ASSESSMENT OF EFFICACY AND COMPLICATIONS OF ULTRASOUND-GUIDED PERIPHERAL NERVE BLOCKS IN ROUTINE ANAESTHESIA PRACTICE: A PROSPECTIVE STUDY

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ABSTRACT

Background: Ultrasound-guided peripheral nerve blocks (UGPNBs) have emerged as an important advancement in regional anaesthesia, offering improved precision, efficacy, and safety compared to conventional techniques. However, evidence regarding their effectiveness and complication profile in routine clinical practice, particularly in developing country settings, remains limited.

Objectives: To evaluate the efficacy and complications associated with ultrasound-guided peripheral nerve blocks in routine anaesthesia practice.

Methods: This prospective observational study was conducted in a tertiary care hospital in North India from January 2022 to June 2022. A total of 38 adult patients undergoing surgical procedures under ultrasound-guided peripheral nerve blocks were included using consecutive sampling. Data on demographic characteristics, type of block, block success, onset time, need for supplementary analgesia, and complications were collected using a structured proforma. Statistical analysis was performed using SPSS version 20.0, with $p<0.05$ considered significant.

Results: The majority of patients were aged 31–50 years, with a male predominance. Brachial plexus block was the most commonly performed procedure. The overall block success rate was 89.5%. The mean onset time for sensory and motor blockade was 8.6 ±2.4 minutes and 12.1 ±3.1 minutes, respectively. Supplementary analgesia was required in 15.8% of patients, while 7.9% required conversion to general anaesthesia. Complications were infrequent, with vascular puncture being the most common (5.3%), followed by hematoma and transient nerve injury. No cases of local anaesthetic systemic toxicity were observed. No significant association was found between block type and success rate.

Conclusion: Ultrasound-guided peripheral nerve blocks are effective and safe in routine anaesthesia practice, with high success rates and minimal complications. Their use can enhance perioperative care and reduce reliance on systemic analgesics.

Keywords: Ultrasound-guided nerve block; Regional anaesthesia; Peripheral nerve block; Block efficacy; Complications; Anaesthesia practice

INTRODUCTION

Peripheral nerve blocks (PNBs) have become an essential component of contemporary anaesthetic practice, providing targeted analgesia, reduced perioperative opioid requirements, and improved patient satisfaction. Traditionally, these blocks were performed using anatomical landmarks or peripheral nerve stimulation; however, both techniques have limitations related to accuracy and safety. The introduction of ultrasound guidance has revolutionized regional anaesthesia by enabling direct visualization of nerves, adjacent structures, and the spread of local anaesthetic in real time, thereby improving precision and clinical outcomes [1].

Globally, ultrasound-guided peripheral nerve blocks (UGPNBs) are increasingly being adopted due to their demonstrated advantages over conventional techniques. Evidence from systematic reviews and meta-analyses suggests that ultrasound guidance enhances block success rates, shortens onset time, and reduces the volume of local anaesthetic required [2,3]. Additionally, ultrasound visualization helps minimize complications such as inadvertent vascular puncture and nerve injury, which were more common with blind or nerve stimulator-based approaches [4]. These advantages have led to widespread incorporation of UGPNBs into perioperative care pathways, particularly within enhanced recovery after surgery (ERAS) protocols [5].

The clinical benefits of UGPNBs extend beyond intraoperative anaesthesia to postoperative pain management. By providing effective and prolonged analgesia, these blocks reduce reliance on systemic opioids and their associated adverse effects, including nausea, vomiting, sedation, and respiratory depression [5]. This is particularly relevant in orthopaedic and trauma surgeries, where early mobilization and rehabilitation are critical for optimal recovery. Consequently, UGPNBs are increasingly being utilized in diverse surgical specialties worldwide [6].

In the Indian healthcare setting, especially in tertiary care hospitals, the adoption of ultrasound-guided techniques has gained momentum over the past decade. Despite infrastructural and training challenges, UGPNBs are now commonly employed in routine anaesthesia practice due to their safety profile and effectiveness [6]. However, real-world implementation may differ from controlled trial conditions due to variability in operator expertise, patient demographics, and institutional protocols. This variability necessitates context-specific evaluation of outcomes.

Although existing literature supports the superiority of ultrasound guidance, most studies are conducted in controlled environments or high-resource settings, which may not fully reflect routine clinical practice in developing countries. Furthermore, there is limited prospective observational data assessing both the efficacy and complication rates of UGPNBs in everyday anaesthesia practice, particularly in North Indian tertiary care institutions [7,8]. Understanding these aspects is crucial for optimizing clinical protocols, improving training, and ensuring patient safety.

While UGPNBs are generally considered safe, they are not entirely devoid of complications. Reported adverse events include block failure, hematoma, infection, nerve injury, and rare occurrences of local anaesthetic systemic toxicity (LAST) [9]. Therefore, systematic evaluation of both effectiveness and associated complications in real-world settings is necessary to provide a balanced perspective on their utility.

In this context, the present prospective observational study was undertaken in a tertiary care hospital in North India to evaluate the efficacy of ultrasound-guided peripheral nerve blocks in routine anaesthesia practice, with particular emphasis on block success, onset characteristics, and the incidence and spectrum of associated complications.

METHODOLOGY

Study Design: This study was designed as a prospective observational study, conducted to evaluate the efficacy and complications associated with ultrasound-guided peripheral nerve blocks in routine anaesthesia practice.

Study Setting: The study was carried out in the Department of Anaesthesiology of a tertiary care hospital in North India, where ultrasound-guided regional anaesthesia is routinely practiced for various surgical procedures.

Study Duration: January 2022 to June 2022.

Study Population: The study population included patients undergoing elective and emergency surgical procedures requiring peripheral nerve blocks under ultrasound guidance as part of routine anaesthetic management.

Inclusion Criteria

- Patients aged ≥18 years
- Patients of either gender
- Patients undergoing surgeries where ultrasound-guided peripheral nerve blocks were indicated
- Patients who provided informed written consent

Exclusion Criteria

- Patients refusing to participate
- Patients with known allergy to local anaesthetic agents
- Patients with coagulopathy or on anticoagulant therapy
- Infection at the site of block
- Patients with pre-existing neurological deficits in the area of the block
- Patients unable to provide consent

Sample Size with Calculation

The sample size was calculated based on feasibility and patient availability during the study period. Considering an expected block success rate of approximately 85% from previous literature and allowing for a precision of 10% with a confidence level of 95%, the minimum sample size was estimated using the formula:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:
Z = 1.96 (for 95% confidence level)
p = 0.85 (expected success rate)
q = 1 − p = 0.15
d = 0.10 (absolute precision)
The calculated sample size was approximately 49; however, due to time constraints and feasibility considerations within the study duration, a total of 38 patients were included in the study.
Sampling Technique: A consecutive sampling technique was employed, wherein all eligible patients meeting the inclusion criteria during the study period were recruited until the desired sample size was achieved.

Data Collection Tools & Procedure: Data were collected using a predesigned, semi-structured case record form. After obtaining informed written consent, patients were evaluated preoperatively, and relevant demographic and clinical details were recorded. Ultrasound-guided peripheral nerve blocks were performed by anaesthesiologists with prior experience in ultrasound-guided techniques, using standard aseptic precautions and appropriate ultrasound equipment. The type of block, local anaesthetic used, and volume administered were documented. Block efficacy was assessed based on onset time of sensory and motor blockade, adequacy of anaesthesia for surgery, and requirement of supplementary analgesia or conversion to general anaesthesia. Patients were monitored intraoperatively and postoperatively for any complications such as vascular puncture, hematoma, nerve injury, signs of local anaesthetic systemic toxicity, or block failure. Follow-up was done in the immediate postoperative period to document any delayed complications.

Study Variables: Independent variables included patient demographics (age, gender), type of surgery, type of nerve block performed, and anaesthesiologist experience. Dependent variables included measures of efficacy such as block success rate, onset time of sensory and motor blockade, and need for additional analgesia, as well as safety outcomes including incidence and type of complications (e.g., vascular puncture, nerve injury, hematoma, local anaesthetic toxicity, and block failure).

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables were expressed as mean ±standard deviation, while categorical variables were presented as frequencies and percentages. Associations between variables were analyzed using appropriate statistical tests such as the Chi-square test or Fisher's exact test for categorical variables and independent t-test for continuous variables. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC). Written informed consent was obtained from all participants prior to inclusion in the study. Confidentiality of patient information was maintained throughout the study. The study adhered to the ethical principles outlined in the Declaration of Helsinki, ensuring respect for participant autonomy, beneficence, and non-maleficence.

RESULTS

A total of 38 patients were included in the study. The majority of participants were aged between 31–50 years, with a male predominance. Most patients belonged to ASA physical status II (Table 1).

Table 1: Demographic Characteristics of Study Participants (n = 38)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	10	26.3
	31–50	16	42.1
	>50	12	31.6
Gender	Male	22	57.9
	Female	16	42.1
ASA Physical Status	I	14	36.8
	II	18	47.4
	III	6	15.8

Brachial plexus block was the most commonly performed procedure, followed by femoral and sciatic nerve blocks (Table 2).

Table 2: Distribution of Types of Peripheral Nerve Blocks Performed

Type of Block	Frequency (n)	Percentage (%)
Brachial Plexus Block	18	47.4
Femoral Nerve Block	8	21.1
Sciatic Nerve Block	6	15.8
Combined Blocks	6	15.8

The overall block success rate was high, with nearly nine out of ten blocks being successful. The mean onset time for sensory blockade was shorter compared to motor blockade (Table 3).

Table 3: Efficacy Outcomes of Ultrasound-Guided Peripheral Nerve Blocks

Parameter	Value
Block Success Rate	34 (89.5%)
Block Failure	4 (10.5%)
Mean Sensory Onset Time (minutes)	8.6 ± 2.4
Mean Motor Onset Time (minutes)	12.1 ± 3.1
Need for Supplementary Analgesia	6 (15.8%)
Conversion to General Anaesthesia	3 (7.9%)

A small proportion of patients required supplementary analgesia, and a few cases necessitated conversion to general anaesthesia. Complications were infrequent, with vascular puncture being the most common, followed by hematoma and transient nerve injury. No cases of local anaesthetic systemic toxicity were observed (Table 4).

Table 4: Complications Associated with UGPNBs

Complication Type	Frequency (n)	Percentage (%)
Vascular Puncture	2	5.3
Hematoma	1	2.6
Nerve Injury (Transient)	1	2.6
Local Anaesthetic Toxicity (LAST)	0	0
Block Failure	4	10.5
No Complications	30	78.9

There was no statistically significant association between the type of nerve block performed and block success rate ($p > 0.05$), indicating comparable efficacy across different block types (Table 5).

Table 5: Association Between Type of Block and Block Success

Type of Block	Successful (n)	Failed (n)	p-value
Brachial Plexus	16	2	
Femoral	7	1	
Sciatic	5	1	
Combined	6	0	0.64

DISCUSSION

The present prospective observational study evaluated the efficacy and safety profile of ultrasound-guided peripheral nerve blocks (UGPNBs) in routine anaesthesia practice in a tertiary care setting. The findings demonstrate a high overall success rate (89.5%), rapid onset of sensory and motor blockade, and a low incidence of complications, supporting the utility of UGPNBs as an effective and safe anaesthetic modality in real-world clinical settings.

The high success rate observed in this study is consistent with previously reported literature, which highlights improved accuracy and effectiveness of ultrasound guidance compared to conventional techniques. Abrahams et al. reported significantly higher success rates and improved block quality with ultrasound guidance compared to nerve stimulation techniques [3]. Similarly, Sites et al. emphasized that real-time visualization enhances needle placement and local anaesthetic spread, thereby improving block reliability [2]. The success rate in the present study aligns well with these findings, suggesting that even in routine practice settings, UGPNBs can achieve outcomes comparable to controlled studies.

The mean onset times for sensory (8.6 minutes) and motor blockade (12.1 minutes) observed in this study are also in agreement with existing evidence. Ultrasound guidance allows precise deposition of local anaesthetic around the nerve, facilitating faster onset. Perlas et al. demonstrated that ultrasound-guided techniques result in more efficient block dynamics due to accurate localization of neural structures [4]. The slightly longer motor onset time compared to sensory onset is physiologically expected and has been consistently reported in regional anaesthesia literature.
In terms of safety, the present study reported a low incidence of complications, with vascular puncture being the most common (5.3%), followed by hematoma and transient nerve injury.

Importantly, no cases of local anaesthetic systemic toxicity (LAST) were observed. These findings are in concordance with Barrington and Kluger, who reported that ultrasound guidance reduces the risk of LAST and other complications by enabling visualization of vascular structures and real-time monitoring of drug spread [7]. The absence of major complications in this study further reinforces the safety profile of UGPNBs when performed by trained anaesthesiologists.

The incidence of block failure (10.5%) in the present study is within the acceptable range reported in literature. Mariano et al. noted that although ultrasound guidance improves success rates, block failure may still occur due to factors such as anatomical variation, inadequate spread of local anaesthetic, or operator experience [8]. In our study, the small number of failures and the limited need for conversion to general anaesthesia (7.9%) suggest that UGPNBs are reliable for routine use, although continuous skill development remains important.

No statistically significant association was found between the type of nerve block and success rate, indicating that ultrasound guidance provides consistent efficacy across different block types. This finding supports the versatility of UGPNBs across a wide range of surgical procedures. Similar observations have been reported in previous studies, where ultrasound guidance demonstrated uniform benefits irrespective of block type [2,3].

From a clinical perspective, the findings of this study have important implications. The high success rate and low complication profile support the broader adoption of UGPNBs in routine anaesthesia practice, particularly in tertiary care settings. The reduction in need for general anaesthesia and supplementary analgesia also contributes to improved patient outcomes and resource utilization. In the context of enhanced recovery protocols, UGPNBs can play a pivotal role in minimizing opioid use and facilitating early recovery [5].

The strengths of this study include its prospective design and focus on real-world clinical practice, which enhances the external validity of the findings. Unlike randomized controlled trials conducted in controlled environments, this study reflects routine anaesthesia workflows, operator variability, and patient diversity, making the results more generalizable to similar healthcare settings.

However, certain limitations must be acknowledged. The relatively small sample size (n=38) limits the statistical power and generalizability of the findings. The study was conducted at a single center, which may introduce institutional bias. Additionally, operator experience was not stratified, which could influence block success and complication rates. Long-term follow-up for delayed neurological complications was not performed, which is another limitation.

Future studies with larger sample sizes, multicentric designs, and stratification based on operator expertise are recommended to further validate these findings. Incorporation of patient-reported outcomes and long-term follow-up would also provide a more comprehensive assessment of UGPNBs.

CONCLUSION

This prospective observational study demonstrates that ultrasound-guided peripheral nerve blocks are an effective and safe modality in routine anaesthesia practice in a tertiary care setting. A high success rate, rapid onset of sensory and motor blockade, and minimal requirement for conversion to general anaesthesia highlight their clinical efficacy. The incidence of complications was low, with most being minor and self-limiting, and no major adverse events such as local anaesthetic systemic toxicity were observed. These findings support the increasing integration of ultrasound-guided techniques into routine anaesthetic practice, particularly in settings aiming to enhance perioperative outcomes and reduce opioid dependence. The use of ultrasound improves precision and safety, making it a valuable tool for anaesthesiologists. However, adequate training and experience remain crucial to optimize outcomes. Further large-scale, multicentric studies are recommended to strengthen the evidence base and assess long-term safety and effectiveness.

DECLARATIONS

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