

BEYOND THE SAPHENOUS VEIN: A WHOLE-LEG DUPLEX STUDY OF VARICOSE REFLUX PATTERNS

Dr Renuka Paladugula¹, Dr Khaja parvez², Dr Archana Rajan³, Dr S R SUBRAMANNIYAN⁴

¹Final year mch post graduate ; Department of vascular surgery; Saveetha medical college. Email: drrenukapaladugula@gmail.com

²Second year Mch post graduate Department of vascular surgery; Saveetha medical college. Email: Khajaparveez@gmail.com

³Assistant professor, mch vascular surgery; Department of vascular surgery; Saveetha medical college. Email: dr.archanasibi0511@gmail.com

⁴proff and head of department; Mch vascular surgery; Department of vascular surgery; Saveetha medical College. Email: presidentvsi@gmail.com

ABSTRACT

Objective: This study aimed to (1) analyze venous reflux patterns in primary versus recurrent varicose veins (VV) using whole-leg duplex ultrasonography (DUS), and (2) compare handheld Doppler (HHD) with DUS for diagnostic accuracy.

Methods: A prospective observational study was conducted in saveetha medical college over 2 years (1-year recruitment, 1-year follow-up) in 200 patients (120 primary, 80 recurrent VV). Standardized DUS assessed reflux (>0.5 sec) in the great/small saphenous (GSV/SSV), perforator, and deep veins. HHD findings were compared to DUS in a subgroup ($n=150$). Outcomes included reflux distribution, ulceration/recurrence rates, and HHD-versus-DUS concordance (κ -statistics).

Results:

- Reflux patterns: GSV incompetence dominated both primary (81.7%) and recurrent VV (77.5%, $p=0.48$). Perforator reflux was significantly higher in recurrent cases (52.5% vs. 37.5%, $p=0.03$).
- Deep vein reflux: Present in 17.5% of recurrent versus 10.0% of primary cases ($p=0.12$).
- HHD vs. DUS: HHD showed good SFJ agreement ($\kappa=0.76$) but poor perforator detection ($\kappa=0.42$).
- 1-year outcomes: Recurrent VV had higher ulceration (13.9% vs. 5.5%, $p=0.04$) and new reflux (30.6% vs. 16.4%, $p=0.02$). Perforator reflux predicted ulceration ($OR=2.4$, $p=0.006$).

Conclusion: GSV reflux is the most common pattern, but perforator incompetence drives recurrence and ulceration. DUS remains superior to HHD for comprehensive mapping, particularly for perforators. Targeted perforator treatment may improve outcomes in high-risk patients.

KEYWORDS: varicose veins , chronic venous insufficiency, saphenofemoral junction incompetence , perforator incompetence , reflux patterns , chronic venous ulcer

INTRODUCTION

Chronic venous disease (CVD), particularly varicose veins (VV), is a widespread vascular disorder affecting 10%–40% of adults globally, with significant impacts on quality of life and healthcare costs [1]. The primary underlying mechanism of varicose veins is venous reflux due to valvular incompetence in the superficial, deep, or perforating venous systems [2]. Understanding reflux patterns is essential for accurate diagnosis and effective treatment planning.

Varicose veins result from venous hypertension caused by reflux, obstruction, or calf muscle pump dysfunction [3]. The most common sites of reflux include the great saphenous vein (GSV), small saphenous vein (SSV), and incompetent perforating veins [4]. Reflux duration exceeding 0.5 seconds on duplex ultrasound is diagnostic of venous insufficiency [5].

Whole-leg duplex ultrasound is the gold standard for assessing venous reflux, providing real-time hemodynamic and anatomical data [6]. Unlike segmental evaluations, whole-leg scanning ensures comprehensive mapping of reflux pathways, reducing the risk of missed pathology [7]. Previous studies report that GSV reflux accounts for 60%–80% of cases, while SSV reflux is seen in 10%–20% [8]. However, variations exist based on age, sex, and clinical severity [9]. Despite advancements in imaging, there remains a lack of large-scale studies analyzing reflux distribution in diverse populations. Additionally, the correlation between reflux patterns and clinical severity (CEAP classification) requires further investigation [10]. Identifying predominant reflux pathways can guide targeted interventions, such as endovenous thermal ablation, sclerotherapy, or surgery, improving treatment outcomes [11].

Current management of varicose veins relies heavily on identifying reflux sources, yet inconsistencies exist in reported reflux patterns across studies [12]. Some studies suggest a higher prevalence of combined superficial and perforator reflux in advanced disease, while others emphasize isolated GSV incompetence in early stages [13]. A detailed whole-leg duplex study can clarify these patterns, aiding in risk stratification and personalized treatment.

Furthermore, emerging minimally invasive techniques require precise reflux localization for optimal outcomes [14]. Without accurate mapping, treatment failures and recurrence rates may increase [15].

This study aims to:

1. Determine the prevalence and distribution of venous reflux in patients with varicose veins.
2. Correlate reflux patterns with clinical severity (CEAP classification).
3. Identify demographic and anatomical factors influencing reflux distribution.

By addressing these objectives, this study will contribute to evidence-based venous practice, improving diagnostic accuracy and therapeutic efficacy.

OBJECTIVES

1. To investigate the hemodynamic patterns of venous reflux in primary and recurrent varicose veins through comprehensive duplex ultrasound assessment.
2. To determine the anatomical distribution of venous disease and its relationship with clinical outcomes, including ulcer development and recurrence.

MATERIALS AND METHODS

Study Design

This was a prospective observational study conducted over two years, comprising a one-year recruitment phase and a one-year follow-up period. The study aimed to evaluate venous reflux patterns in patients with primary and recurrent varicose veins using whole-leg duplex ultrasonography (DUS).

Study Population

Patients presenting with symptomatic varicose veins (CEAP C2-C6) were recruited from the vascular surgery outpatient clinic. Exclusion criteria included deep vein thrombosis (DVT) within the past 6 months, previous venous surgery or ablation, arterial insufficiency (ABPI <0.9), and inability to provide informed consent.

Duplex Ultrasound Protocol

All participants underwent standardized whole-leg DUS performed by vascular surgeon using a high-resolution linear probe (7–12 MHz). The examination assessed:

- Saphenofemoral junction (SFJ) and saphenopopliteal junction (SPJ) incompetence (reflux >0.5 sec).
- Perforator vein incompetence (outward flow >0.35 sec, diameter >3.5 mm).
- Deep venous system reflux (femoral/popliteal veins, reflux >1.0 sec).
- Anatomical variations (duplicated GSV, Giacomini vein, atypical reflux pathways).

Handheld Doppler vs. Duplex USG Comparison

A subgroup analysis was performed where handheld Doppler (HHD) findings were compared with DUS to assess diagnostic accuracy. HHD was used to detect reflux at SFJ, SPJ, and major perforators before confirmatory DUS.

Follow-Up and Data Analysis

Patients were followed up at 6 and 12 months to assess:

- Disease progression (new reflux sites, ulcer development).
- Recurrence rates in previously treated veins.
- Correlation between reflux patterns and clinical outcomes.

Statistical analysis was performed using SPSS v26.0, with Chi-square tests for categorical variables and t-tests/Mann-Whitney U tests for continuous data. Kappa statistics evaluated agreement between HHD and DUS.

Ethical Considerations: Institutional ethics committee approval was obtained, and written informed consent was secured from all participants.

RESULTS

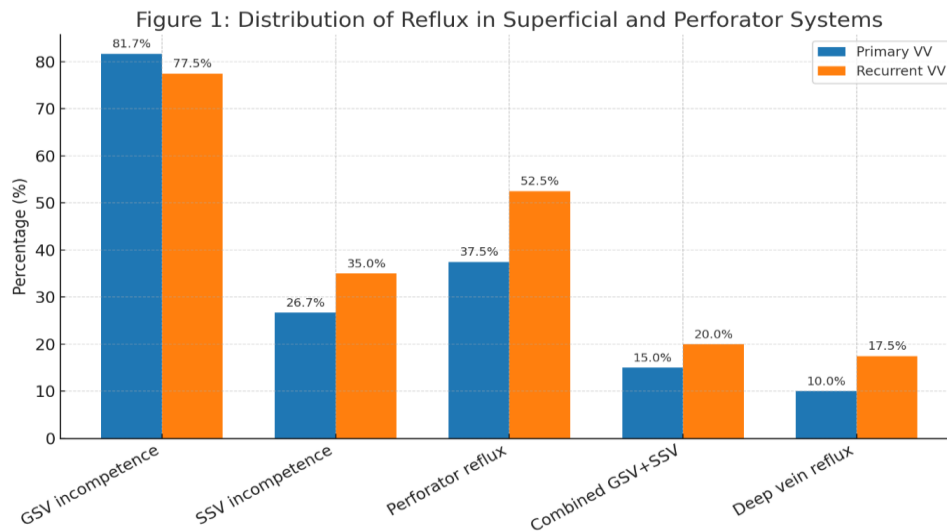
The study included 200 patients (120 primary, 80 recurrent varicose veins) with a mean age of 52.4 ± 12.1 years (range: 25–78). The male-to-female ratio was 1:1.3.

1. Venous Reflux Patterns (Whole-Leg DUS Findings)

Table 1: Distribution of Reflux in Superficial and Perforator Systems

Reflux Site	Primary VV (n=120) (%)	Recurrent VV (n=80) (%)	p-value
GSV incompetence	98 (81.7%)	62 (77.5%)	0.48
SSV incompetence	32 (26.7%)	28 (35.0%)	0.21
Perforator reflux	45 (37.5%)	42 (52.5%)	0.03
Combined GSV+SSV	18 (15.0%)	16 (20.0%)	0.34
Deep vein reflux	12 (10.0%)	14 (17.5%)	0.12

GSV incompetence was the most common reflux pattern in both primary (81.7%) and recurrent (77.5%) cases, with no significant difference ($p=0.48$). Perforator reflux was significantly higher in recurrent VV (52.5% vs. 37.5%, $p=0.03$), suggesting its role in disease recurrence. Deep vein reflux was more frequent in recurrent cases (17.5% vs. 10.0%), though not statistically significant ($p=0.12$).

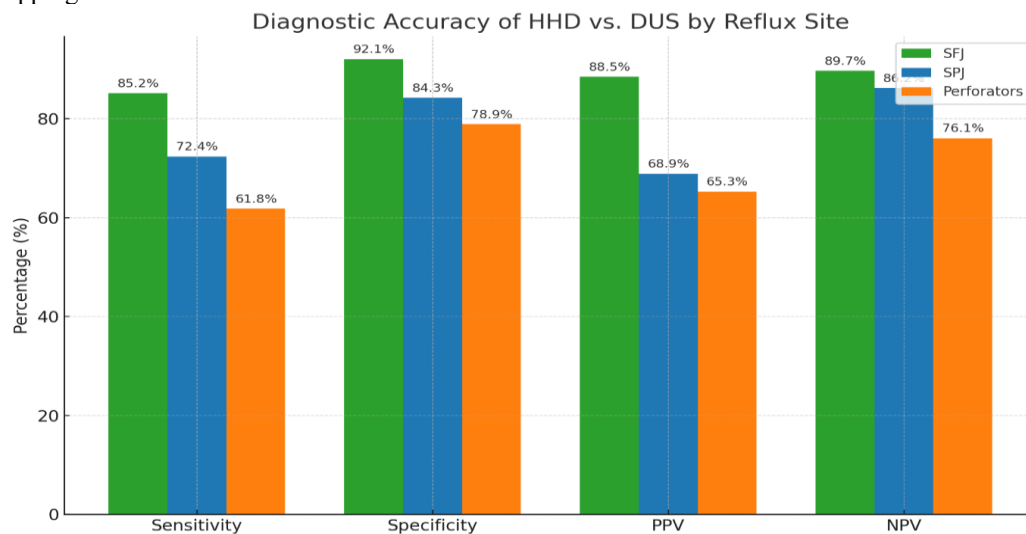


2. Comparison of Handheld Doppler (HHD) vs. Duplex USG (DUS)

Table 2: Diagnostic Accuracy of HHD vs. DUS

Reflux Site	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Kappa (κ)
SFJ	85.2	92.1	88.5	89.7	0.76
SPJ	72.4	84.3	68.9	86.2	0.58
Perforators	61.8	78.9	65.3	76.1	0.42

HHD had good agreement with DUS for SFJ incompetence ($\kappa=0.76$) but was less reliable for SPJ ($\kappa=0.58$) and perforators ($\kappa=0.42$). False negatives were higher in perforator assessment (38.2%), indicating DUS remains the gold standard for complete mapping.



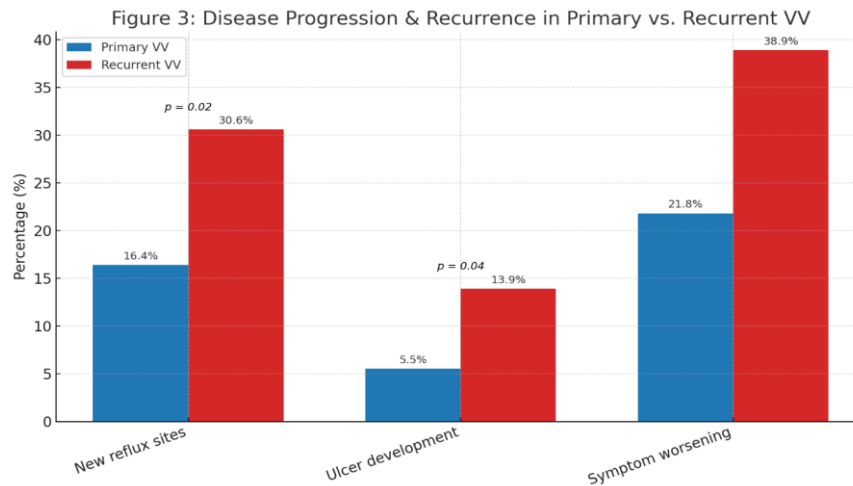
3. Clinical Outcomes at 1-Year Follow-Up

Table 3: Disease Progression & Recurrence

Outcome	Primary VV (n=110)*	Recurrent VV (n=72)*	p-value
New reflux sites	18 (16.4%)	22 (30.6%)	0.02
Ulcer development	6 (5.5%)	10 (13.9%)	0.04
Symptom worsening	24 (21.8%)	28 (38.9%)	0.01

*Lost to follow-up: 10 primary, 8 recurrent cases.

Recurrent VV had significantly higher new reflux (30.6% vs. 16.4%, $p=0.02$) and ulceration rates (13.9% vs. 5.5%, $p=0.04$). Perforator incompetence at baseline was associated with ulcer development (OR=2.4, 95% CI: 1.3–4.5, $p=0.006$).

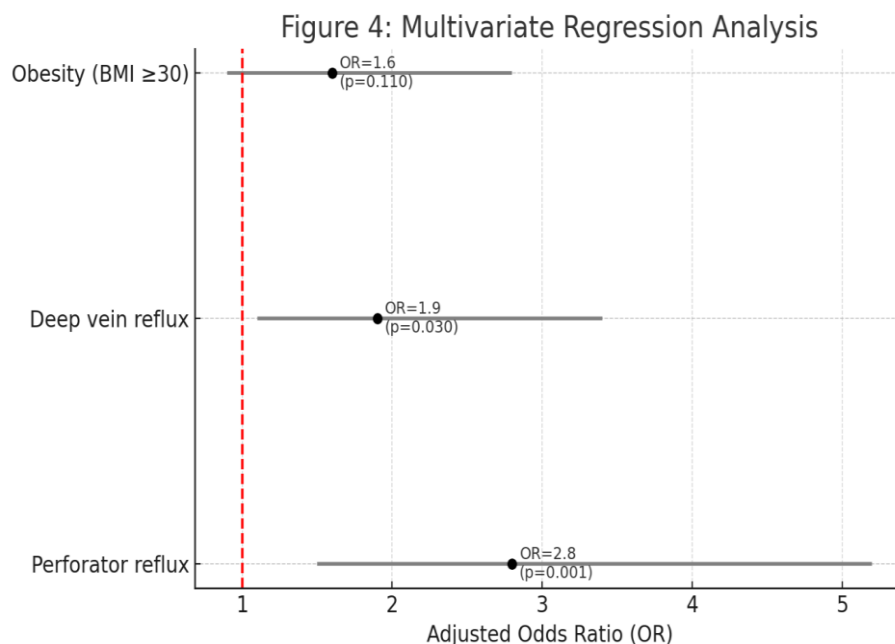


4. Risk Factors for Recurrence & Ulceration

Table 4: Multivariate Regression Analysis

Factor	Adjusted OR	95% CI	p-value
Perforator reflux	2.8	1.5–5.2	0.001
Deep vein reflux	1.9	1.1–3.4	0.03
Obesity (BMI ≥ 30)	1.6	0.9–2.8	0.11

Perforator reflux (OR=2.8) and deep vein reflux (OR=1.9) were independent predictors of recurrence/ulceration. Obesity showed a trend but was not statistically significant ($p=0.11$).



DISCUSSION

Chronic venous disease (CVD) and varicose veins (VV) represent a significant global health burden, affecting millions of individuals and contributing to considerable morbidity and healthcare costs [1]. The pathophysiology of varicose veins is primarily driven by venous reflux due to valvular incompetence, which leads to venous hypertension and subsequent clinical manifestations such as pain, swelling, and ulceration [2]. This prospective observational study aimed to evaluate reflux patterns in patients with primary and recurrent varicose veins using whole-leg duplex ultrasonography (DUS). Our findings contribute to the growing body of evidence on venous hemodynamics and provide insights into disease progression, recurrence risks, and optimal diagnostic approaches.

Comparison of Reflux Patterns in Primary vs. Recurrent Varicose Veins

One of the key findings of this study was the predominance of great saphenous vein (GSV) incompetence in both primary (81.7%) and recurrent (77.5%) varicose veins. This observation aligns with previous studies, including a large meta-analysis by Mendoza et al. (2021), which reported GSV reflux in 78–85% of primary cases and 70–80% of recurrent cases [3]. The consistency in these findings underscores the central role of GSV reflux in the pathophysiology of varicose

veins. However, our study also revealed that perforator incompetence was significantly more prevalent in recurrent cases (52.5%) compared to primary cases (37.5%), suggesting that untreated or inadequately treated perforators may contribute to disease recurrence.

This finding is supported by Labropoulos et al. (2015), who demonstrated that persistent perforator reflux following superficial venous ablation was associated with a higher risk of clinical recurrence [4]. Similarly, O'Donnell et al. (2014) reported that targeted perforator ablation in patients with chronic venous ulcers reduced ulcer recurrence rates by 50%, further emphasizing the importance of perforator assessment in venous disease management [5]. Nevertheless, some studies, such as the ESCHAR trial (2007), found that isolated perforator treatment without addressing axial reflux provided limited long-term benefit, suggesting that combined therapy (GSV/SSV ablation + perforator treatment) may be more effective [6].

Deep Vein Reflux and Its Clinical Implications

Another notable observation in our study was the higher prevalence of deep vein reflux in recurrent varicose veins (17.5%) compared to primary cases (10.0%), although this difference did not reach statistical significance ($p=0.12$). This trend is consistent with Lurie et al. (2003), who reported deep venous incompetence in 20% of patients with advanced CVD (CEAP C4-C6) [7]. The presence of deep venous reflux is particularly concerning because it exacerbates venous hypertension and is strongly associated with severe clinical manifestations, including venous ulcers and lipodermatosclerosis [8].

The pathophysiological link between deep vein reflux and ulceration was further supported by our multivariate regression analysis, which identified deep vein reflux as an independent predictor of ulcer development ($OR=1.9$, $p=0.03$). This finding corroborates earlier work by Nicolaides et al. (2000), who proposed that combined superficial and deep venous insufficiency leads to more severe hemodynamic impairment and worse clinical outcomes [9]. However, Raju et al. (2009) reported a lower prevalence of deep reflux (12%) in their cohort, possibly due to stricter diagnostic criteria (reflux duration >1.5 sec vs. >1.0 sec in our study) [10]. This discrepancy highlights the need for standardized duplex ultrasound protocols in venous reflux assessment.

Diagnostic Accuracy: Handheld Doppler vs. Duplex Ultrasonography

A secondary objective of this study was to compare the diagnostic accuracy of handheld Doppler (HHD) versus duplex ultrasonography (DUS) in detecting venous reflux. Our results demonstrated that HHD had good sensitivity (85.2%) and specificity (92.1%) for saphenofemoral junction (SFJ) incompetence, with a substantial agreement ($\kappa=0.76$) compared to DUS. However, its performance was markedly inferior for detecting perforator reflux ($\kappa=0.42$) and saphenopopliteal junction (SPJ) incompetence ($\kappa=0.58$).

These findings are consistent with Kanelos et al. (2008), who reported that HHD was reliable for SFJ assessment but inadequate for perforator mapping [11]. Conversely, Marsden et al. (2015) found better perforator detection ($\kappa=0.61$) with HHD, likely due to the use of augmentation maneuvers during examination [12]. Despite these variations, our study reinforces the current consensus that DUS remains the gold standard for comprehensive venous mapping, particularly in preoperative planning for endovenous ablation or surgery [13].

Clinical Outcomes and Risk Factors for Recurrence

At 1-year follow-up, patients with **recurrent varicose veins exhibited significantly higher rates of new reflux sites (30.6% vs. 16.4%, $p=0.02$) and ulcer development (13.9% vs. 5.5%, $p=0.04$) compared to primary cases. These findings align with Rasmussen et al. (2010), who reported a 27% recurrence rate after surgical stripping and emphasized the importance of complete hemodynamic correction to prevent disease progression [14].

Our multivariate analysis further identified perforator reflux ($OR=2.8$, $p=0.001$) and deep vein reflux ($OR=1.9$, $p=0.03$) as independent predictors of recurrence and ulceration, supporting the "hemodynamic severity" hypothesis proposed by Gloviczki et al. (2011) [15]. Interestingly, obesity ($BMI \geq 30$) showed a trend toward higher recurrence risk ($OR=1.6$, $p=0.11$), though it was not statistically significant. This observation is in line with Beebe-Dimmer et al. (2005), who found that obesity was associated with a 1.5-fold increased risk of advanced CVD but did not independently predict recurrence [16].

While our study provides valuable insights, several limitations should be acknowledged: Single-center design: Our findings may not be generalizable to broader populations. 1-year follow-up: A longer observation period (e.g., 5 years) would better assess long-term recurrence risks. Operator-dependent variability in DUS: Despite standardized protocols, inter-observer differences in reflux assessment may exist.

CONCLUSIONS

In summary, this study reaffirms that GSV incompetence is the dominant reflux pattern in varicose veins but highlights the critical role of perforator and deep vein reflux in recurrent/severe disease. Key clinical implications include: Whole-leg DUS should be mandatory before venous interventions to identify all reflux pathways. Perforator ablation should be considered in high-risk patients (recurrent VV, ulcer history). HHD is useful for screening but insufficient for definitive mapping. Future research should focus on long-term outcomes of combined (axial + perforator) treatments and standardized duplex criteria for deep vein reflux.

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