

Role of Colour Doppler Imaging in Lower Limb Swelling

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Abstract: Background: Lower limb swelling has diverse etiologies, often requiring imaging for accurate diagnosis. Color Doppler ultrasonography is a non-invasive and cost-effective tool for evaluation of lower limb swellings. Aim: To assess the effectiveness of Color Doppler ultrasonography in diagnosing vascular causes of lower limb swelling and localizing affected vessels. Materials and Methods: This prospective study, conducted at Guru Nanak Dev Hospital, Amritsar (over a period of two year), included 100 patients aged >14 years with lower limb swelling. Exclusions were systemic causes and non-consent. All patients underwent clinical evaluation and Color Doppler using a Mindray DC-8 system. Results and Discussion: Doppler imaging successfully identified vascular pathology in most cases of lower limb swelling and helpful in differentiating arterial from venous causes and localizing vessel involvement also helpful in ruling out associated other soft tissue abnormalities. Conclusion: Color Doppler ultrasonography is an effective, first-line modality for evaluating lower limb swelling, guiding diagnosis and management while minimizing invasive testing.

Keywords: Color Doppler ultrasonography, lower limb swelling, vascular diagnosis, non-invasive imaging, clinical evaluation

1. Introduction

Swelling of the lower limbs is a frequently encountered clinical symptom with a broad differential diagnosis, ranging from vascular disorders and systemic conditions to localized musculoskeletal or lymphatic pathologies. Accurate and timely identification of the underlying cause is crucial for effective treatment and improved patient outcomes. While traditional imaging modalities like venography, CT angiography, and MR angiography have been utilized for vascular assessment, these often involve ionizing radiation, high cost, or invasive procedures.¹

Color Doppler ultrasound has emerged as a non-invasive, readily available, and cost-effective diagnostic tool that integrates real-time anatomical imaging with dynamic evaluation of blood flow. Its utility lies in detecting venous thrombosis, assessing arterial perfusion, evaluating hemodynamic changes, and characterizing soft tissue lesions. The superficial location of vascular structures in the limbs enhances the efficacy of this modality, enabling high-resolution visualization and accurate functional assessment. This study explores the clinical applications and diagnostic value of Color Doppler in evaluating lower limb swelling, highlighting its role in guiding management and reducing the reliance on more invasive techniques.²

2. Materials and Methods

This prospective observational study was conducted at Guru Nanak Dev Hospital, Amritsar, over a time period of two year, following ethical approval. It included 100 patients over 14

years of age presenting with unilateral or bilateral lower limb swelling due to suspected arterial or venous causes. Patients with systemic causes or those who did not consent were excluded.

Written informed consent was obtained, and clinical details were recorded in a standardized proforma. All patients underwent grayscale ultrasound and color Doppler evaluation using Mindray DC-8 Doppler machine with linear (3–12 MHz) and curved (3–5 MHz) transducers. Examinations were performed in various patient positions depending on the area of interest.

Both arterial and venous systems were assessed, with special attention to vessel anatomy, pulsatility, compressibility, and wall characteristics. Additional findings such as lymphadenopathy, cysts, hematomas, and edema were noted. In suspected non-vascular cases, a limited two-point Doppler study was conducted.

Color Doppler imaging was used to assess flow presence, direction, and pattern. The Valsalva maneuver was employed to evaluate venous reflux. Spectral Doppler measurements, including PSV, EDV, RI, and PI, were taken at relevant segments. Thrombus presence, perforator vein competence, and distal vein patency were evaluated.

3. Results

The study included 100 patients with lower limb swelling, predominantly in the 31–60 years age group, with an average age of 46.8 years. There was a clear male predominance (M:

F = 3.2:1). Most patients (64%) presented with swelling involving the whole leg. Unilateral swelling was slightly more common on the left (34%) than the right (28%), while 38% had bilateral involvement.

Common associated symptoms included varicosities (34%) and pain (28%). Diabetes (24%), obesity (26%), and smoking/ alcohol history (17%) were notable risk factors. Trauma (14%) and post-surgical complications (2%) were less frequent.

Gray scale ultrasound revealed subcutaneous edema in 45%, lymphadenopathy in 26%, and cellulitis in 14%. Less frequent findings included Baker's cysts (7%), osteomyelitis (6%), and soft tissue masses (2%).

Color Doppler detected deep vein thrombosis in 22% of patients, most commonly in the common femoral and popliteal veins, with statistically significant associations. Varicose veins were the most common pathology (32%), showing significant findings at the saphenofemoral and saphenopopliteal junctions. Arterial abnormalities were noted in 8–10% of patients, including intimal thickening, plaques, stenosis, and occlusions. These findings also showed statistical significance ($p < 0.05$).

Waveform analysis indicated arterial stenosis of varying degrees in a small number of patients, with most showing normal triphasic patterns.

4. Discussion

This study comprehensively evaluated the clinical and Doppler characteristics of 100 patients with lower limb swelling, emphasizing the interplay between venous, arterial, and soft tissue pathologies. Most patients were aged 31–60 years, with a peak in the 31–40 group (30%), followed by 41–50 (29%) and 51–60 (24%). These trends align with Narra RK et al. (2018)⁴ and Cesarone MR et al. (2002)⁵, while Adebayo OL et al. (2025)⁶ reported a younger mean age and wider variation.

A male predominance was observed (78%), consistent with Narra RK et al. (2018)⁴ and Adebayo OL et al. (2025)⁶, possibly reflecting gender-based differences in risk exposure or healthcare behaviour. Clinically, whole-leg swelling was most common (64%), with bilateral involvement in 38% and a left-sided predominance in unilateral cases, supporting anatomical explanations by Dodd H and Cockett FD (1976)⁷, Abuzaid SH et al. (2016)⁸.

Common symptoms included pain (28%), varicosities (34%), skin discoloration (24%), and ulceration (14%), echoing findings by Narra RK et al. (2018)⁴ and Attaran RR et al. (2023)⁹. Risk factors like diabetes (24%), obesity (26%), smoking (17%), and trauma (14%) correspond with reports from Alamri AS et al. (2023)¹⁰, Kesieme et al. (2011)¹¹, and Kirankumar K et al. (2020)¹².

Grey-scale ultrasound frequently showed subcutaneous edema (45%) and lymphadenopathy (26%), consistent with Edzie EL et al. (2021)¹³, Boyd DA (2004)¹⁴, and Baz AA and Hassan TA (2018)¹⁵. Venous Doppler identified thrombi in 32 venous segments—especially the common femoral and

popliteal veins (8% each)—with findings consistent with Ibrahim MZ et al. (2020)¹⁶, Tuladhar AS et al. (2022)¹⁷, and Adeyinka AO (2010)¹⁸.

Statistical analysis showed strong associations between thrombi and altered Doppler signals ($p \leq 0.001$), aligning with diagnostic accuracy reported by Cavaye et al. (1990)¹⁹ and Baxter et al. (1990)²⁰. Among superficial veins, SFJ incompetence (26%) and SPJ incompetence (16%) were most frequent, supported by Huh S et al. (2011)²¹, Sharma D et al. (2020)²², and Azhar et al. (2017)²³, with a significant Chi-square result ($\chi^2 = 28.38$, $p < 0.001$).

Arterial grayscale findings were mostly normal (67%), though 13% had intimal thickening, 12% soft plaques, and 8% calcifications. Stenosis and occlusion were found in 8% and 2% respectively, with a statistically significant link to swelling ($\chi^2 = 7.815$, $p < 0.05$), in line with Islam SN et al. (2021). Most Doppler waveforms were normal (90%), though a minority showed monophasic patterns or occlusion, consistent with Xenogiannis et al. (2012)²⁴ and Rooke TW et al. (2011)²⁵.

Colour Doppler showed venous and soft tissue causes to be more prevalent than arterial ones: varicose veins (32%), DVT (22%), PAD (8%), lymphadenopathy (26%), cellulitis (14%), and other soft tissue findings matched distributions noted by Abuzaid SH et al. (2016)²⁶, Gorman W et al. (2000)²⁷, and Ely JW et al. (2006)²⁸. Doppler proved highly effective, with high sensitivity for varicose veins and DVT, as supported by Sharma D et al. (2020).

No significant correlation was found between vascular pathology and side of limb involved ($p = 0.76$), indicating equal likelihood of right or left limb presentation. This emphasizes the need for thorough bilateral assessment regardless of side.

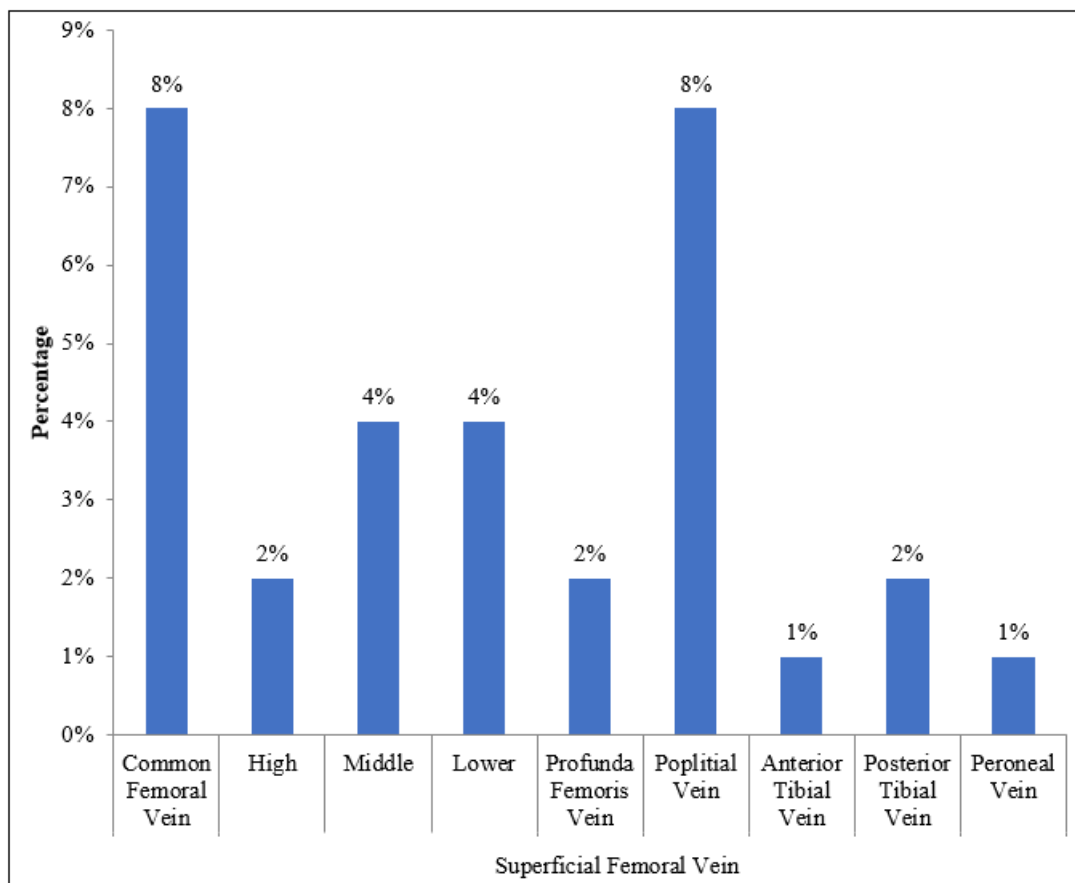
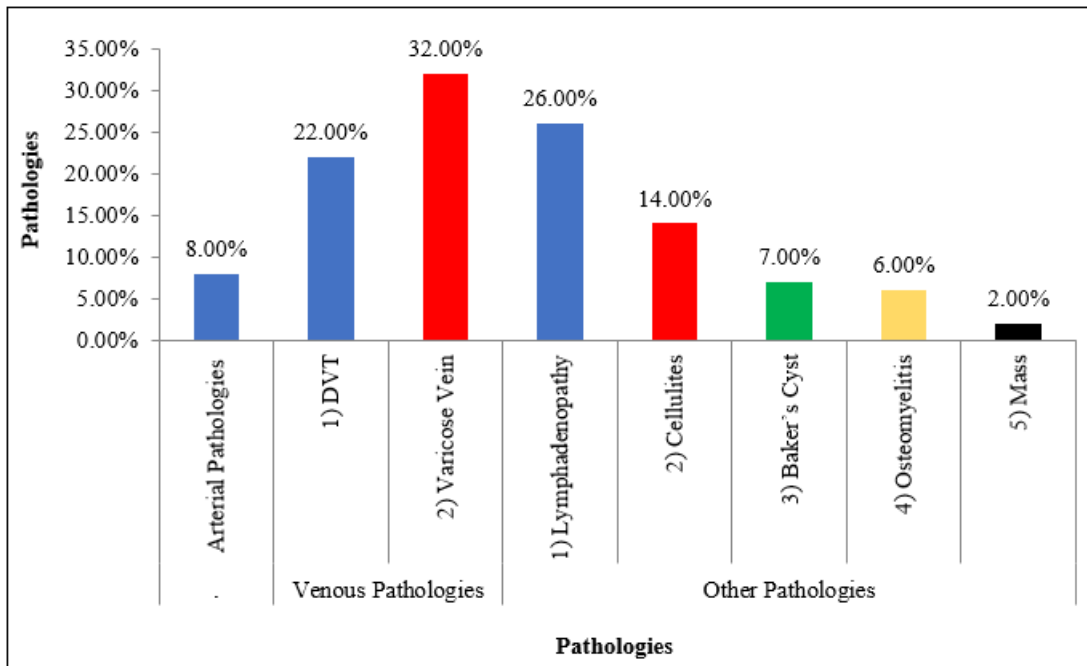
5. Summary

This study assessed 100 patients with lower limb oedema, revealing a predominance of middle-aged males. Whole-leg swelling (64%) was the most common presentation, often left-sided in unilateral cases. Common symptoms included varicosities (34%) and pain (28%).

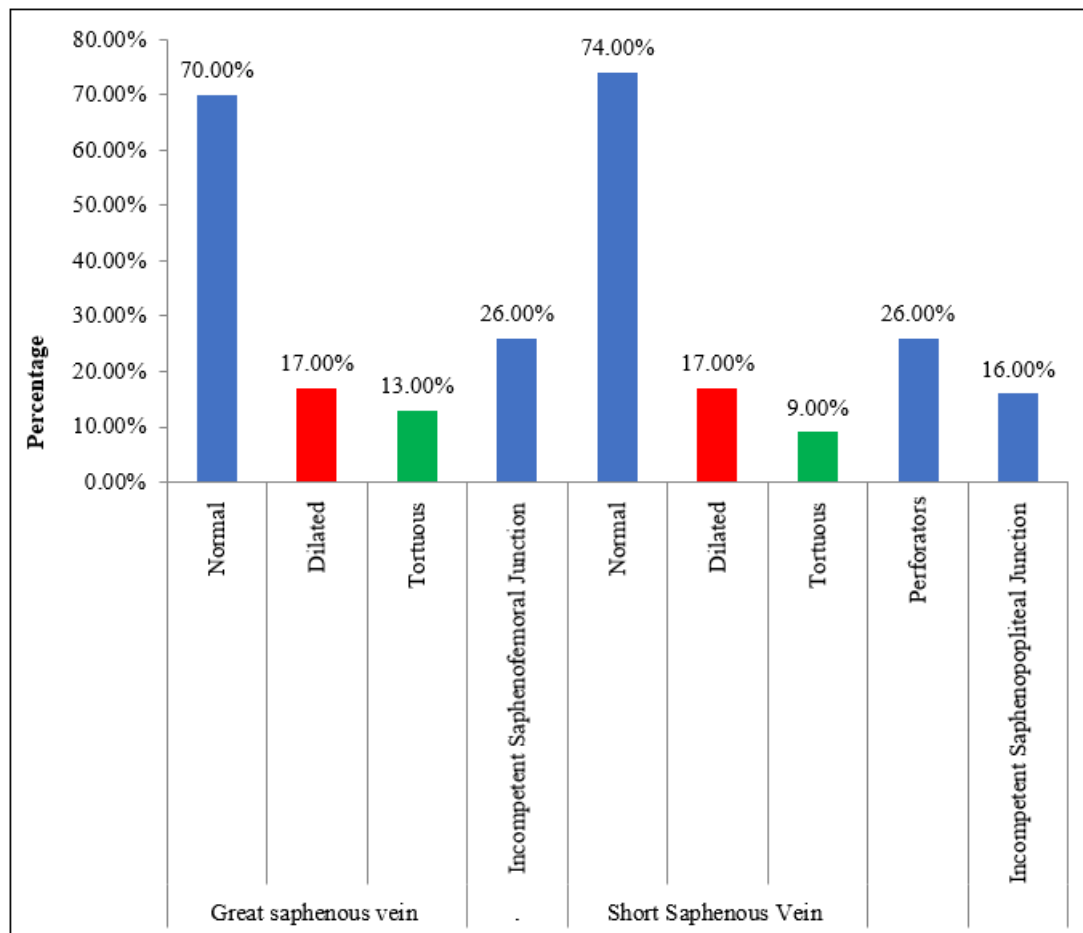
Key risk factors identified were obesity (26%), diabetes (24%), smoking, alcohol use (17% each), and trauma (14%). Grayscale ultrasound showed subcutaneous edema (45%) and lymphadenopathy (26%) as leading soft tissue findings.

Colour Doppler detected venous thrombosis mainly in the common femoral and popliteal veins, with significant associations of absent or diminished flow. SFJ incompetence (26%) was the most common superficial venous abnormality. Arterial changes were less frequent but included intimal thickening (13%) and stenosis (8%).

Venous and soft tissue causes were more prevalent than arterial ones, reinforcing Colour Doppler's value as a sensitive, non-invasive diagnostic tool. No significant link was found between vascular pathology and limb side, supporting the need for bilateral assessment.



Distribution of DVT (Thrombus) in Lower Limb Swelling (N=100)



Colour Doppler Imaging of Varicose Veins in Cases of Lower Limb Swelling (N=100)

6. Conclusion

This comprehensive study highlights the multifactorial aetiology of lower limb swelling, with venous, arterial, and soft tissue abnormalities all contributing to the clinical presentation. Colour Doppler ultrasound proved to be an indispensable, non-invasive diagnostic tool, offering high sensitivity and specificity in identifying vascular pathologies, particularly varicose veins and deep vein thrombosis (DVT), which were the most commonly observed conditions.

Venous disorders were significantly more prevalent than arterial abnormalities, with 32% of patients presenting with varicose veins and 22% with DVT, compared to 8–10% showing signs of peripheral arterial disease (PAD). Soft tissue findings such as lymphadenopathy (26%), cellulitis (14%), and cystic or inflammatory changes further expanded the differential diagnosis.

Anatomical trends, such as higher incidence of left-sided DVT, were noted but did not show statistically significant correlation with the side of limb affected. Furthermore, significant associations were established between clinical symptoms, venous incompetence, and thrombus presence, particularly in the femoropopliteal venous segments.

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