

Assessment of Lower Limb Venous Insufficiency Using Color Duplex Modality: A Retrospective Study

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Abstract:

Background: Chronic venous insufficiency (CVI) is a common vascular disorder characterized by compromised venous return from the lower limbs, frequently presenting with symptoms like leg pain, edema, and varicosities. Non-invasive diagnostic tools, particularly color duplex ultrasonography, have become the cornerstone in the evaluation of CVI due to their reliability and accessibility.

Objectives: To assess the pattern, distribution, and severity of lower limb venous insufficiency using color duplex ultrasonography in a defined population through a retrospective analysis.

Methods: A retrospective observational study was conducted in the Department of Radiology, Sri Krishna Medical College, and Hospital, Muzaffarpur, Bihar, India. A total of 120 patients who underwent color duplex ultrasonography for clinically suspected lower limb venous insufficiency between April 2020 and March 2021 were included. Patient demographics, clinical presentation, and ultrasonographic findings were reviewed. Reflux was analyzed in the superficial, perforator, and deep venous systems.

Results: Among the 120 patients, 72 (60%) were male and 48 (40%) were female, with a mean age of 47.3 ± 12.1 years. The predominant symptom was lower limb swelling (68%), followed by pain (55%) and visible varicose veins (42%). Color duplex evaluation revealed venous reflux in the great saphenous vein (GSV) in 78 patients (65%), small saphenous vein (SSV) in 34 patients (28%), and perforator veins in 46 patients (38%). Deep venous reflux was identified in 26 patients (22%). Bilateral venous insufficiency was seen in 52 patients (43%). Reflux severity was categorized as mild (28%), moderate (46%), and severe (26%).

Conclusion: Color duplex ultrasonography proves to be an effective, non-invasive modality for diagnosing and classifying lower limb venous insufficiency. The findings underscore the predominance of superficial venous reflux, particularly involving the GSV, and reinforce the importance of early imaging for timely intervention.

Keywords: Chronic Venous Insufficiency, Color Duplex Ultrasound, Lower Limb Veins, Venous Reflux, Varicose Veins, Retrospective Study.

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Introduction

Chronic venous insufficiency (CVI) is a progressive vascular disorder characterized by inadequate venous return due to valve incompetence in the superficial, deep, or perforator venous systems of the lower limbs [1]. It represents a significant healthcare burden globally, particularly in developing countries, where delayed presentation and underdiagnosis are common [2]. CVI affects up to 40% of the adult population and is associated with a wide range of clinical manifestations, from cosmetic concerns like varicose veins to debilitating complications such as venous ulcers and skin changes (lipodermatosclerosis, hyperpigmentation, and eczema) [3].

The pathophysiology of CVI is multifactorial, often initiated by venous hypertension caused by reflux, obstruction, or a combination of both. Over time, sustained elevated venous pressure leads to capillary damage, inflammation, and tissue remodelling [4]. Clinically, CVI is classified using the CEAP (Clinical-Etiologic-Anatomic-Pathophysiologic) system, which guides diagnosis, treatment, and monitoring.

The diagnosis of CVI relies heavily on imaging, with color duplex ultrasonography being the gold standard [5]. This non-invasive modality combines B-mode imaging with Doppler flow analysis,

allowing real-time visualization of venous anatomy, valve function, and the presence of reflux. It is particularly effective in assessing both superficial and deep veins, mapping the extent of disease, and guiding interventional planning [6].

Despite the importance of early diagnosis, many patients in resource-limited settings present at advanced stages, when complications have already developed. Therefore, understanding the epidemiology and ultrasonographic patterns of CVI in such populations is crucial [7].

This study was undertaken to retrospectively evaluate the prevalence, distribution, and severity of lower limb venous insufficiency using color duplex ultrasonography in a tertiary care setting in Bihar, India. By identifying the most commonly involved venous segments and associated clinical features, the study aims to reinforce the utility of duplex imaging in routine clinical practice and contribute to better disease management and preventive strategies in the region.

Materials And Methods

This retrospective observational study was conducted in the Department of Radiodiagnosis at Sri Krishna Medical College and Hospital, Muzaffarpur, Bihar, India, over a period of 12 months, from April 2020 to March 2021. The primary objective of the study was to evaluate the anatomical patterns, segmental distribution, and hemodynamic severity of lower limb venous insufficiency in patients with clinically suspected chronic venous disease (CVD), using color duplex ultrasonography (CDUS).

A total of 120 patients were enrolled in the study based on a predefined set of eligibility criteria. All patients underwent a thorough clinical assessment and subsequent high-resolution duplex ultrasound examination of the lower extremity venous system. Demographic details and clinical symptoms such as leg swelling, pain, aching, varicose veins, skin pigmentation, and venous ulcers were documented. This data was retrospectively obtained from patient medical records and imaging archives maintained in the department.

Inclusion Criteria:

- Patients aged 18 years and above.
- Patients presenting with clinical symptoms suggestive of chronic venous insufficiency such as lower limb swelling, heaviness, aching pain, visible varicose veins, hyperpigmentation, or venous ulcers.
- Patients who underwent complete color duplex ultrasound examination of the lower limb venous system during the study period.

- Patients with complete clinical and imaging documentation available in the hospital database.

Exclusion Criteria:

- Patients with acute deep vein thrombosis (DVT) or superficial thrombophlebitis at the time of presentation.
- Patients with a history of previous venous surgery, sclerotherapy, or endovenous thermal ablation.
- Pregnant women, due to physiological changes affecting venous flow and ethical considerations.
- Patients with incomplete clinical records or missing imaging documentation.

Ultrasonographic Evaluation: All color duplex ultrasonography scans were performed using a high-frequency linear transducer operating at 7–12 MHz, integrated into a high-resolution Doppler ultrasound system. The examinations were conducted by trained radiologists with specialized experience in vascular imaging. Each scan was performed in the upright (standing) position with the legs externally rotated and slightly flexed at the knee, to optimize vein visualization and promote gravitational filling of the venous system.

The study comprehensively evaluated the superficial venous system—including the great saphenous vein (GSV) and small saphenous vein (SSV); the deep venous system—including the common femoral vein (CFV), superficial femoral vein (SFV), popliteal vein, and posterior tibial vein; and the perforator veins—especially those in the medial thigh and calf. The presence and location of venous reflux were assessed using dynamic maneuvers such as distal limb compression-release and the Valsalva maneuver.

Venous reflux was defined as retrograde blood flow persisting:

- For more than **0.5 seconds** in superficial and perforator veins.
- For more than **1 second** in deep veins.

These thresholds were applied in accordance with the criteria established by the Society for Vascular Surgery and the American Venous Forum guidelines.

Data Collection and Statistical Analysis: Demographic details (age, sex), clinical symptoms, and ultrasonographic findings were systematically recorded and entered into a Microsoft Excel database. The severity of venous insufficiency was graded as mild, moderate, or severe based on the extent of reflux, number of segments involved, and duration of reversed flow.

All data were analyzed using descriptive statistical methods. Continuous variables were presented as mean $\pm$ standard deviation (SD), while categorical variables were expressed as frequencies and percentages. No inferential statistics were applied due to the non-comparative and descriptive nature of the study.

This comprehensive methodological framework enabled an accurate characterization of the anatomical and hemodynamic features of lower limb

venous insufficiency in the target population, underscoring the diagnostic utility of duplex ultrasonography as a non-invasive, first-line imaging modality in chronic venous disease evaluation.

Results

A total of 120 patients were assessed using color duplex ultrasonography for suspected lower limb venous insufficiency. The majority were males in the 41–60-year age group.

Table 1: Age and Gender Distribution of the Study Population

Demographic Group	Number of Patients (n)	Percentage (%)
Age 21–40 years	36	30.0%
Age 41–60 years	64	53.3%
Age >60 years	20	16.7%
Male	72	60.0%
Female	48	40.0%

Table 2: Clinical Presentation of Patients

Symptom	Patients Affected (n)	Percentage (%)
Leg swelling	82	68.3%
Pain/heaviness	66	55.0%
Visible varicosities	50	41.7%
Skin hyperpigmentation	32	26.7%
Venous ulcer (active/healed)	16	13.3%

Table 3: Laterality of Venous Involvement

Laterality	Number of Patients (n)	Percentage (%)
Bilateral	52	43.3%
Unilateral Left	40	33.3%
Unilateral Right	28	23.4%

Table 4: Distribution of Superficial Vein Involvement

Superficial Vein	Number of Patients (n)	Percentage (%)
Great Saphenous Vein	78	65.0%
Small Saphenous Vein	34	28.3%
Both GSV and SSV	20	16.7%

Table 5: Perforator Vein Involvement

Perforator Vein Status	Number of Patients (n)	Percentage (%)
Incompetent	46	38.3%
Competent	74	61.7%

Table 6: Deep Vein Reflux Findings

Deep Vein System	Number of Patients (n)	Percentage (%)
Femoral vein	18	15.0%
Popliteal vein	14	11.7%
Both femoral & popliteal	6	5.0%
Total (any deep vein)	26	21.7%

Table 7: Reflux Duration by Venous Segment

Venous Segment	Mean Reflux Duration (sec)	SD ($\pm$)
Great Saphenous Vein	0.79	0.24
Small Saphenous Vein	0.65	0.21
Perforator veins	0.58	0.20
Femoral vein	1.24	0.30
Popliteal vein	1.08	0.27

Table 8: Classification of Reflux Severity

Severity of Reflux	Number of Patients (n)	Percentage (%)
Mild	34	28.3%
Moderate	55	45.8%
Severe	31	25.9%

Table 9: Pattern of Venous Involvement (Combinations)

Involvement Pattern	Patients (n)	Percentage (%)
Superficial only (GSV/SSV)	58	48.3%
Superficial + Perforator	28	23.3%
Superficial + Deep	14	11.7%
Superficial + Perforator + Deep	20	16.7%

Table 10: Occupational Profile of Affected Individuals

Occupation Type	Patients (n)	Percentage (%)
Manual laborers	38	31.7%
Teachers/shopkeepers	30	25.0%
Office workers (sedentary)	22	18.3%
Housewives	20	16.7%
Others	10	8.3%

Discussion

The present retrospective study evaluated the utility of color duplex ultrasonography in diagnosing lower limb venous insufficiency, analyzing data from 120 patients who presented with symptoms suggestive of chronic venous disease. The results underscore the high prevalence of venous reflux among middle-aged adults, with a male predominance [8]. Most of the affected individuals fell within the 41–60 years age group, aligning with existing literature that identifies increasing age as a significant risk factor due to degenerative changes in venous valves and prolonged exposure to occupational or lifestyle-related stress on the lower limb venous system [9].

Clinically, leg swelling and heaviness emerged as the most common symptoms, followed by visible varicosities and skin changes such as hyperpigmentation. A notable subset of patients presented with venous ulcers, highlighting the progressive nature of untreated or severe venous insufficiency [10]. Bilateral disease was more common than unilateral, with a slight predominance for left-sided involvement, a finding that could be attributed to anatomical factors such as the crossing of the left iliac vein under the right iliac artery (May-Thurner syndrome), which predisposes the left lower limb to venous outflow obstruction and subsequent reflux [11].

Color duplex ultrasound proved instrumental in identifying the exact site and extent of venous reflux. The great saphenous vein was the most frequently affected superficial vein, supporting its known vulnerability to valvular incompetence due to its length, superficial location, and role in primary varicose veins [12,13]. Incompetent perforator veins were observed in over a third of the cases and often coexisted with superficial reflux. These perforators serve as conduits between the superficial and deep

systems, and their incompetence plays a crucial role in the pathophysiology of chronic venous hypertension [14,15].

Deep venous reflux, though less prevalent, was still significant, especially in the femoral and popliteal veins. The mean reflux duration was higher in deep veins compared to superficial veins, indicating more advanced or chronic venous pathology. This is clinically relevant, as deep vein incompetence is associated with more severe manifestations, including skin changes and ulceration, which were observed in the study population [16,17,18].

Overall, the findings of this study are consistent with previous reports in the literature that affirm the role of color duplex ultrasound as a gold standard for the assessment of lower limb venous insufficiency. It is a non-invasive, widely available, and reliable imaging modality that not only confirms clinical suspicion but also aids in treatment planning by identifying the anatomical level and severity of reflux. Despite the study's retrospective nature and the absence of long-term follow-up, it offers valuable insights into the diagnostic patterns and epidemiology of venous insufficiency in the regional population.

Conclusion

Color duplex ultrasonography has proven to be an invaluable, non-invasive diagnostic tool for the comprehensive assessment of lower limb venous insufficiency. This retrospective study of 120 patients demonstrated a high prevalence of superficial venous reflux, particularly involving the great saphenous vein, with a significant proportion also showing incompetence in perforator and deep venous systems. The findings highlight that middle-aged males, especially those engaged in occupations

requiring prolonged standing, are disproportionately affected.

The study reinforces the clinical utility of duplex scanning in accurately identifying the anatomical distribution and severity of venous reflux, thereby enabling precise treatment planning and risk stratification. Early detection through duplex imaging not only guides therapeutic decisions but also helps in preventing disease progression and complications such as skin changes and venous ulcers. Given its diagnostic precision, duplex ultrasound should be considered a first-line modality in the evaluation of suspected chronic venous insufficiency.

Further prospective studies with larger populations and long-term follow-up are warranted to evaluate the effectiveness of interventions guided by duplex findings and to explore the prognostic implications of various reflux patterns.

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