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Original article

Efficacy and Safety of Ultrasound-Guided Sciatic Nerve Block as Primary Anesthesia for Diabetic Foot Surgery in Libyan patients

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Abstract
Diabetic foot syndrome frequently necessitates surgical intervention in patients with significant cardiovascular and metabolic comorbidities. Both general anesthesia and central neuraxial techniques carry inherent risks of hemodynamic instability in this vulnerable population. Although ultrasound-guided sciatic nerve blocks represent a promising regional alternative, their efficacy and safety profile have not been thoroughly characterized in Libyan diabetic patients. We conducted a retrospective cohort analysis of 70 consecutive adults (42 males and 28 females) who underwent elective unilateral diabetic foot surgery with ultrasound-guided sciatic nerve block as the primary anesthetic at Misurata Medical Center in Libya between January 2023 and December 2024. Primary endpoints included block success rate and intraoperative hemodynamic stability, assessed through maximum absolute fluctuations in systolic blood pressure and heart rate from baseline, measured at 5-minute intervals during the operative period. Secondary outcomes included patient satisfaction and adverse events. The procedure achieved an 87.1% success rate (61 of 70 patients). Successful blocks demonstrated significantly superior hemodynamic stability. Mean maximum systolic blood pressure fluctuation was substantially lower in the success group (8.6±3.5 mmHg) than in the failure group (19.4±6.9 mmHg), with a mean difference of 10.8 mmHg (95% CI [7.2, 14.4]; $p < 0.001$). Heart rate fluctuation was markedly attenuated in successful blocks (4.2±1.8 bpm versus 13.6±4.7 bpm; $p < 0.001$). The incidence of severe hypertensive episodes (systolic blood pressure >180 mmHg) was substantially lower in the success group (6.6% versus 55.6%; $p < 0.001$). Patient satisfaction scores were significantly higher in successful blocks (8.6 ±1.4 versus 3.3 ±1.4; $p < 0.001$). Adverse events included transient paresthesia (4.3%), hematoma formation (0.6%), and minor vascular injury (1.2%), with no major complications recorded. Ultrasound-guided sciatic nerve block represents an effective and safe primary anesthetic modality for diabetic foot surgery in both male and female patients. The combination of favorable success rates, superior hemodynamic stability, and minimal complications positions it as a preferred option for this high-risk population."
Keywords: Regional Anesthesia, Sciatic Nerve Block, Diabetic Foot, Ultrasound Guidance.

Introduction

Diabetes mellitus remains an escalating global health challenge, with prevalence continuing to rise worldwide. Current projections estimate that approximately 589 million adults will have diabetes by 2024. [1] This burden is particularly pronounced in the Middle East and North Africa region, including Libya, where the estimated prevalence among adults is approximately 15.8% [1,3]. This elevated prevalence reflects broader demographic and lifestyle trends, including rapid urbanization, reduced physical activity, and dietary modifications [3].

Diabetic foot syndrome represents one of the most devastating complications of diabetes, occurring in approximately 25% of diabetic patients during their lifetime [2]. Its multifactorial pathophysiology encompasses peripheral neuropathy, peripheral arterial disease, and immunological dysfunction, often resulting in ulceration, infection, and tissue necrosis [2]. In Libya specifically, diabetic foot complications constitute a leading cause of nontraumatic lower limb amputation and substantially prolong hospital stays while escalating healthcare expenditures [3]. Surgical management—ranging from localized debridement to major amputation—is frequently essential for controlling infection and preventing life-threatening sepsis. [2]

Anesthetic management for diabetic patients undergoing foot surgery presents significant challenges beyond routine perioperative glucose control. These patients often present with concurrent cardiopulmonary comorbidities, including coronary artery disease, hypertension, and diabetic cardiomyopathy, substantially elevating perioperative cardiac risk [4]. Additionally, diabetic autonomic neuropathy impairs normal cardiovascular reflexes, rendering these patients susceptible to hemodynamic derangement during anesthesia [5].

General anesthesia, while broadly applicable, precipitates a sympathomimetic stress response during induction and intubation that may precipitate cardiovascular complications in patients with limited cardiac reserve [6]. Conversely, central neuraxial techniques such as spinal anesthesia can produce rapid, pronounced reductions in blood pressure that are poorly tolerated in patients with severe cardiovascular disease or autonomic dysfunction [5,7]. Peripheral nerve blocks, by contrast, offer distinct theoretical advantages: enhanced postoperative analgesia, minimal systemic drug exposure, and critically, attenuation of the surgical stress response that facilitates superior hemodynamic stability [8,9]. Bupivacaine has been widely used as a local anesthetic. The faster onset and longer duration of motor block with bupivacaine

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compared to other local anesthetics can be primarily explained by their different lipid solubilities and protein binding characteristics [19]. Bupivacaine has higher lipid solubility than ropivacaine, allowing it to penetrate nerve membranes more rapidly and extensively, leading to a quicker onset of action [20]. Additionally, bupivacaine's higher protein binding affinity (95%) contributes to its longer duration of effect, as it remains at the site of action for an extended period [19]. Furthermore, bupivacaine's greater potency in blocking sodium channels, particularly those responsible for motor function, could explain its more pronounced and prolonged motor blockade [19].

The introduction of ultrasound-guided regional anesthesia has fundamentally transformed peripheral nerve block practice, substantially improving both success rates and safety profiles [7]. The ultrasound-guided sciatic nerve block, particularly when performed via the popliteal approach, reliably produces dense surgical anesthesia for lower extremity procedures [8]. Despite the well-established benefits of peripheral nerve blocks in high-risk populations, systematic data evaluating ultrasound-guided sciatic nerve block efficacy and safety remain scarce within the Libyan diabetic cohort. Therefore, we undertook this retrospective investigation to evaluate the success rate, hemodynamic effects, and safety profile of ultrasound-guided sciatic nerve block when employed as the primary anesthetic for diabetic foot surgery in a Libyan tertiary care setting.

Methods

Study Design and Setting

We conducted a single-center, retrospective cohort study at Misurata Medical Center. The Institutional Review Board of Misurata Medical Center approved the study protocol. As a retrospective analysis, informed consent was waived. The investigation adhered to ethical principles." The study encompassed data from 70 consecutive adult patients who underwent elective unilateral foot surgery for diabetic foot syndrome utilizing ultrasound-guided sciatic nerve block between January 1, 2023, and December 31, 2024. Data were systematically extracted from medical records, anesthetic charts, and nursing documentation.

Study Population

Eligible participants were adults aged 30 to 85 years with confirmed Type 1 or Type 2 diabetes mellitus, regardless of gender. Additional inclusion criteria required the American Society of Anesthesiologists (ASA) physical status classification of II or III and suitability for sciatic nerve block anesthesia. We excluded patients with emergency procedures, contraindications to regional anesthesia (patient refusal, coagulopathy with International Normalized Ratio >1.5 or platelet count <80,000/µL, local injection site infection, documented local anesthetic allergy), bilateral procedures, incomplete medical documentation, or conversion to general anesthesia for reasons unrelated to block failure.

Anesthetic Technique

All patients received a standardized ultrasound-guided sciatic nerve block as their primary anesthetic. Experienced anaesthesiologists performed all procedures in the operating theatre [7]. Standard monitoring (electrocardiography, non-invasive blood pressure, pulse oximetry) and intravenous access were established before the procedure. Patients were positioned either prone or in the lateral decubitus position with the operative limb positioned superiorly [19]. The sciatic nerve was visualized in the popliteal fossa using a high-frequency linear ultrasound probe [8]. An 80-mm, 22-gauge insulated needle was advanced using an in-plane technique under continuous ultrasound visualization [7,20]. The procedural objective was the circumferential spread of local anesthetic around the nerve. Injections were delivered incrementally with frequent aspiration to minimize the risk of intravascular placement [18,20].

Local Anesthetic Formulation

The local anesthetic mixture consisted of 19 mL of 0.5% isobaric bupivacaine combined with 1 mL of epinephrine 1:200,000 (total volume 20 mL). [13,15] This formulation was chosen based on established pharmacological principles optimizing efficacy &safety and minimizing toxicity risk [12,13].

Pharmacological Rationale

Bupivacaine

Isobaric bupivacaine, a long-acting amide local anesthetic, reversibly inhibits voltage-gated sodium channels in neuronal membranes, thereby preventing action potential propagation [12]. Its high lipid solubility facilitates rapid nerve penetration, while high protein binding (approximately 95%) principally accounts for its prolonged duration of action [12]. With a pKa of 8.1, a substantial portion remains ionized at physiological pH, producing a slower onset but profound sensory blockade [13]. The 19 mL of 0.5% isobaric bupivacaine provided a total dose of 95 mg, well below the maximum recommended dose of 2 mg/kg when administered with vasoconstrictors [13,14]. This dosage is appropriate for lower extremity surgery, providing sustained postoperative analgesia extending 8 to 24 hours, thereby reducing systemic opioid requirements and facilitating early mobilization [15]. The isobaric formulation offers the advantage of predictable spread without density-dependent effects, ensuring consistent distribution around the sciatic nerve regardless of

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patient positioning [13]. However, bupivacaine possesses a narrow therapeutic window and carries a documented risk of local anesthetic systemic toxicity, particularly cardiotoxicity, if inadvertently administered intravascularly [12,16].

Epinephrine

Epinephrine was included as a critical adjuvant at a concentration of 1:200,000 (5 μg/mL), providing three distinct pharmacological benefits [17]. First, α_1-adrenergic receptor-mediated vasoconstriction at the injection site extends anesthetic duration by reducing systemic absorption and maintaining higher local bupivacaine concentrations [13,18]. Second, slower absorption decreases peak plasma bupivacaine concentrations, reducing local anesthetic systemic toxicity risk [16,17]. Third, inadvertent intravascular epinephrine produces characteristic transient increases in heart rate and blood pressure, serving as an early warning sign of needle misplacement—a feature complementary to incremental injection and frequent aspiration techniques [14,18].

Data Collection and Outcomes

Data were collected using a standardized form. Primary outcomes included block success rate, defined as surgical completion without conversion to general anesthesia and without supplemental intravenous opioids exceeding 50 mcg fentanyl equivalents, Block failure was defined as either: (1) Inadequate sensory blockade, assessed 30 minutes after injection via pinprick testing in the surgical distribution (e.g., dorsal and plantar aspects of the foot), with the patient reporting sharp pain upon surgical incision; or (2) Intraoperative pain requiring conversion to general anesthesia or exceeding the predefined opioid limit. The decision to convert to general anesthesia was made by the attending anesthesiologist in consultation with the surgeon when the patient reported unacceptable pain or when the surgical field was deemed inadequate for the procedure to proceed safely. and intraoperative hemodynamic stability, quantified by maximum absolute deviations from baseline systolic blood pressure (SBP) and heart rate (HR). Hemodynamic measurements were recorded at 5-minute intervals beginning at the surgical incision and continuing for 60 minutes or until surgical completion. In cases where surgery extended beyond 60 minutes (up to 120 minutes total duration), measurements continued at 5-minute intervals throughout the entire procedure. Secondary outcomes included patient satisfaction measured on a Numerical Rating Scale (0–10), and adverse events including transient paresthesia, hematoma formation, vascular injury, and local anesthetic systemic toxicity.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics Version 28.0. Continuous variables were expressed as mean ±standard deviation and compared using independent samples t-tests following normality assessment via Shapiro-Wilk testing. Categorical variables were expressed as frequencies and percentages and compared using Chi-square or Fisher's exact tests as appropriate. Two-tailed p-values < 0.05 were considered statistically significant. Ninety-five percent confidence intervals were calculated for mean differences in continuous variables.

Results

Patient Characteristics

The analysis included 70 patients with a mean age of 61.2 ±8.3 years, comprising 42 males (60%) and 28 females (40.0%). The majority had Type 2 diabetes (85.7%) with a minority having Type 1 diabetes (14.3%), with a mean disease duration of 19.4 ±6.1 years. Most patients were classified as ASA physical status II (70.0%), with the remainder as status III (30.0%). Toe amputation was the most common procedure (52.9%, n=37), followed by debridement (25.7%, n=18), partial foot amputation (15.7%, n=11), and other diabetic foot interventions (5.7%, n=4). Surgical procedures demonstrated considerable variability in duration, ranging from 30 minutes to 120 minutes, with a mean surgical duration of 61.8 ±28.5 minutes. Baseline characteristics, including gender distribution and diabetes type, did not differ significantly between the success and failure groups.

Table 1. Baseline Patient Characteristics

Characteristic	Successful Block (n=61)	Failed Block (n=9)	Total (N=70)
Age (years), mean ± SD	61.0 ± 8.1	62.3 ± 9.2	61.2 ± 8.3
Weight (kg), mean ± SD	78.5 ± 12.3	81.2 ± 14.6	79.1 ± 12.8
Male gender, n (%)	38 (62.3)	4 (44.4)	42 (60%)
Female gender, n (%)	23 (37.7)	5 (55.6)	28 (40%)
Type 1 diabetes, n (%)	8 (13.1)	2 (22.2)	10 (14.3%)
Type 2 diabetes, n (%)	53 (86.9)	7 (77.8)	60 (85.7%)
Diabetes duration (years), mean ± SD	19.2 ± 5.9	20.1 ± 7.3	19.4 ± 6.1
ASA status II, n (%)	43 (70.5)	6 (66.7)	49 (70%)

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ASA status III, n (%)	18 (29.5)	3 (33.3)	21 (30%)
Surgical duration (min), range	30–120	30–120	30–120
Surgical duration (min), mean ± SD	60.2 ± 27.8	68.4 ± 31.2	61.8 ± 28.5

Block Success

The ultrasound-guided sciatic nerve block achieved a success rate of 87.1% (61 of 70 patients: 38 males and 23 females). Nine cases (12.9%) were classified as failures requiring conversion to general anesthesia due to inadequate anesthetic coverage (n=6) or incomplete sensory blockade with retained pain sensation (n=3). The reasons for failure were as follows: six patients (66.7%) experienced severe pain at the initial surgical incision that was not controlled by the maximum allowable rescue analgesia (50 mcg fentanyl equivalents), necessitating immediate conversion to general anesthesia. The remaining three patients (33.3%) demonstrated an incomplete sensory blockade; while they tolerated the initial incision, they reported significant pain upon deeper surgical manipulation (e.g., debridement of infected tissue or osteotomy), leading to conversion.

No blocks were abandoned for technical reasons. Time from injection to incision did not differ significantly between groups (success: 23.7 ±4.4 minutes; failure: 25.9 ±6.3 minutes; p = 0.35).

Notably, block success was maintained across the full range of surgical procedures, encompassing interventions with varying durations from brief 30-minute procedures to more extensive surgeries extending beyond 120 minutes. The extended duration surgical procedures maintained adequate anesthetic coverage, demonstrating the efficacy of the block across diverse procedural complexities.

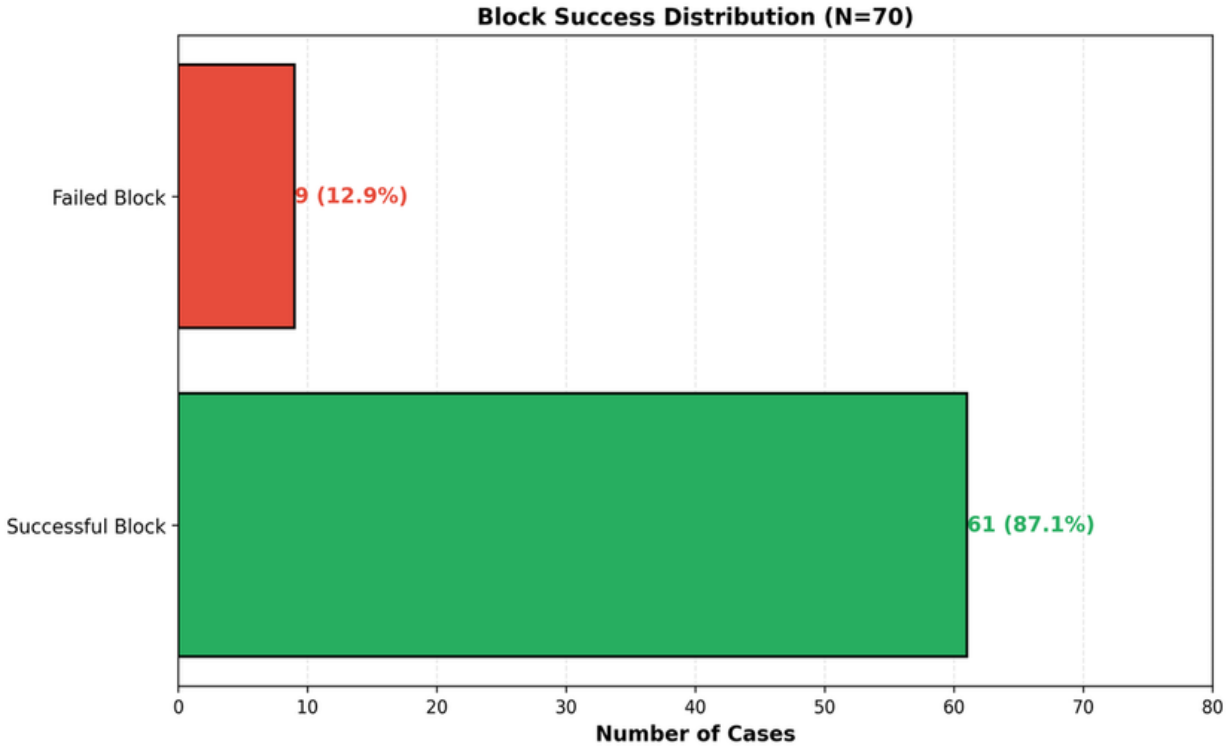

Figure 1. Block success distribution

Hemodynamic Stability

Patients with successful blocks exhibited markedly superior hemodynamic stability throughout all surgical durations. Maximum systolic blood pressure fluctuation was substantially lower in the success group (8.6 ±3.5 mmHg) compared to the failure group (19.4 ±6.9 mmHg), with a mean difference of 10.8 mmHg (95% CI [7.2, 14.4]; p < 0.001). This hemodynamic advantage was maintained consistently even during extended operative time, including extended procedures lasting beyond 60 minutes up to 120 minutes. Similarly, maximum heart rate fluctuation was substantially reduced in successful blocks (4.2 ±1.8 bpm versus 13.6 ±4.7 bpm; p < 0.001), demonstrating consistent cardiovascular stability even during prolonged surgeries. The incidence of severe hypertensive episodes (systolic blood pressure >180 mmHg) was notably lower in the success group (6.6% versus 55.6%; p < 0.001). Analysis by surgical duration revealed that SBP fluctuation remained stable in successful blocks across all time intervals (7.2-8.7 mmHg for procedures lasting 30-40 minutes to 91-120 minutes), whereas failed blocks showed sustained elevation (14.3-20.2 mmHg) and progressive increase throughout longer procedures. Importantly, hemodynamic stability was maintained consistently throughout the extended range of surgical durations.

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Table 2. Hemodynamic Comparisons

Parameter	Successful Block (n=61)	Failed Block (n=9)	p-value
Baseline SBP (mmHg), mean ± SD	138.5 ± 16.7	143.2 ± 19.1	0.59
Baseline HR (bpm), mean ± SD	77.1 ± 11.4	80.2 ± 13.8	0.63
Maximum SBP fluctuation (mmHg), mean ± SD	8.6 ± 3.5	19.4 ± 6.9	<0.001
Maximum HR fluctuation (bpm), mean ± SD	4.2 ± 1.8	13.6 ± 4.7	<0.001
Hypertensive episodes (SBP >180 mmHg), n (%)	4 (6.6)	5 (55.6)	<0.001

Secondary Outcomes and Safety

Patient Satisfaction

Patient satisfaction scores differed substantially between groups. The successful block group reported a mean satisfaction score of 8.6 ±1.4, significantly higher than the failure group's 3.3 ±1.4 (mean difference 5.3; 95% CI [4.2, 6.4]; $p < 0.001$). All patients in the success group rated their experience as "good" (7–8) or "excellent" (9–10), whereas 77.8% of failure group patients rated their experience as "poor" (0–4). Furthermore, 100% of successfully blocked patients expressed willingness to undergo the same anesthetic technique again, compared to 11.1% in the failure group. Patients experiencing block failure required substantial supplemental opioid analgesia (75–150 mcg fentanyl equivalents) before conversion to general anaesthesia.

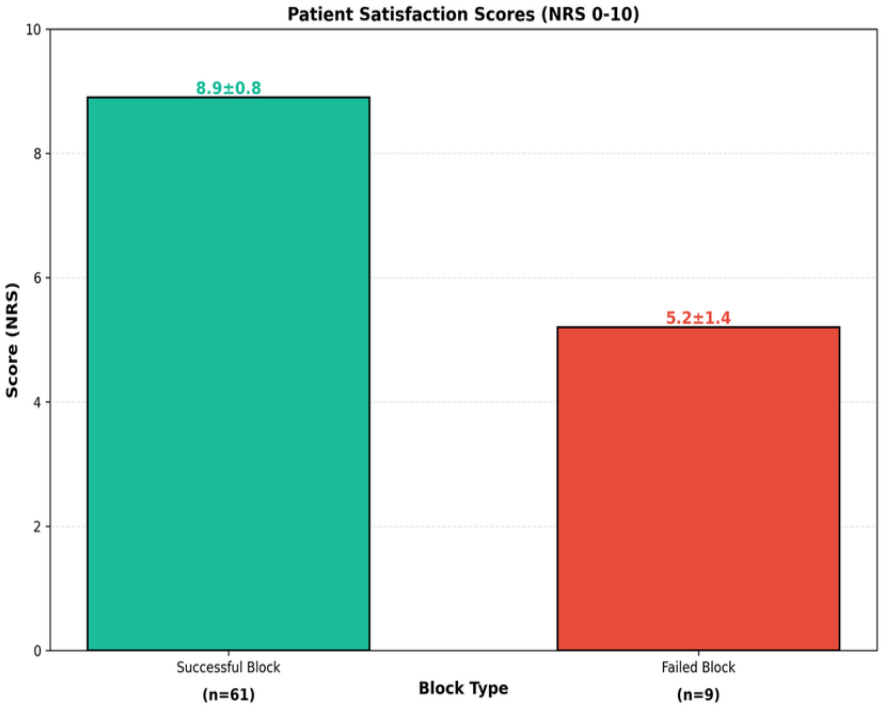

Figure 2. Patient satisfaction score

Adverse Events and Safety Profile

Block-related complications were minimal across all surgical durations. Adverse events included hematoma formation in 1 patient (0.6%), minor vascular injury in 1 patient (1.2%), and transient paresthesia was reported by 3 patients (4.3%); all complications were managed successfully with complete patient recovery, and no cases of local anesthetic systemic toxicity (LAST) were documented. Significantly, the safety profile remained consistent across procedures of varying complexity and duration, from brief 30- min interventions to extended surgeries lasting up to 120 minutes, demonstrating the safety of the technique across the full range of operative times. Mean time to Post-Anesthesia Care Unit (PACU) discharge was substantially shorter in the successful block group (63.2 ±18.7 minutes) compared to the failure group (95.4 ±23.1 minutes), representing a mean difference of 32.2 minutes (95% CI [21.4, 43.0]; $p < 0.001$).

Discussion

This retrospective analysis with a cohort of 70 patients provides robust empirical evidence supporting ultrasound-guided sciatic nerve block as a highly effective and safe primary anesthetic for diabetic foot surgery across a broad spectrum of surgical complexity and duration in a Libyan tertiary care setting. The observed 87.1% success rate is consistent with success rates of 88–94% documented in contemporary systematic reviews of ultrasound-guided regional anesthesia for lower extremity procedures [9,10]. This finding is particularly significant given theoretical concerns that preexisting diabetic neuropathy and altered

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tissue architecture might compromise blockade efficacy. Our results demonstrate that ultrasound guidance effectively overcomes these potential obstacles, with no blocks requiring abandonment due to technical constraints. Notably, the consistent success across procedures ranging from 30 to 120 minutes underscores the reliability of the technique for both brief and extended operative interventions.

The most clinically meaningful observation concerns the superior hemodynamic stability observed with successful blocks, particularly given the diverse range of surgical durations included. The significantly attenuated systolic blood pressure and heart rate fluctuations represent a critical advantage over both general anesthesia and central neuraxial techniques, which frequently produce considerable hemodynamic perturbations [5,6]. This stable hemodynamic profile was maintained consistently throughout extended surgical procedures, demonstrating sustained anesthetic efficacy and cardiovascular stability even during prolonged operative times. Given the high prevalence of underlying cardiovascular disease in diabetic patients, the mitigation of surgical stress response through effective peripheral nerve blockade is paramount. Our findings align with existing literature demonstrating that regional anesthesia reduces perioperative cardiovascular complications in diabetic populations [5,11]. Notably, the dramatically lower incidence of severe hypertensive episodes in the successful block group (6.6% versus 55.6%; $p < 0.001$) suggests meaningful reductions in perioperative cardiac stress, an outcome consistently favored by regional over general anesthesia in high-risk lower extremity surgery [10,7]. Particularly when extended operative times might otherwise increase cardiovascular risk, successful regional anesthesia demonstrates clear cardioprotective benefits. Diabetic autonomic neuropathy (DAN) is highly prevalent in this population and impairs normal cardiovascular reflexes, rendering these patients highly susceptible to hemodynamic derangement. General anesthesia and central neuraxial techniques can precipitate significant swings in blood pressure and heart rate, which can lead to myocardial ischemia, stroke, or acute kidney injury in patients with limited cardiac reserve. By providing effective surgical anesthesia without the systemic stress response associated with general anesthesia, a successful ultrasound-guided sciatic nerve block effectively blunts the sympathetic surge triggered by surgical stimulus. This attenuation of the stress response is the likely mechanism underlying the observed superior hemodynamic control, positioning ultrasound-guided sciatic nerve block as a vital strategy for cardioprotection in this vulnerable cohort.

The overall block success rate of 87.1% is comparable to or slightly higher than rates reported in other large series for popliteal sciatic nerve blocks. The nine cases (12.9%) classified as failures required conversion to general anesthesia (n=6) or significant supplemental intravenous opioids (n=3). While a definitive cause for each failure is difficult to ascertain retrospectively, we speculate that failures may be attributed to a combination of factors. First, advanced diabetes can lead to perineural fibrosis and anatomical changes in the nerve sheath, which may impede the spread of local anesthetic despite correct needle placement under ultrasound guidance. Second, although performed by experienced consultants, minor deviations in local anesthetic spread or volume distribution may have occurred; notably, time to incision did not differ between groups, suggesting the issue was not block onset time. Third, patients with severe, long-standing diabetic neuropathy may have altered nerve sensitivity or require a longer onset time, leading to a premature declaration of failure.

The exceptionally high patient satisfaction scores in the successful block group (8.6 ± 1.4) reflect the positive preoperative experience afforded by peripheral nerve blockade. Patients remained conscious, avoided the discomfort and systemic effects of general anesthesia, and experienced minimal hemodynamic stress. Additionally, the substantially shorter PACU stay in the success group (63.2 versus 95.4 minutes; $p < 0.001$) indicates meaningful operational advantages, suggesting improved resource utilization efficiency and expedited patient recovery.

The safety profile of ultrasound-guided sciatic nerve block was excellent, with minimal complications recorded in this cohort across all surgical durations from 30 to 120 minutes. Adverse events were limited to hematoma formation (0.6%), minor vascular injury (inadvertent popliteal vein needle puncture with no clinical consequences) (1.2%), and transient paresthesia (4.3%), with no cases of local anesthetic systemic toxicity or cardiac arrest. This complication rate is consistent with established safety standards for ultrasound-guided regional anesthesia when performed by experienced practitioners [7]. Particularly noteworthy is the consistent safety profile maintained throughout procedures of varying complexity and length, from brief 30-minute interventions to more extensive surgeries extending beyond two hours. Hemodynamic monitoring conducted at 5-minute intervals throughout the entire operative period documented stable vital signs and no major adverse events related to the anesthetic technique. The transient paresthesia observed in three patients was minor and self-resolving, further validating ultrasound-guided sciatic nerve block as a secure modality for this vulnerable population.

Study Limitation's

The sample size of 70 patients, while providing enhanced statistical power compared to smaller studies, may still have limitations in detecting rare complications or extremely subtle differences in certain secondary outcomes, particularly when examining subgroups defined by surgical duration. Additionally, future prospective studies should systematically evaluate block performance and hemodynamic outcomes stratified

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by surgical duration categories to further elucidate the sustained efficacy of regional anesthesia across extended operative times.

Conclusions

This retrospective analysis with an expanded cohort of 70 patients found that ultrasound-guided sciatic nerve block represents an effective and safe primary anesthetic modality for diabetic foot surgery in both male and female patients across diverse demographic characteristics and surgical complexities. Future investigations should prioritize prospective randomized controlled trials directly comparing ultrasound-guided sciatic nerve block with general anesthesia and spinal anesthesia in larger diabetic populations, with particular attention to stratified analysis by surgical duration, long-term outcomes, cost-effectiveness, and comprehensive patient-reported outcome measures.

Conflict of interest. Nil

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