ISSN 2380-3940

WOMEN'S HEALTH
Open Journal

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PUBLISHERS

Commentary

Measurement of Women's Leg Edema Using Ultrasonography

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Article information
Received: April 13th, 2020; **Revised:** April 20th, 2020; **Accepted:** April 21st, 2020; **Published:** April 28th, 2020

Cite this article
Ikuta E, Watanabe Y, Yanagisawa N, et al. Measurement of women's leg edema using ultrasonography. *Women Health Open J.* 2020; 6(1): 5-7.
doi: 10.17140/WHOJ-6-136

Peripheral edema is the swelling of lower legs or hands. Venous edema, which differs from lymphedema, occurs when something disrupts the usual balance of body fluids[1] and involves the accumulation of fluid in the extracellular compartment, which results in an increase in the volume of interstitial fluid.[2] Physiologically, a balance exists between intravascular hydrostatic and oncotic pressures and the interstitial pressure.[3] Transcapillary hydrostatic pressure tends to drain fluid from blood vessels, whereas oncotic pressure (hypoalbuminemia) tends to produce fluid retention in blood vessels. Venous edema consists of excess low-viscosity, protein-poor interstitial fluid resulting from increased capillary filtration that cannot be accommodated by a normal lymphatic system.[4] Thus, fluid movement occurs from the venous system into the extravascular space. Initially, gravity pulls the fluid down into both legs and feet.

Leg edema can occur under both normal and disease conditions. Under normal conditions, it occurs in cases of sitting or standing too long, pregnancy, excessive salt intake, and drug reactions-, just to name a few. Under disease conditions, it occurs in cases of venous insufficiency, deep vein thrombosis (DVT), heart failure, preeclampsia, cirrhosis, pulmonary hypertension, and renal failure, among others.[5]

Pitting edema is a characteristic of leg edema, and is detected when pressure that is applied to the skin leaves a depression when removed. This method of detection of leg edema is a qualitative diagnostic method performed. In brief, there is not a quantitative method to measure leg edema.

Ultrasonography is a quantitative imaging method that is easy to use and produces consistent results between operators. Furthermore, when using a portable ultrasound device, a doctor or nurse can perform this imaging method easily in an outpatient setting. In particular, this approach will also prove useful for the assessment of the effects of treatments for leg edema.

Several attempts to observe skin edema using ultrasonography have been made.

In gravity dependent edema, the echogenicity on ultrasonography was reported to be higher in the lower leg than in the upper leg, without a marked difference between the medial and lateral sides.[6] In addition, the subcutaneous echogenicity of chronically edematous legs prior to sleep was reported to be higher than that of reduced legs in the early morning.[7]

Using high-frequency ultrasound, Volikova et al measured the dermal thickness (between the surface of the epidermis and the interface of the dermis) of the legs of patients with a history of previous DVT and symptoms of post-thrombotic syndrome (PTS) and age-matched healthy controls.[8] The median dermal thickness in the control group was 1.34 mm, while that in the PTS group without ulceration was 2.16 mm (p<0.001), with the PTS group showing thicker skin than the control group.

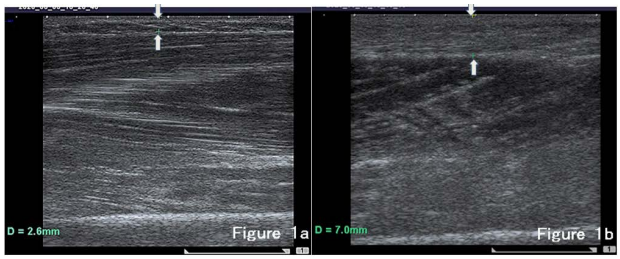
Ciggiati reported the ultrasonographic findings of skin changes in legs with chronic venous disease.[9] In apparently normal skin of C2 class (varicose vein) according to of the clinical-etiology-anatomy-pathophysiology (CEAP) classification, the main ultrasonographic findings were a normal skin appearance, dermal edema or inflammatory infiltration of the cutaneous layer and/or of the subcutaneous layer. In C3 class (edema) of the CEAP classification, by contrast, the findings were homogeneous subcutaneous thickening, presence of anechoic lacunae and presence of dermal edema. These findings are drawn as the same images under both normal and disease conditions.

Of note, the subcutaneous layer, or subdermal layer, consists mainly of adipose tissue and collagen and contains abundant lymphatic and blood vessels, making it a suitable environment for the accumulation of extracellular fluid, much of which is found in the collagen network that surrounds adipocytes.[10] Therefore, venous edema tends to first appear in the subcutaneous layer of the legs and feet.

A previous study evaluated the subcutaneous tissue thickness of the arms, thighs and abdomen in women using ultrasonography.[11] At the arm, the subcutaneous tissue thickness ranged from 3.30 to 18.20 mm; at the thigh, range was 2.70 to 25.20 mm; at the abdomen, the range was 3.40 to 25.20 mm in women. In all cases, the subcutaneous tissue thickness increased as the body mass index (BMI) increased.

We recently measured the skin thickness (including the epidermis, dermis and subcutaneous tissue) in pregnant women with leg edema using B-scan portable ultrasonography as a quantitative method.[12] The skin thickness of the legs in pregnant women with edema was significantly higher than that in pregnant women without edema (6.4±0.3 mm *vs.* 4.6±0.4 mm) (p=0.0001) (Figure 1). The cut-off for the measurement of skin edema compared with non-edema in all legs was 4.7 mm, with a sensitivity of 83.9%, a specificity of 66.7% and an accuracy of 77.6%. However, we faced a problem in that fatty legs showed a thick skin, even in cases without edema.

Figure 1. *Ultrasonographic Measurements of Skin Thickness in Women with and without Leg Edema*



*(**a**) Using ultrasonography (7.5-MHz Linear Array Probe, Siemen), the distance between the skin surface and the fascia was measured as the skin thickness (between the epidermis, dermis, and subcutaneous layers). The skin thickness was 2.6 mm in a woman without edema. (**b**) The skin thickness was 7.0 mm in a woman with edema.*

In the future, we should develop accurate methods for measuring the volume of fluid that accumulates in the leg's skin layer and carefully monitor cases of lower limb skin edema while providing early treatment.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Watanabe Y, koshiyama M, Seki K, Nakagawa M, Ikuta E, Oowaki M, et al. Development and themes of giagnostic and treatment procedures for decondary leg lymphedema in patients with gynecologic cancers. *Healthcare (Basel).* 2019; 7: 1-19. doi: 10.3390/healthcare7030101

2. Watanabe Y, Koshiyama M, Yanagisawa N. Treatment of leg and foot edema in women. *Women Health Open J.* 2017; 3: 68-73. doi: 10.17140/WHOJ-3-124

3. Priollet P. Venous edema of the lower limbs. Phlebolymphology Website. https://www.phlebolymphology.org/venous-edema-of-the-lower-limbs/. Accessed March 5, 2020.

4. Gorman WP, Davis KR, Donnelly R. ABC of arterial and venous disease. Swollen lower limb-1: General assessment and deep vein thrombosis. *BMJ.* 2000; 320: 1453-1456. doi: 10.1136/bmj.320.7247.1453

5. Ely JW, Osheroff JA, Chambliss ML, Ebell MH. Approach to leg edema of unclear etiology. *J Am Board Fam Med.* 2006; 19: 148-160. doi: 10.3122/jabfm.19.2.148

6. Suehiro K, Morikage N, Murakami M, Yamashita O, Ueda K, Samura M, et al. Subcutaneous tissue ultrasonography in legs with dependent edema and secondary lymphedema. *Ann Vasc Dis.* 2014; 7: 21-27. doi: 10.3400/avd.oa.13-00107

7. Iuchi T, Kobayashi M, Tsuchiya S, Ohno N, Dai M, Matsumoto M, et al. Objective assessment of leg edema using ultrasonography with a gel pad. *PloS One.* 2017; 12: 1-11. doi: 10.1371/journal.pone.0182042. eCollection 2017

8. Volkova AI, Edwards J, Stacey MC, Wallace HJ. High-frequency ultrasound measurement for assessing post-thrombotic syndrome and monitoring compression therapy in chronic venous disease. *J Vasc Surg.* 2009; 50: 820-825. doi: 10.1016/j.jvs.2009.05.060

9. Caggiati A. Ultrasonography of skin changes in legs with chronic venous disease. *Eur J Endovasc Surg.* 2016; 52: 534-542. doi: 10.1016/j.ejvs.2016.03.022

10. Comley K, Fleck NA. A micromechanical model for the Young's modulus of adipose tissue. *Int J Solids Struct.* 2010; 47: 2982-2990. doi: 10.1016/j.ijsolstr.2010.07.001

11. Jain SM, Pandey K, Lahoti A, Rao PK. Evaluation of skin and

subcutaneous tissue thickness at insulin injection sites in Indian, insulin naïve, type-2 diabetic adult population. *Indian J Endocrinol Metab.* 2013; 17: 864-870. doi: 10.4103/2230-8210.117249

12. Yanagisawa N, Koshiyama M, Watanabe Y, Sato S, Sakamoto S. A quantitative method to measure skin thickness in leg edema in pregnant women using B-scan portable ultrasonography: A comparison between obese and non-obese women. *Med Sci Monit.* 2019; 25: 1-9. doi: 10.12659/MSM.911799