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Optimal reverse Trendelenburg angle for vascular intervention during radiofrequency ablation of chronic venous insufficiency under spinal anesthesia

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ABSTRACT

Introduction: Chronic venous insufficiency (CVI) is a common vascular disorder significantly affecting patients' quality of life. Radiofrequency ablation (RFA) has become a key treatment, offering minimally invasive options with faster recovery. The reverse Trendelenburg (RT) position is frequently used to enhance venous dilation, facilitating vascular access during the procedure. However, the optimal RT angle remains unclear, particularly regarding vascular access success and hemodynamic stability. This study evaluated the effects of 15° and 30° reverse Trendelenburg (RT) angles on venous dilation, vascular access success, and hemodynamic stability during radiofrequency ablation (RFA) of the great saphenous vein (GSV) under spinal anesthesia for chronic venous insufficiency (CVI). The aim was to balance improved venous access against the risk of hemodynamic complications.

Materials and Methods: In this retrospective analysis, 521 patients undergoing RFA for GSV insufficiency were assigned to group A (15° RT, n=264) or group B (30° RT, n=257). The primary outcomes included changes in GSV diameter, incidence of hypotension, bradycardia, and vasoactive medication requirements. Secondary outcomes included the rate of complete vein closure, confirmed by duplex ultrasound 24 h post-procedure.

Results: The 30° RT position led to a significantly larger increase in GSV diameter than the 15° position (24.5% vs. 16.0%, p=0.019). However, the 30° angle was also linked to a higher occurrence of hypotension (20.6% vs. 7.5%, p<0.001) and bradycardia (10.5% vs. 2.2%, p<0.001). No significant differences were observed between the groups regarding the secondary outcome of vein closure (p>0.05).

Conclusion: Although a 30° RT angle enhanced venous dilation, it also increased the risk of hemodynamic instability. Tailoring patient positioning based on individual risk factors is essential for balancing venous access and procedural safety in RFA for CVI.

Keywords: Reverse Trendelenburg Position, Radiofrequency Ablation (RFA), Hemodynamic Stability

Introduction

Chronic venous insufficiency (CVI) is a common vascular disorder characterized by impaired venous return, leading to a spectrum of symptoms ranging from mild discomfort to serious complications.[1] Over the past two decades, minimally invasive endovenous techniques have become the cornerstone of surgical treatment for chronic venous insufficiency, supplanting conventional approaches. Th-

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ese techniques provide patients with safer, less invasive options, minimizing postoperative discomfort and faster recovery times, marking a significant advancement in the management of venous disease.[2, 3] Among the various treatment modalities, radiofrequency ablation (RFA) has gained popularity due to its effectiveness, minimal invasiveness, and reduced recovery times compared to traditional surgical interventions.[4] However, optimizing procedural conditions, particularly patient positioning, remains an area of active investigation.

Lower extremity venous duplex examinations were first performed in patients in the reverse Trendelenburg (RT) position.[5] Theoretically, successful cannulation for RFA is most likely when the vein is maximally dilated. Many studies have proven that RT position increases vessel diameter and facilitates vascular intervention.[6-8] Positioning a patient in RT posture during spinal anesthesia can facilitate vascular access during procedures and may also introduce risks of hemodynamic instability, such as hypotension or bradycardia. Various mechanisms contribute to hypotension during and after spinal anesthesia, with the most widely accepted explanation being reduced peripheral vascular resistance due to the spinal block's effect on the preganglionic sympathetic nerves. This block affects hemodynamics by lowering preload, afterload, myocardial contractility, and heart rate. Preload is particularly affected by vasodilation, caused by the sympathetic blockade, leading to peripheral blood pooling and diminished venous return.[9, 10] Although studies have outlined the overall benefits of the RT position, the optimal angle that maximizes the diameter of the great saphenous vein (GSV) during RFA for CVI under spinal anesthesia remains underexplored. This study aimed to determine the ideal RT angle that enhances GSV diameter, facilitating vascular access during RFA performed with spinal anesthesia.

Materials and Methods

Study Design and Population

We conducted a retrospective analysis of patients who underwent RFA for the GSV to treat CVI between January 2020 and February 2024. This study was approved by the Institutional Review Board and Ethics Committee of Local University (approval number: 2024/11). Written informed consent was obtained from all participants prior to inclusion. The research was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki.

The study included hemodynamically stable patients aged 18–75 years of either sex, with an American Society of Anesthesiologists (ASA) score of 1 or 2, and confirmed CVI requiring RFA intervention. Excluded from the study were individuals with contraindications to spinal anesthesia, significant comorbidities impacting hemodynamic stability, or a history of previous vascular interventions. Moreover, patients with an ASA physical status greater than 2, those with cardiovascular, renal, hepatic, respiratory, endocrine, or neuromuscular disorders, as well as individuals with epilepsy, psychiatric conditions, coagulopathy, spinal deformities, and allergies to anesthetic agents were excluded. Further exclusion criteria included significant edema in the lower extremities, venous thrombosis, prior vascular surgery in the same limb, anatomical anomalies of the GSV, and individuals unable to maintain the RT position to maintain the consistency and accuracy of ultrasound measurements.

The patient was positioned on the operating table, and a venous catheter was placed in the forearm using an 18G cannula. Standard monitoring, including electrocardiogram (ECG), non-invasive blood pressure (NIBP), and oxygen saturation (SpO_2), was initiated. Preoperative vital signs, such as SpO_2, diastolic and systolic blood pressure, mean arterial pressure, and pulse, were recorded. Following aseptic precautions, a subarachnoid puncture was performed at the L3-4 or L4-5 interspace using a 26G x 3.5-inch Quincke BD needle (0.45 mm x 90 mm). An intrathecal injection of 10 mg of 0.5% heavy bupivacaine was administered at a rate of 0.2 mL per second, with the bevel of the spinal needle oriented laterally. Each patient received 2 mL of 0.5% bupivacaine. After administering spinal anesthesia, patients remained in a supine position for 10 min to allow for adequate block onset. No sedation was administered to avoid interference with the evaluation of sensory blockade. Patients with an incomplete or partial block or those in whom access to the L3-4 or L4-5 space could not be achieved due to spinal block issues were excluded. Blood pressure (mean, systolic, and diastolic), respiratory rate, heart rate, and SpO_2 were continuously monitored. Patients were grouped based on their clinical characteristics and the RT angle used during the procedure, as documented in the medical records. The selected angle, as recorded in the medical charts, was maintained throughout the RFA procedure. Patient assignment to either the 15° or 30° RT position was based on the operating surgeon's preference at the time of the procedure. This retrospective analysis utilized existing clinical data to compare outcomes across the groups. These specific angles were selected by clinical experience and evidence from the literature, which highlighted their relevance in enhancing venous return and facilitating vascular access.[8, 11-14]

The 15° RT angle is commonly utilized in clinical practice due to its effectiveness in increasing venous diameter without significantly compromising hemodynamic stability.[8, 11, 12] This moderate elevation is often sufficient to improve venous visualization and access, making it a standard choice for procedures requiring optimal vascular conditions.

Conversely, a 30° angle, although less commonly employed, has been associated with further increases in venous dilation, potentially enhancing procedural success by improving the visibility and accessibility of target vessels.[13, 14] However, this steeper angle may result in an increased risk of hypotension as it leads to more pronounced venous pooling and reduced preload, which can be exacerbated by spinal anesthesia. A comparison between these two angles was intended to determine the optimal balance between procedural efficacy and hemodynamic safety during RFA for CVI.

Hypotension, defined as a systolic blood pressure of less than 90 mmHg or a mean arterial pressure (MAP) decrease of more than 20% from baseline, was managed with an intravenous bolus of 6 mg ephedrine. In cases of bradycardia, characterized by a heart rate of less than 45 beats per min, 0.6 mg of atropine was administered intravenously.

Ultrasound Measurements

Duplex ultrasound, utilizing a two-dimensional 7.5-MHz linear probe, measured the diameter of the GSV at a single anatomical point 2 cm below the saphenofemoral junction. The first measurement was taken 10 min after spinal anesthesia with the patient in the supine position. The second measurement was performed 10 min after placing the patient in either a 15° or 30° RT position. The percentage increase in GSV diameter between the two measurements was calculated to assess the degree of vein dilation. All measurements were performed by an experienced vascular surgeon who remained blinded to the RT angle assignment.

Operative Techniques

Once spinal anesthesia was confirmed, patients were positioned in the RT position according to their assigned group (group A: 15°; group B: 30°). The target limb underwent sterile preparation and draping. Under ultrasound guidance, the GSV was cannulated, and a guidewire was introduced. A 6F sheath was then advanced over the guidewire, positioning the RFA catheter at the saphenofemoral junction. The 7 cm Closure Fast™ (Covidien, Dublin, Ireland) system was used for RFA. Ablation followed a standardized protocol involving controlled energy delivery and the application of tumescent anesthesia along the GSV to achieve effective vessel closure and reduce thermal damage to surrounding tissues.

Outcome Measures

The primary outcomes assessed included the occurrence of hypotension and bradycardia during the procedure, the total dose of vasoactive medications administered, procedure duration, and patient-reported pain scores on a numerical rating scale (NRS) at 6 and 24 h post-procedure. The secondary outcome was the success rate of venous ablation, defined as complete closure of the target vein verified by duplex ultrasound 24 h after the procedure. Additionally, any complications, such as deep vein thrombosis (DVT), skin burns, hematoma, or nerve injuries, were documented.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics software, version 25 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test assessed the normality of data distribution. Qualitative variables were summarized as frequencies and percentages, parametric variables were described as means with standard deviations, and nonparametric variables were expressed as medians with interquartile ranges (IQRs). The chi-square test was used to compare categorical variables. The relationship between parametric continuous variables and dependents was determined using the independent sample t-test. Statistical significance was set at $p<0.05$.

Results

Patient characteristics

A total of 521 patients were included in the study, with 264 assigned to group A (15° RT) and 257 to group B (30° RT). Demographic comparisons between the two groups showed no significant differences ($p>0.050$) (Table 1). Baseline variables, such as age, sex, body mass index (BMI), and ASA classification, were similarly distributed across both groups, with no statistically significant differences ($p>0.05$).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Characteristic	Group A (15°)	Group B (30°)	p
Number of Patients (n)	264	257	-
Age (years, mean±SD)	54.9±8.5	55.7±9.8	0.451
Gender (n, %)			
Male	126 (47.7)	122 (47.4)	0.852
Female	138 (52.2)	135 (52.5)	0.786
Body Mass Index (kg/m², mean±SD)	27.4±3.2	26.7±3.5	0.620
ASA Physical Status (n, %)			
I	193 (73.1)	187 (72.7)	0.852
II	71 (26.8)	70 (27.2)	0.784
Baseline Hemodynamic Parameters			
Systolic BP (mm Hg, mean±SD)	129.7±14.9	130.5±15.2	0.792
Diastolic BP (mm Hg, mean±SD)	77.8±10.1	78.3±9.8	0.693
Heart Rate (bpm, mean±SD)	73.4±10.5	73.1±12.2	0.820

ASA: American Society of Anesthesiology; BMI: Body Mass Index; BP: Blood Pressure.

Hemodynamic Outcomes

Hypotension was significantly more prevalent in group B (30º) than in group A (15º) (20.6% vs. 7.5%, p<0.001). Bradycardia also occurred more frequently in group B (10.5% vs. 2.2%, p<0.001). Consequently, the use of ephedrine or atropine was notably higher in the 30º group (8.1% vs. 1.5%, p<0.001) (Fig. 1). None of the patients died, and one required coronary angiography. For all other measured variables, no significant differences were observed between the two groups (Table 2).

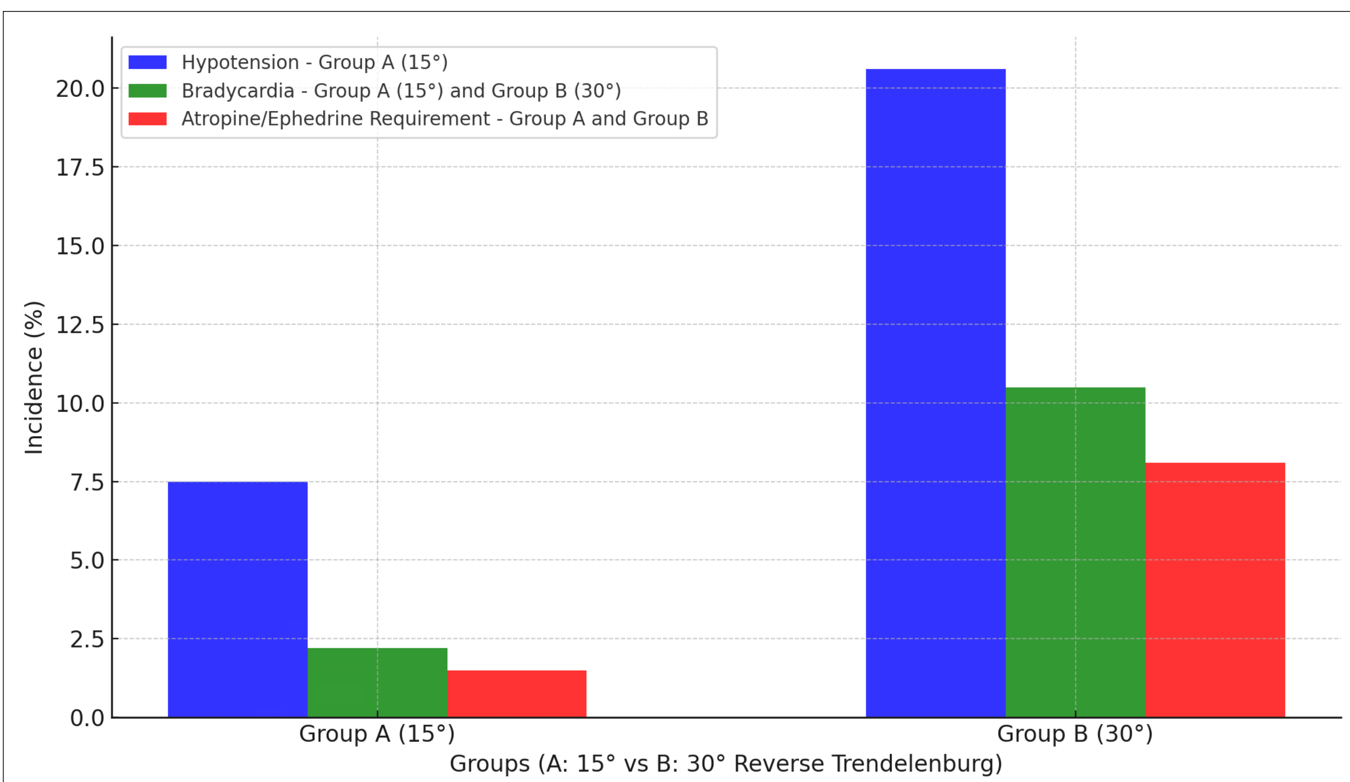

Figure 1. Hypotension, Bradycardia, and Atropine/Ephedrine Requirement by Group A and B.

Table 2. Procedural Outcomes and Complications

Secondary Outcomes	Group A (15°) n=264	Group B (30°) n=257	p
Hypotension (n, %)	20 (7.5)	53 (20.6)	<0.001
Bradycardia (n, %)	6 (2.2)	27 (10.5)	<0.001
Ephedrine/Atropine Requirement (n, %)	4 (1.5)	21 (8.1)	<0.001
Numerical Rating Scale (6h, median (IQR))	1(0-4)	1(0-5)	0.564
Numerical Rating Scale (24h, median (IQR))	1(0-4)	1(0-4)	0.478

Venous Diameter Changes

When assessing the percentage increase in the GSV diameter, post-procedure measurements revealed greater dilation in the 30° group compared to the 15° group (8.0±0.8 mm vs. 7.3±0.7 mm, p=0.024). Furthermore, the percentage increase in vein diameter was significantly larger in the 30° group (24.5±4.6% vs. 16.0±3.5%, p=0.019). Pre-procedure GSV diameters were comparable between the groups, with no statistically significant differences (Table 3).

Procedural Success and Complications

Complete vein closure, as confirmed by duplex ultrasound 24 h after the procedure, was achieved in all patients from both groups (100%), with no statistically significant differences (p>0.05). Complication rates were also similar in both groups, with no statistically significant differences (p>0.05).

Patient-reported pain scores, measured using the Numerical Rating Scale (NRS) at 6 and 24 h post-procedure, were comparable between the groups. The NRS scores at the 6th h (1 [0–4] vs. 1 [0–5]) and at the 24th h (1 [0–4] vs. 1 [0–4]) showed no significant differences between the groups (p>0.05). Additionally, the duration of the procedure did not differ significantly between groups A and B (p>0.05).

Discussion

This study compared the effects of two RT angles (15° and 30°) on procedural outcomes, venous diameter, and hemodynamic stability in patients undergoing RFA of the GSV under spinal anesthesia for CVI. These findings provide important insights for optimizing patient positioning during RFA and balancing venous dilation with the risk of hemodynamic complications. Our results demonstrate that the 30° RT position leads to greater venous dilation than the 15° position, with a larger percentage increase in the GSV diameter. This improved dilation can facilitate enhanced vascular access during RFA, aligning with previous research that suggests steeper head-up positions enhance venous dilation and vessel visualization in the lower limbs.[11, 15] Although a 30° angle provided improved venous access, it was associated with a higher risk of hemodynamic instability, reflected by the greater occurrence of hypotension and bradycardia in this group. Hypotension, characterized by a reduction in the systolic blood pressure or mean arterial pressure, was significantly more prevalent in the 30° group. Additionally, bradycardia was more frequently observed, leading to an increased need for vasoactive agents such as ephedrine and atropine. After spinal anesthesia, hemodynamic disturbances such as hypotension, bradycardia, and the need for vasoactive medications, including ephedrine and atropine, are common.[16-18] The underlying mechanisms of hypotension and bradycardia during spinal anesthesia are well-estab-

Table 3. Vena Saphena Magna Percentage Increase

Outcome	Group A (15°)	Group B (30°)	p
Pre-procedure Vein Diameter (mm, mean±SD)	6.3±0.5	6.4±0.6	0.68
Post-procedure Vein Diameter (mm, mean±SD)	7.3±0.7	8.0±0.8	0.024*
Percentage Increase in Vein Diameter (%, mean±SD)	16.0±3.5	24.5±4.6	0.019*

lished. Spinal anesthesia induces sympathetic block, leading to peripheral vasodilation, venous pooling, and a subsequent decrease in systemic vascular resistance.[19-21] In this study, these effects were exacerbated by the RT position, particularly at steeper angles. The gravitational shift in blood flow in this position likely contributed to venous pooling and further impaired venous return, which, when combined with the effects of spinal anesthesia, heightened the risk of hemodynamic instability.

A study comparing a 10° RT position with the supine position immediately following spinal anesthesia in orthopedic procedures found that the RT position significantly restricted the sensory block level and extended the duration of unilateral spinal anesthesia.[22, 23] This suggests that variations in head-up positioning can affect venous dilation, the distribution of anesthetic agents, and their clinical effects. Although limiting the spread of the sensory block may reduce some of the risks associated with spinal anesthesia, the increase in hypotension and bradycardia observed with steeper RT angles should be carefully considered. Hypotension in the head-up position after spinal anesthesia is likely due to venous blood pooling, exacerbated by gravitational forces and the body's reduced ability to maintain venous return. Similarly, a study in patients undergoing hepatectomy found that a 10° RT position reduced central venous pressure without significantly reducing systolic blood pressure.[24] These results underscore the need to carefully tailor patient positioning based on the specific procedure and individual patient characteristics. The cause of hypotension in the head-up position after spinal anesthesia may be venous blood accumulation. In some studies involving cesarean sections, the application of elastic bandages has been found to prevent it.[25-27] Another study reported that the 10° RT position after spinal anesthesia for cesarean section reduced hypotension and ephedrine consumption without any adverse effects.[28] The hemodynamic effects observed in this study, particularly the increased incidence of hypotension and bradycardia at the 30° RT angle, reflect a delicate balance between enhanced venous dilation and the maintenance of circulatory stability. The exacerbation of venous pooling due to the steeper head-up angle likely contributed to the observed hemodynamic instability, compounded by venous insufficiency inherent in our patient population. In patients with compromised venous return, gravitational forces during RT positioning may lead to significant reductions in preload; thereby, decreasing the cardiac output and systemic perfusion. This physiological shift underscores the importance of individualized patient management when using this position during RFA. However, the cerebrospinal fluid (CSF) concentration of bupivacaine administered during spinal anesthesia varies from person to person.[29] This variability can affect the spread of anesthetic block, particularly when steeper RT angles are used, as the combined effect of the positional change and spinal anesthesia on venous return becomes more pronounced. Case reports have documented incidences of bradycardia and hypotension developing during postoperative follow-up in patients placed in the RT position after spinal anesthesia.[30, 31]

The results of our study, combined with those of previous studies, emphasize the importance of individualized patient management during procedures involving spinal anesthesia and RT positioning. Clinicians must carefully balance the advantages of improved venous dilation with the potential risk of hemodynamic instability, especially in patients with underlying venous insufficiency or cardiovascular risk factors. Practical approaches such as moderating the degree of head-up tilt, employing compression devices, or optimizing fluid management may help mitigate the risks of hypotension and bradycardia while ensuring sufficient venous access.

This study had a few limitations. Firstly, the retrospective design posed a risk of selection bias, and the single-center nature may have restricted the broader applicability of the results. Secondly, the focus was primarily on short-term outcomes, such as procedural success and immediate postoperative hemodynamic changes, without long-term follow-up data.

Conclusion

In conclusion, our study highlighted the trade-offs between using 15° and 30° RT positions during RFA for CVI. Although a 30° angle provided enhanced venous dilation and potentially improved procedural access, it also increased the risk of hemodynamic instability, including hypotension, bradycardia. Clinicians should carefully assess patient risk factors and consider employing supportive measures to maintain hemodynamic stability with steeper RT angles. A patient-specific approach, integrating individual venous anatomy, anesthetic requirements, and cardiovascular status, is essential for optimizing outcomes during RFA procedures. Future research should explore long-term outcomes and evaluate strategies to mitigate these risks.

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Disclosures

Ethichs Committee Approval: This study was approved by the Institutional Review Board and Ethics Committee of Local University (approval number: 2024/11).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to the retrospective nature of the study and the inclusion of patient-specific information, data sharing is subject to ethical and privacy restrictions as outlined by the Institutional Review Board.

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