The Journal of Sexual Medicine, 2023, **20**, 1367–1368
https://doi.org/10.1093/jsxmed/qdad140
Expert Opinion

Clitoris color Doppler ultrasound: a 2023 update

Elisa Maseroli, MD, PhD[1], Linda Vignozzi, MD, PhD[1,2,*], Yacov Reisman, MD, PhD, FECSM, ECPS[3,4]

[1]Andrology, Women's Endocrinology and Gender Incongruence Unit, Careggi University Hospital, Florence 6772829, Italy
[2]Department of Experimental and Clinical Biomedical Sciences "Mario Serio", University of Florence, Florence 6772829, Italy
[3]Sexual Medicine, Flare-Health, Amsterdam, Netherlands Oudezijds Achterburgwal 141-D, 1012DG Amsterdam, Netherlands
[4]Center for Sexual Health, Reuth Rehabilitation Hospital, Tel-Aviv, 6772829, Israel

*Corresponding author: Viale Pieraccini 6, 50139 Florence, Italy. Email: linda.vignozzi@unifi.it

Keywords: cardiovascular risk; clitoris; female sexual dysfunction; genital blood flow; metabolic syndrome; ultrasound.

Clitoral Doppler ultrasound (CDU) is a noninvasive and easily applicable test used to assess the vascular patency and perfusion of clitoral arteries by measuring the rate of change in blood flow. Among hemodynamic parameters assessed during CDU, the pulsatility index (PI) is proposed to reflect genital vascular resistance and predict cardiovascular risk factors. The PI is an intrinsic Doppler ultrasound value, which is automatically calculated from different hemodynamic parameters during a defined cardiac cycle and is obtained by the following formula: (peak systolic velocity – minimal diastolic velocity) / mean velocity. Importantly, since PI is derived from multiple flow parameters derived on the same Doppler spectrum, it is considered to mitigate potential instrument-dependent errors or an inappropriate angle of insonation by the sonographer. Moreover, PI was recognized for its safety, repeatability, and sensitivity in monitoring early and minimal changes of hemodynamic parameters. Based on these favorable characteristics, PI has been adopted in clinical practice for measuring vascular resistance in pulsatile systems across various pathologic conditions.[1]

The clinical application of PI has been demonstrated in different vascular beds, including the lung, brain, kidney, and uteroplacental circulation. In these settings, PI serves as a direct indicator of increased resistance and microatherosclerosis. Additionally, studies have shown that PI in cerebral arteries increases with conditions such as hyperlipemia, hypertension, diabetes, and aging, highlighting its potential as a valuable diagnostic tool for assessing these risk factors.

Interestingly, Battaglia et al were the first to find that PI in clitoral arteries, as assessed by CDU, was significantly higher in heavy smokers as compared with nonsmoking women (see Cipriani and Simon[2] for a review). This finding suggests that unhealthy lifestyle factors may contribute to alterations in the stiffness of female clitoral blood vessels. Clitoral corpora cavernosa tissue was also found to be extremely sensitive to metabolic cues. For instance, evidence shows that diabetic women have higher collagen condensation and decreased smooth muscle content in the clitoral tissue as compared with nondiabetic women, highlighting the impact of diabetes on clitoral health. In line with this, significant associations have been established between clitoral smooth muscle cell atrophy and cardiovascular mortality, as determined through histomorphometric analysis in autoptic specimens.[2]

Research employing animal models substantiated these human data and expanded our understanding of potential disease mechanisms.[3] Atherosclerosis-induced chronic arterial insufficiency has been shown to impair erection and increase collagen deposition in the clitoral erectile tissue as compared with control groups. Similarly, a severe alteration of vasorelaxant mechanisms in the internal pudendal artery, which supplies the clitoris and vagina, has been observed in female Goto-Kakizaki type 2 diabetic rats.[3]

Recently, when assessed in a population of women presenting with sexual dysfunction (SD), clitoral PI increased as a function of the severity of metabolic syndrome (MetS), a cluster of interconnected factors that indicate cardiovascular risk outcomes.[4] Even though MetS encompasses hyperinsulinemia, dysglycemia, high triglycerides, low high-density lipoprotein cholesterol, and elevated blood pressure, insulin resistance is recognized at the core of the syndrome. Consistent with this, a tight association between clitoral PI and parameters related to insulin resistance, such as insulin and triglyceride levels, as well as waist circumference, was found in women presenting with SD, even when adjusting for age and other confounding factors. Additionally, clitoral PI exhibited positive correlations with a higher HOMA-IR (Homeostatic Model Assessment for Insulin Resistance), total cholesterol levels, and low-density lipoprotein cholesterol levels. A significant difference was also detected in women with SD when stratified according to body mass index. Women who were obese (body mass index $\geq$30 kg/m^2) displayed significantly higher PI values vs those who were nonobese.[4] In a subsequent study enrolling a larger sample population, clitoral PI was confirmed to be strongly associated with several indices of MetS, providing further support for the notion that clitoral arteries might mirror cardiovascular atherosclerosis; this association offers potential for early detection of coronary artery disease (reviewed by Cipriani and Simon[2]). In the male counterpart, penile vascular

Received: July 11, 2023. **Revised:** September 11, 2023. **Accepted:** October 1, 2023

impairment is considered an early manifestation of a broader subclinical systemic disorder that might result in cardiovascular disease. The mechanistic hypothesis of "artery size" is often used to explain the relationship between erectile dysfunction and coronary artery disease. This theory essentially draws on the following concept: as atherosclerosis is a systemic disease, all vascular beds might be involved to a similar extent, but symptoms do not manifest simultaneously across vascular districts. This is primarily due to smaller vessels (ie, the penile artery) showing lower tolerance to the same volume of atherosclerotic plaque as larger ones (ie, the coronary artery).[5]

In this context, it is important to emphasize that clitoral arteries have an even smaller diameter (range, 0.7-1.1 mm) than penile arteries (averaging 1-2 mm). This size difference suggests that assessing narrowing and resistance in clitoral arteries might be even more accurate in predicting cardiovascular risk than in the male counterpart. Therefore, the purpose of this Expert Opinion article is to briefly summarize evidence on the use of CDU, while recognizing the areas of uncertainty in the field and fostering future research and specifically designed studies to assess the predictive value of this technique.

With the growing body of evidence supporting the role of vascular evaluation of the clitoris with ultrasound as a potential marker of forthcoming cardiovascular risk in females, the European Society for Sexual Medicine has developed the ESSM Female Ultrasound School (EFUS).[6] The EFUS aims to offer high-level "female ultrasound courses" to train and educate experts in the field of female ultrasound for the evaluation of female SD. The primary goal is to promote standardization of methodology in the assessment of female SD while ensuring the highest level of quality and expertise in this specialized area.

EFUS will also foster the wider adoption and dissemination of the CDU methodology to definitely disentangle the role of clitoral vascular impairment as a harbinger of cardiovascular health, which may stimulate exploring the role of CDU in the diagnostic armory of female SD.

Author contributions

Conceptualization: E.M., L.V., Y.R. Methodology: E.M., L.V., Y.R. Writing–original draft: E.M., L.V. Writing–review and editing: E.M., L.V., Y.R. Supervision: L.V., Y.R.

Funding

None.

Conflicts of interest

The authors declare no competing interests.

References

1. Lim HS, Gustafsson F. Pulmonary artery pulsatility index: physiological basis and clinical application. *Eur J Heart Fail*. 2020;**22**(1):32–38. https://doi.org/10.1002/ejhf.1679.
2. Cipriani S, Simon JA. Sexual dysfunction as a harbinger of cardiovascular disease in postmenopausal women: how far are we? *J Sex Med*. 2022;**19**(9):1321–1332. https://doi.org/10.1016/j.jsxm.2022.06.007.
3. Angulo J, Hannan JL. Cardiometabolic diseases and female sexual dysfunction: animal studies. *J Sex Med*. 2022;**19**(3):408–420. https://doi.org/10.1016/j.jsxm.2021.12.009.
4. Maseroli E, Fanni E, Cipriani S, *et al*. Cardiometabolic risk and female sexuality: focus on clitoral vascular resistance. *J Sex Med*. 2016;**13**(11):1651–1661. https://doi.org/10.1016/j.jsxm.2016.09.009.
5. Montorsi P, Ravagnani PM, Galli S, *et al*. Association between erectile dysfunction and coronary artery disease: role of coronary clinical presentation and extent of coronary vessels involvement—the COBRA trial. *Eur Heart J*. 2006;**27**(22):2632–2639. https://doi.org/10.1093/eurheartj/ehl142.
6. European Society for Sexual Medicine. EFUS: ESSM female ultrasound school. August 2023. https://www.essm.org/education/efus-essm-female-ultrasound-school/