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Evaluating the Comparative Accuracy of Posture-Specific Measurements of Vein Diameters (GSV and SSV) in Chronic Venous Insufficiency

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ABSTRACT

Background: Chronic venous insufficiency (CVI) represents a significant global health burden, with a prevalence ranging between 25-33% in adult populations. Duplex ultrasonography serves as the cornerstone for diagnosing CVI, yet substantial variability exists in measurement protocols, particularly regarding patient positioning. The physiological effects of hydrostatic pressure in upright positions significantly increase venous dilation compared to supine measurements, potentially impacting diagnostic accuracy and correlation with clinical disease severity.

Materials and Methods: This comprehensive review synthesizes evidence from clinical studies investigating the relationship between great saphenous vein (GSV) and small saphenous vein (SSV) diameters measured in different positional orientations (supine, standing, reverse Trendelenburg) and their correlation with venous reflux and CEAP (Clinical, Etiological, Anatomical, Pathophysiological) clinical classification. Analysis of diagnostic cutoff values, receiver operating characteristic (ROC) curves, and methodological considerations for posture-specific imaging protocols are examined.

Conclusion : Evidence consistently demonstrates that standing-position measurements yield significantly larger venous diameters compared to supine positioning, with mean differences of 19-24% in saphenous trunk diameter between positions. Standing measurements exhibit stronger correlation with clinical CEAP classification and improved diagnostic accuracy for detecting pathological reflux. The optimal cutoff diameter for predicting GSV reflux ranges from 5.05-5.88 mm in standing positions, compared to 3.55-5.29 mm for SSV reflux. Standardization of posture during venous duplex ultrasonography is essential for accurate diagnosis, with standing positioning recommended for optimal correlation with clinical disease severity.

KEYWORDS: chronic venous insufficiency, great saphenous vein, small saphenous vein, postural variation, vein diameter, Doppler ultrasound, CEAP classification, venous reflux

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INTRODUCTION

Chronic venous disease (CVD) encompasses a spectrum of pathological conditions ranging from telangiectasias to venous ulceration, resulting from venous hypertension due to valvular incompetence, obstruction, or muscular dysfunction. The global prevalence of CVD is substantial, affecting between 25-33% of the adult population, with women demonstrating higher predisposition than men [1]. In specific populations, such as northern India, prevalence rates of 46.7% in females and 27.8% in males have been reported [2]. The clinical and economic burdens of CVI are considerable, encompassing direct healthcare costs, reduced productivity, and diminished quality of life for affected individuals.

The CEAP (Clinical, Etiological, Anatomical, Pathophysiological) classification system remains the international standard for grading venous disease severity, providing a comprehensive framework for standardized reporting [3]. Concurrently, the Venous Clinical Severity Score (VCSS) offers a complementary tool for quantitative assessment, demonstrating strong correlation with CEAP stages (Spearman's correlation coefficient $r = 0.740$, $P < 0.001$) [4]. Despite these standardized assessment tools, objective anatomical parameters that reliably correlate with disease severity remain an area of ongoing investigation.

Duplex ultrasonography represents the gold standard for evaluating venous morphology and hemodynamics in CVI, enabling precise measurement of vein diameters and detection of pathological reflux, defined as retrograde flow duration exceeding 0.5 seconds [5]. However, significant methodological variability exists in clinical practice, particularly regarding patient positioning during examination. The venous system demonstrates marked sensitivity to postural changes, with increasing diameters observed in veins below heart level when moving from supine to standing positions [6]. This physiological response to hydrostatic pressure challenges the diagnostic accuracy of supine-only measurements, potentially underestimating venous dilation and compromising correlation with clinical severity.

This review aims to critically evaluate the comparative accuracy of posture-specific measurements of GSV and SSV diameters,

synthesizing current evidence regarding optimal positioning for ultrasound assessment, diagnostic cutoff values correlated with position, and the relationship between posture-specific diameters and clinical disease severity classification.

MATERIALS AND METHODS

This comprehensive review synthesizes evidence from clinical studies investigating the relationship between great saphenous vein (GSV) and small saphenous vein (SSV) diameters measured in different positional orientations (supine, standing, reverse Trendelenburg) and their correlation with venous reflux and CEAP (Clinical, Etiological, Anatomical, Pathophysiological) clinical classification. Analysis of diagnostic cutoff values, receiver operating characteristic (ROC) curves, and methodological considerations for posture-specific imaging protocols are examined.

DISCUSSION

The evaluation of chronic venous insufficiency has evolved significantly with advances in duplex ultrasonography, yet the optimization of measurement protocols remains crucial for diagnostic accuracy. Our analysis of the current evidence reveals several important aspects regarding posture-specific venous diameter measurements.

The venous system demonstrates remarkable geometric plasticity in response to positional changes, with veins below heart level exhibiting substantial diameter increases when moving from supine to upright positions. A comprehensive scoping review of 108 studies on position-dependent vascular imaging confirmed that the venous system proves more sensitive to postural changes than the arterial system, with increasing diameters of veins below the level of the heart when transitioning from supine to prone to standing positions [6]. This phenomenon is attributable to increased hydrostatic pressure in dependent positions, resulting in venous distension. The magnitude of postural diameter change (PDC) can be quantified as (standing diameter − lying diameter)/standing diameter × 100, with median PDC of approximately 19-24% in saphenous trunks [7].

The clinical implications of this positional variation are substantial, as demonstrated by studies utilizing various imaging modalities. Magnetic resonance venography studies have shown that common femoral vein area increases significantly with prone positioning (83 ± 35 mm^2) compared to supine positioning (59 ± 21 mm^2, $p = 0.02$), with further augmentation following hydration [8]. These findings underscore the dynamic nature of venous geometry and highlight the limitations of supine-only assessment for capturing maximal venous dimensions relevant to pathological states.

The relationship between venous diameter and pathological reflux has been extensively investigated, with mounting evidence supporting position-specific diagnostic thresholds. A retrospective analysis of 213 extremities using computed tomography venography demonstrated that the mean diameter of the GSV measured 5 cm distal to the saphenofemoral junction was significantly larger in patients with reflux (8.07±1.82 mm) compared to those without reflux (5.11±1.20 mm, $p < 0.05$) [9]. Similarly, for the SSV, diameters measured 5 cm distal to the saphenopopliteal junction were significantly increased in refluxing veins (7.65±1.74 mm) versus non-refluxing veins (5.04±1.80 mm, $p < 0.05$) [9].

Receiver operating characteristic analysis has yielded position-optimized cutoff values for predicting reflux. For standing assessments, the optimal GSV threshold diameter is approximately 5.88 mm measured 5 cm distal to the saphenofemoral junction (sensitivity 91.4%, specificity 81.8%), while for SSV, a cutoff of 5.29 mm measured 5 cm distal to the saphenopopliteal junction provides optimal predictive value (sensitivity 94.9%, specificity 75.0%) [9]. These values contrast with those derived from supine measurements, where cutoff values of 5.05 mm for GSV and 3.55 mm for SSV have been proposed [10], highlighting the significant impact of positioning on diagnostic parameters.

The clinical utility of posture-specific venous measurements extends beyond reflux detection to correlation with disease severity stratification. The CEAP classification system provides a standardized framework for clinical staging, and evidence suggests that standing venous measurements demonstrate stronger correlation with advanced CEAP classes than supine measurements. Notably, postural diameter change itself may have clinical significance, with one study demonstrating significantly reduced PDC in C4-C6 limbs (16%) compared to C0-C1 (23%) or C2-C3 limbs (21%, $p = 0.016$) [7]. This suggests that venous compliance diminishes with disease progression, potentially representing a novel parameter for severity assessment.

The relationship between vein diameter and clinical scoring extends beyond CEAP classification. Studies investigating the Venous Clinical Severity Score have demonstrated significant correlation with anatomical parameters, supporting the integration of objective diameter measurements with clinical assessment tools [4]. Furthermore, evidence suggests that a small saphenous vein diameter of ≥4 mm is associated with venous reflux and represents a relevant threshold for intervention consideration [11].

LIMITATIONS AND FUTURE DIRECTIONS

Current literature exhibits methodological heterogeneity in measurement protocols, including variations in exact anatomical reference points, timing of assessment after positional change, and technical parameters. Additionally, patient-specific factors such as age, body mass index, and hydration status influence venous dimensions, potentially confounding diameter interpretations [7][8].

CONCLUSION

The comprehensive evaluation of evidence regarding posture-specific venous diameter measurements yields several definitive conclusions with significant clinical implications. First, venous diameter demonstrates substantial positional dependence, with standing measurements yielding consistently larger values than supine assessments across multiple anatomical segments of both the great and small saphenous veins. The mean postural diameter change of 19-24% observed in saphenous trunks underscores the hemodynamic relevance of upright positioning for capturing venous dimensions reflective of ambulatory venous hypertension.

Second, standing-position measurements exhibit superior correlation with clinical disease severity as classified by the CEAP system and demonstrate enhanced diagnostic accuracy for detecting pathological reflux. The established cutoff values of 5.88 mm for GSV and 5.29 mm for SSV in upright positions provide optimized sensitivity and specificity for reflux prediction, supporting their integration into standardized diagnostic protocols. The observed reduction in postural diameter change with advancing CEAP classification further suggests that compliance alterations accompany disease progression, potentially representing an additional parameter for severity assessment.

Future efforts should focus on validating position-adjusted diagnostic criteria across diverse populations and establishing consensus guidelines for posture-specific venous duplex ultrasonography in chronic venous insufficiency evaluation.

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