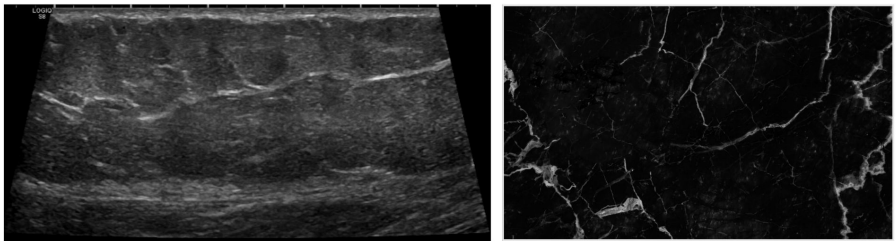
(a) (b)

Figure 5. LDHC 2. (a) Ultrasonographic image of the medial aspect of the proximal leg demonstrating the following features: Architecture: bulging; Septa: irregular, with approximately 50% disruption; Hyperechoic nodules: absent; Dermis: preserved; Dermis-hypodermis junction: preserved. (b) Schematic diagram illustrating LDHC 2.



(a) (b)

Figure 6. LDHC 3. Ultrasonographic image of the medial aspect of the proximal leg demonstrating the following features: Architecture: bulging deep hypodermis and disorganized superficial hypodermis; Septa: irregular, with disruption primarily in the superficial hypodermis; Hyperechoic nodules: present; Dermis: asymmetric thickening; Dermis-hypodermis junction: irregular line. (b) Schematic representation of LDHC 3.



(a) (b)

Figure 7. LDHC 4. (a) Ultrasonographic image of the lateral thigh demonstrating the following features: Architecture: "marbled" pattern; Septa: irregular, with branching and verticalization, more than 50% disruption; Hyperechoic nodules: absent; Dermis: asymmetric thickening; Dermis-hypodermis junction: "serrated" pattern. (b) The image of Marquina marble shows disorganized streaks across the stone in all directions.

4. DISCUSSION

Current functional classification primarily emphasizes clinical signs involving the skin, subcutaneous tissue, and lymphatic system. This approach does not clearly address inflammatory and fibrotic changes associated with tissue remodeling and functional impairment.

Standardized imaging protocols for lipedema are essential to improve diagnostic accuracy and minimize unnecessary imaging studies. Ultrasound has become widely recognized as a valuable imaging modality for evaluating soft tissue disorders, offering a cost-effective and accessible alternative to magnetic resonance imaging (MRI) and other advanced imaging techniques [10, 11].

The proposed classification provides a novel framework integrating ultrasonographic findings with tissue remodeling processes, such as inflammation and fibrosis, features inadequately addressed by existing classifications [3, 8]. Nevertheless, the LDHC is preliminary, and multicenter studies are necessary to validate its clinical applicability, reproducibility, and correlation with histopathology and clinical outcomes.

Strengths and Implications

- Practical application: the classification provides a structured approach to evaluating lipedema using ultrasound, a cost-effective imaging modality already performed as a complementary examination in diagnosis.
- Clinical relevance: by identifying specific ultrasonographic patterns, the classification may guide treatment decisions and monitor therapeutic outcomes.

Limitations and Future Directions

- Validation needed: the proposed classification has not been validated in larger, multicenter studies.
- Correlation with outcomes: further research is required to establish relationships between ultrasonographic patterns, symptoms, histopathological findings, and treatment efficacy.
- Operator dependence: standardization of imaging protocols and operator training is essential for broader applicability.

Prospective multicenter studies should involve standardized clinical criteria for patient selection and include control cohorts (obese and lymphedema patients) to establish the specificity or LDHC features. Utilizing standardized high-frequency ultrasound (10 - 15 MHz) protocols targeting predefined anatomical regions will help ensure reproducibility and consistency. Validation should encompass intra and interobserver agreement (Cohen's kappa) and analyses correlating ultrasonographic findings with clinical severity scores and histopathologic features from surgical samples. Additionally, longitudinal assessments are commended to evaluate LDHC's ability to track disease progression and therapeutic response.

5. CONCLUSIONS

Lipedema remains underdiagnosed due to limited awareness and inconsistent diagnostic criteria. This study introduces a qualitative ultrasound classification system to characterize structural patterns in dermis and hypodermis of lipedema. The proposed classification aims to assess procedural risks, guide optimal treatment decisions, and evaluate treatment efficacy.

Although preliminary, the LDHC highlights the potential of ultrasound as a diagnostic tool for lipedema. Multicenter studies could complement the validation process and help assess the classification and its reproducibility. Validation if ultrasonographic findings patterns truly correspond to the clinical progression of the disease. These steps will refine its clinical utility, potentially improving patient care and outcomes.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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