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A COMPARATIVE EVALUATION OF SCLEROSANTS USED IN THE MANAGEMENT OF VARICOSE VEINS

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ABSTRACT

Background: Varicose veins, a manifestation of chronic venous insufficiency, often result from perforator vein incompetence (PVI). Sclerotherapy, which uses agents such as sodium tetradecyl sulfate (STS) and polidocanol, offers minimally invasive management. This study aimed to compare the efficacy and safety of STS and polidocanol in treating perforator incompetence in the lower extremities.

Methods: This prospective, hospital-based comparative study evaluated the efficacy and safety of STS and polidocanol foam sclerotherapy in treating perforator incompetence in the lower extremities. Fifty patients with varicose veins and perforator incompetence were randomly assigned to receive either STS (Group 1, n=50) or polidocanol (Group 2, n=50) foam sclerotherapy. Patients were assessed at baseline and followed up at 2-, 4-, 8-, and 12-weeks post intervention. The primary outcome was anatomical success, defined as complete or partial obliteration of the treated perforator vein, without reflux. The secondary outcomes included clinical success, wound healing, and adverse events.

Results: Both groups were comparable in terms of age, sex, comorbidities, CEAP grade, diabetes duration, and HbA1c levels ($P > 0.05$). Group B showed significantly better wound healing (68% vs. 52% complete healing, $P = 0.025$), greater vein closure (72% vs. 36% complete closure, $P = 0.0007$), and reduced reflux (16% vs. 44%, $P = 0.002$). Adverse events were more frequent in Group A, including higher rates of hyperpigmentation (32% vs. 12%), paraesthesia (20% vs. 8%), skin necrosis (8% vs. 0%), and superficial vein thrombosis (12% vs. 4%). No anaphylactic shock was reported, and symptomatic DVT occurred only in Group A (4%).

Conclusion: Polidocanol foam sclerotherapy demonstrated superior efficacy and safety over STS for treating perforator incompetence, with better healing, higher closure rates, and fewer complications than STS.

Keywords: Varicose veins, Sclerotherapy, Polidocanol, Sodium tetradecyl sulfate, Perforator incompetence, Foam sclerotherapy

INTRODUCTION

Varicose veins represent a common clinical manifestation of chronic venous insufficiency (CVI), affecting up to 30% of the adult population globally.[1,2] These veins primarily result from venous valve dysfunction, which causes retrograde blood flow, venous hypertension, and the progressive dilation of superficial and perforator veins.[3] Among the contributing factors, perforator vein incompetence is identified as a key factor in the pathophysiology of chronic venous disorders, particularly in advanced stages associated with oedema, skin changes, and venous ulcers.[4]

Perforating veins that connect the superficial and deep venous systems are crucial for maintaining unidirectional blood flow. When these veins become incompetent, they permit the reflux of high-pressure blood from the deep to the superficial system, thereby exacerbating venous hypertension.[5] Therefore, addressing incompetent perforators is essential for comprehensively treating CVI and varicose veins. Historically, surgical ligation has been employed; however, less invasive methods such as sclerotherapy have attained greater recognition due to their reduced morbidity, improved patient tolerance, and favourable cosmetic outcomes.[5,6,7]

Sclerotherapy involves the administration of a sclerosant solution directly into an incompetent vein, resulting in endothelial damage, thrombosis, and subsequent fibrosis, eventually resulting in vein obliteration.[8,9] This

procedure is widely used for both cosmetic and therapeutic purposes, with increasing applications in the treatment of deeper and larger-diameter veins, including perforators.[10] Among the available sclerosants, sodium tetradecyl sulfate (STS) and polidocanol (POL) are two commonly used agents.[8,9] Both are detergent-based sclerosants but differ in chemical composition, potency, and tissue reactivity.

STS, an anionic surfactant, is recognised for its potent endothelial destructive properties, making it particularly effective in larger and higher-pressure venous segments. However, it is also associated with a relatively higher incidence of local inflammatory responses and complications, such as pigmentation and phlebitis.[11] In contrast, polidocanol, a non-ionic surfactant, exhibits a milder action profile with improved local tolerance and fewer inflammatory adverse events, although it may result in a potentially slower onset of sclerosis in certain cases.[12,13]

Although both agents are widely used, direct comparisons assessing their effectiveness in treating perforator vein incompetence are limited. Considering the anatomical and haemodynamic features of perforators and their role in chronic venous disease progression, a direct evaluation of these sclerosants is clinically important. Our study aimed to compare STS and polidocanol in treating perforator incompetence of the lower extremities via sclerotherapy to determine which agent offers better effectiveness and safety. The results of this study will help clinicians make informed choices regarding sclerosant selection, thereby enhancing treatment outcomes and slowing the progression of chronic venous disease.

MATERIALS AND METHODS

This prospective hospital-based comparative study was conducted in 100 patients with varicose veins and perforator incompetence at the Department of Vascular Surgery, Saveetha Medical College and Hospital, for a period of 2 years, from March 2023 to March 2025. The study was approved by the Institutional Ethics Committee (IEC), and informed consent was obtained from all patients before the study initiation.

Inclusion criteria

The study included patients aged ≥ 18 years with unilateral or bilateral primary symptomatic varicose veins (grade C_2 or higher according to the clinical, etiologic, anatomical, and pathophysiological [CEAP] classification system, with C_0 indicating no signs of venous disease, C_1 telangiectases or veins ≤3 mm in diameter, C_2 varicose veins >3 mm in diameter, C_3 the presence of oedema, C_4 skin and subcutaneous changes, C_5 healed ulcers, and C_6 active ulceration) and perforator incompetence on duplex ultrasonography with or without a nonhealing ulcer.

Exclusion criteria

Patients having clinical or radiological evidence of deep venous thrombosis, superficial-vein thrombosis, pregnancy, deranged coagulation profile, cardiac anomalies any other secondary varicose vein, congenital varicose vein and not giving consent contraindications to the use of foam or general or regional anaesthesia, perforators < 2 mm or more than 6 mm were excluded for this study

Methods

All Patients underwent a comprehensive baseline assessment upon enrolment. Demographic information, including age, sex, and diabetes duration, was recorded. A detailed medical history was obtained to identify comorbidities such as hypertension, dyslipidaemia, and previous venous disease. Baseline vein characteristics, such as the size, depth, and anatomical location of perforators, were evaluated and documented using duplex ultrasonography. Standardised techniques ensured consistent vein measurements among patients. Blood samples were also collected for laboratory analyses, including glycated haemoglobin (Hba1c) and lipid profiles, to assess the baseline metabolic status.

Patients (n=100) were randomly assigned to two treatment groups. In Group 1 (n=50), patients received STS foam sclerotherapy. The procedure involved cannulating incompetent perforator veins using a scalp vein set under ultrasound guidance, followed by the injection of foam prepared by mixing 1 ml of STS with 4 ml of air (1:4 dilution). In Group 2 (n=50), patients received polidocanol-based foam sclerotherapy prepared using 1 ml of polidocanol, 1 ml of normal saline, and 6 ml of air (1:6 dilution). The foam was similarly administered through a scalp vein set after ultrasound-guided cannulation. Immediate post-procedure assessments were conducted for both groups to evaluate procedural success and monitor any acute adverse reactions. A subsequent early evaluation was performed on postoperative day (POD) 2 to assess short-term outcomes.

All patients were scheduled for follow-up visits at 2, 4, 8, and 12-weeks post intervention. During each visit, duplex ultrasound was performed to assess the treated veins for changes in diameter, the presence of reflux, and the degree of anatomical closure. The veins were categorised as completely obliterated, partially occluded, or

patent. The clinical evaluation also included the assessment of skin changes, such as hyperpigmentation, ulceration, or necrosis. Patients were asked to complete a structured questionnaire to report their experiences with the procedure, including comfort and satisfaction with the sclerosant used. Any adverse events, including superficial vein thrombosis, paraesthesia, skin necrosis, anaphylaxis, and signs of deep venous thrombosis, were thoroughly documented.

Data were systematically collected at each time point using standardised case report forms and entered into a secure database. All ultrasonographic assessments were conducted by an experienced vascular sonographer who was blinded to the treatment allocation to minimise the observer bias. Repeated ultrasound imaging provided a consistent anatomical evaluation across time points.

The primary outcome of the study was anatomical success, defined as complete or partial obliteration of the treated perforator vein without reflux, as assessed using duplex ultrasound. The safety profile of each sclerosant was evaluated based on the incidence and severity of adverse events. Secondary outcomes included clinical success, determined by the absence of residual varicosities at 6 weeks and 3 months, and wound healing in patients with venous ulcers. The healing status was categorised as complete, partial, or nonhealing based on clinical examination.

Statistical analysis

Data were presented as mean, standard deviation, frequency and percentage. Continuous variables were compared using the independent sample t-test. Categorical variables were compared using the Pearson chi-square test. Significance was defined by P values less than 0.05 using a two-tailed test. Data analysis was performed using IBM SPSS version 21.0.

RESULTS

The mean age of patients in Group A was 50.92 years, while it was 47.16 years in Group B, with no significant difference (P = 0.245). Most patients in both groups were male (84% in Group A and 72% in Group B), and female patients comprised 16% in Group A and 28% in Group B; this difference was not significant (P = 0.148). Comorbidities were observed in 80% of patients in Group A and 76% in Group B, showing no significant difference (P = 0.629).

Regarding CEAP grades, C2 was observed in 12% and 20% of patients in Groups A and B, respectively; C3 in 24% and 32%, respectively; C4 in 12% and 8%, respectively; C5 in 32% and 16%, respectively; and C6 in 20% and 24%, respectively. The difference in CEAP grading was not significant (P = 0.306). The duration of diabetes was 8.1 ± 1.2 years in Group A and 8.1±1.2 years in Group B, with no significant difference (P = 0.691). The HbA1c level, which indicates blood sugar control, was 7.1±0.9% in Group A and 7.0±0.8% in Group B, with no significant difference (P = 0.679) (Table 1).

Table 1: Comparison of demographics and clinical characteristics between groups

		Group A	Group B	P value
Age (in years)		50.92±11.83	47.16±10.74	0.245
Sex	Male	42(84%)	36(72%)	0.148
	Female	8(16%)	14(28%)	
Comorbidity	Yes	40(80%)	38(76%)	0.629
	No	10(20%)	12(24%)	
CEAP grade	C2	6(12%)	10(20%)	0.306
	C3	12(24%)	16(32%)	
	C4	6(12%)	4(8%)	
	C5	16(32%)	8(16%)	
	C6	10(20%)	12(24%)	
Duration of diabetes (in years)		8.1±1.2	8.1±1.2	0.691
HbA1c (%)		7.1±0.9	7.0±0.8	0.679

In terms of wound healing, complete wound healing was reported in 52% of patients in Group A and 68% in Group B. Partial healing occurred in 12% of Group A and 24% of Group B patients, while nonhealing wounds were more common in Group A (36%) than in Group B (8%) with a significant difference (P = 0.025), with better healing in Group B.

Regarding vein closure, complete closure was reported in 36% of patients in Group A and 72% in Group B. Partial closure was found in 44% of Group A and 24% of Group B, while the vein remained open (patent) in 20% and 4%, respectively, showing a significant difference (P = 0.0007), with Group B showing better vein closure. Reflux was reported in 44% of patients in Group A and 16% in Group B, while it was absent in 56% and 84% (P = 0.002); this difference was significant, with less reflux seen in Group B (Table 2).

Table 2: Comparison of clinical outcomes between the groups

		Group A	Group B	P value
Wound Healing Status	Complete	26(52%)	34(68%)	0.025
	Partial	6(12%)	12(24%)	
	Non-healing	18(36%)	4(8%)	
Closure of the veins	Complete	18(36%)	36(72%)	0.0007
	Partial	22(44%)	12(24%)	
	Patent	10(20%)	2(4%)	
Presence of reflex	Yes	22(44%)	8(16%)	0.002
	No	28(56%)	42(84%)	

Regarding adverse events, superficial vein thrombosis was reported in 12% of patients in Group A and 4% in Group B. Hyperpigmentation occurred in 32% of Group A and 12% of Group B. Paraesthesia was noted in 20% of Group A and 8% of Group B. Skin necrosis was observed in 8% of Group A patients and was not observed in Group B. Anaphylactic shock was not reported in either group. Symptomatic deep vein thrombosis (DVT) occurred in 4% of patients in Group A and was absent in Group B. Overall, adverse events were more commonly reported in Group A than in Group B (Table 3).

Table 3: Comparison of adverse events between the groups

		Group A	Group B
Adverse events/complications	Superficial Vein Thrombosis	6(12%)	2(4%)
	Hyperpigmentation	16(32%)	6(12%)
	Paraesthesia	10(20%)	4(8%)
	Skin Necrosis	4(8%)	0
	Anaphylactic Shock	0	0
	Symptomatic DVT	2(4%)	0

DISCUSSION

In our study, which compared STS and polidocanol for treating perforator incompetence through sclerotherapy, both treatment groups were similar demographically. There were no significant differences between the groups in terms of age, sex distribution, or presence of comorbid conditions, such as diabetes mellitus and hypertension. Additionally, the CEAP classification and HbA1c levels were comparable. This demographic uniformity minimises major confounding factors, allowing for a more confident attribution of observed differences in clinical outcomes to the pharmacodynamic and pharmacokinetic properties of the respective sclerosants. This is consistent with studies by **Rabe et al.** and **Almeida et al.** which emphasised the importance of baseline uniformity for valid intergroup comparisons.[14,15] By matching key variables, including diabetes duration and HbA1c levels, our study strengthens the internal validity of the observed differences in clinical outcomes.

Regarding wound healing outcomes, patients in the polidocanol group showed a higher rate of complete ulcer healing and fewer nonhealing ulcers than those in the STS group. This indicates a more favourable clinical profile for polidocanol in facilitating tissue repair and resolving venous ulceration. Our results are consistent with those of **Guex et al.**, who reported that polidocanol was associated with improved ulcer healing rates and fewer nonhealing cases than STS. The milder detergent action of polidocanol, which causes less perivenous tissue irritation, may explain its enhanced healing profile.[16] In contrast, the more aggressive endothelial disruption caused by STS can lead to increased local inflammation, potentially impeding epithelial repair in ulcerated regions, a phenomenon also noted by **Hamel-Desnos et al.**[17] However, ulcer healing is affected by various factors, including compliance with compression therapy, dressing practices, and nutritional status, which were not specifically controlled in this study design. Therefore, while the difference in wound healing is significant, it should be interpreted cautiously, considering these variables.

In the polidocanol group, the anatomical closure rates and reflux resolution were markedly superior, with more complete vein occlusion and fewer instances of residual reflux than in the STS group. This underscores its superior efficacy in achieving physiological venous correction, which is a fundamental aspect of effective sclerotherapy. These findings are supported by the work of **Rabe et al.**, who found that polidocanol foam achieved higher rates of anatomical closure and reflux elimination in both superficial and perforating veins.[14] The superior efficacy of polidocanol may be attributed to its ability to form a more stable and homogeneous foam, ensuring better contact with the endothelium and more consistent ablation. Conversely, the more potent detergent action of STS, while effective in larger veins, may lead to uneven sclerosis and a higher likelihood of partial closure or recanalization, as noted by **Jia et al.** in their systematic review.[18]

These findings indicate that polidocanol foam provides a more dependable therapeutic outcome from both anatomical and haemodynamic perspectives. However, it is essential to consider the impact of the operator's technique and the interpretation of imaging; unblinded assessments or variations in ultrasound timing could introduce measurement bias. Furthermore, while complete closure is the ideal objective, partial closure can still lead to symptomatic improvement and should not be neglected.

The safety profiles of these two agents revealed significant differences. Group A (STS) experienced a higher incidence of complications, including superficial vein thrombosis, hyperpigmentation, paraesthesia, and notably skin necrosis, which are of considerable clinical concern in patients with chronic venous disease or impaired healing capacity. In contrast, Group B (polidocanol) showed a lower incidence of adverse events, with no reported cases of skin necrosis or symptomatic deep vein thrombosis. The milder irritant profile of polidocanol likely contributes to its superior tolerability, particularly in compromised or elderly patients. These findings are supported by **Hamel-Desnos et al.** and **Guex et al.**, who consistently reported lower rates of local and systemic complications with polidocanol than with STS.[16,17] This suggests that polidocanol may offer a better risk-benefit profile for routine or high-risk sclerotherapy than STS.

However, technique-related variables, such as injection speed, sclerosant concentration, and total volume administered, may have influenced the complication rates and should be standardised in future trials for better reproducibility. Moreover, although immediate adverse events were documented, longer-term follow-up is needed to fully assess chronic complications and late recanalization. While both agents are clinically effective in treating incompetent perforator veins, polidocanol demonstrated superior performance in terms of wound healing, anatomical closure, reflux reduction, and safety.

Limitations:

The small sample size of this study may affect the robustness and generalisability of the findings. A larger sample would provide more statistically significant results, but recruitment and resource constraints posed limitations in this study. The single-centre design restricts the applicability of the results due to specific institutional practices and demographics. The 12-week follow-up period may not fully capture the healing processes, especially for severe ulcers. A longer duration would better evaluate healing trajectories and recurrence rates, though this would increase study complexity.

CONCLUSION

Our study concluded that polidocanol foam sclerotherapy is more effective than STS for treating perforator incompetence in varicose veins. Polidocanol achieved higher vein closure rates, better reflux resolution, and improved wound healing. It showed fewer adverse events, including reduced superficial thrombosis, hyperpigmentation and skin necrosis. With comparable patient demographics, polidocanol demonstrated superior clinical and safety outcomes compared those with of STS.

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