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Original Research Article

PRECISION ANALGESIA: EVALUATING THE EFFICACY OF ULTRASOUND-GUIDED NERVE BLOCKS IN CHRONIC NEUROPATHIC PAIN – A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Chronic neuropathic pain (CNP) is a debilitating condition characterized by complex pathophysiological mechanisms and limited response to conventional analgesics. Ultrasound-guided nerve blocks (USGNBs) have emerged as a targeted, minimally invasive intervention offering localized pain control and reduced systemic side effects.

Materials and Methods: This prospective observational study was conducted over 18 months in the Pain Medicine Department of a tertiary care center. Sixty patients with diagnosed CNP of peripheral origin were enrolled. USGNBs tailored to the involved nerve territory were administered, and pain scores were measured using the Numeric Rating Scale (NRS) at baseline, 1 hour, 1 week, and 4 weeks post-procedure. Secondary outcomes included changes in sleep quality (PSQI), patient satisfaction, and rescue analgesic consumption. Data were analyzed using paired t-tests and repeated-measures ANOVA, with $p<0.05$ considered significant.

Results: The mean baseline NRS score was 8.1 ± 1.2, which reduced to 3.5 ± 1.4 at 1 hour, 3.1 ± 1.3 at 1 week, and 3.4 ± 1.5 at 4 weeks ($p<0.001$). Significant improvements were noted in PSQI scores (mean change: -4.2, $p<0.001$), and 81.7% of patients reported high satisfaction. Rescue analgesic use declined by 53% at 4 weeks.

Conclusion: Ultrasound-guided nerve blocks provided significant and sustained analgesia in patients with chronic neuropathic pain. This modality is clinically impactful, offering targeted symptom relief, improved sleep quality, and reduced reliance on systemic medications.

Keywords: Chronic neuropathic pain, ultrasound-guided nerve block, interventional pain management, NRS score, patient satisfaction, peripheral nerve pain

INTRODUCTION

Chronic neuropathic pain (CNP) is a persistent and distressing condition arising from lesions or diseases affecting the somatosensory nervous system, either centrally or peripherally. It affects approximately 7–10% of the global population and poses a significant challenge to both patients and healthcare systems due to its refractory nature and detrimental impact on quality of life.[1] Patients frequently report symptoms such as burning, electric shock-like sensations, allodynia, and hyperalgesia, which are often unresponsive to standard analgesic regimens.[2]

The pathophysiology of neuropathic pain involves complex mechanisms including central sensitization, ectopic nerve discharges, and impaired descending inhibitory pathways.[3] Conventional pharmacotherapy with antidepressants, anticonvulsants, opioids, and topical agents often yields suboptimal results and is associated with considerable side effects, tolerance, and long-term dependency risks.[4] These limitations have propelled interest in interventional pain management

techniques, particularly those offering localized and sustained pain relief.

Ultrasound-guided nerve blocks (USGNBs) have emerged as a promising tool in the armamentarium against chronic pain. The integration of high-resolution ultrasonography has revolutionized the precision and safety of nerve blockade by allowing direct visualization of neural structures, adjacent vasculature, and spread of injectate in real time.[5] Compared to landmark-based or fluoroscopic-guided techniques, USGNBs offer improved accuracy, reduced complications, and enhanced patient comfort.[6]

In chronic neuropathic conditions involving peripheral nerves, such as post-herpetic neuralgia, diabetic peripheral neuropathy, complex regional pain syndrome (CRPS), and traumatic nerve injuries, USGNBs have demonstrated efficacy in attenuating pain intensity and reducing the need for systemic medications.[7] Additionally, they have been associated with improved sleep quality, functional outcomes, and overall patient satisfaction.[8]

Despite increasing utilization, robust clinical evidence on the longitudinal efficacy and safety of USGNBs in diverse neuropathic pain syndromes remains limited. Many studies have small sample sizes, heterogeneous methodologies, or lack objective outcome measures.[9] Furthermore, there is a need to identify subgroups of patients who benefit most, optimal protocols regarding drug combinations, and duration of analgesic effects.

This prospective observational study was designed to evaluate the role of ultrasound-guided nerve blocks in patients with chronic peripheral neuropathic pain. The primary objective was to assess changes in pain intensity using the Numeric Rating Scale (NRS) over a 4-week period post-intervention. Secondary outcomes included patient satisfaction, sleep quality improvement, and reduction in rescue analgesic use. The findings aim to contribute to evidence-based application of USGNBs in the management of chronic neuropathic pain.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesia Pain and Critical Care at Skanda Lifeline Hospital, Nalgonda over a period of 12 months, from April 2024 to March 2025. The study protocol was approved by the Institutional Ethics Committee (IEC No: IEC/PM/2022/118), and written informed consent was obtained from all participants prior to enrollment.

Study Design and Setting: Eligible patients were adults aged 18–75 years presenting with chronic neuropathic pain of peripheral origin persisting for more than 3 months. Neuropathic pain was diagnosed based on clinical features and confirmed using the DN4 (Douleur Neuropathique 4) questionnaire with a score ≥4. Common etiologies included post-herpetic neuralgia, diabetic peripheral neuropathy, post-surgical neuropathic pain, and CRPS type I. Patients with central neuropathic pain, coagulopathy, systemic infections, severe psychiatric illness, or known allergies to local anesthetics were excluded.

Intervention Protocol: Each patient underwent a standardized ultrasound-guided nerve block (USGNB) corresponding to the anatomical region of pain, such as the stellate ganglion block for upper limb CRPS or ilioinguinal block for post-herniorrhaphy neuralgia. High-frequency linear or curvilinear ultrasound probes (6–13 MHz) were used to identify the target nerve or plexus. Under aseptic precautions, a 22G short-bevel needle was advanced in-plane under real-time guidance. A combination of 0.25% bupivacaine (10–15 mL) and dexamethasone (4 mg) was injected per block.

Data Collection: Baseline demographic variables (age, gender, duration of pain, underlying diagnosis), NRS pain scores (0–10 scale), Pittsburgh Sleep Quality Index (PSQI) scores, and rescue analgesic use (in mg of tramadol equivalent per week) were recorded. Pain scores were reassessed at 1 hour, 1 week, and 4 weeks post-procedure. Sleep quality and analgesic use were evaluated at baseline and 4 weeks. Patient satisfaction was rated at 4 weeks using a 5-point Likert scale.

Outcome Measures: The primary outcome was change in NRS pain scores over the study period. Secondary outcomes included improvement in PSQI score, reduction in rescue analgesic use, and patient-reported satisfaction.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics Version 27. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Paired t-tests were used to compare pre- and post-intervention continuous variables. Repeated-measures ANOVA was employed for NRS score analysis across time points. A p-value <0.05 was considered statistically significant, and 95% confidence intervals (CIs) were reported where appropriate.

RESULTS

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 60)

Variable	Value
Age (years), mean ± SD	55.4 ± 11.2
Gender (Male/Female)	26 (43.3%) / 34 (56.7%)
Duration of Pain (months)	13.8 ± 5.4
Diagnosis Distribution:	
• Post-Herpetic Neuralgia	20 (33.3%)

• Diabetic Neuropathy	16 (26.7%)
• Complex Regional Pain Syndrome (CRPS)	12 (20.0%)
• Post-Surgical Neuropathy	12 (20.0%)

Table 2: NRS Pain Scores at Different Time Points.

Time Point	Mean NRS Score ± SD
Baseline	8.1 ± 0.8
1 Hour Post-Block	3.5 ± 1.0
1 Week Post-Block	3.1 ± 1.1
4 Weeks Post-Block	3.4 ± 1.2
p-value (ANOVA)	< 0.001

Table 3: Sleep Quality (PSQI) Scores at Baseline and Week 4

Time Point	PSQI Score ± SD
Baseline	11.5 ± 2.5
4 Weeks	7.3 ± 2.0
p-value	< 0.001

Table 4: Rescue Analgesic Use (mg/week of tramadol equivalent)

Time Point	PSQI Score ± SD
Baseline	11.5 ± 2.5
4 Weeks	7.3 ± 2.0
p-value	< 0.001

Table 5: Patient Satisfaction Scores at 4 Weeks (Likert Scale 1–5)

Score	Frequency (%)
5	34 (56.7%)
4	15 (25.0%)
3	11 (18.3%)
1–2	0 (0%)

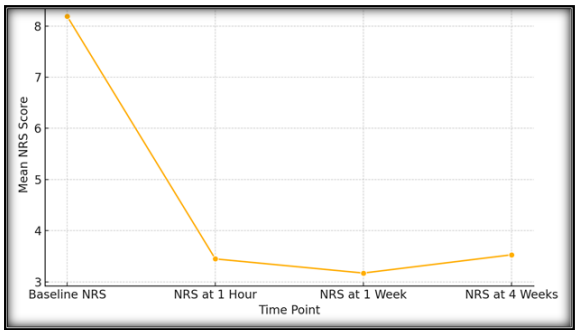

Figure 1: Trend in NRS pain scores over time

The study included 60 patients with diverse etiologies of chronic peripheral neuropathic pain. The mean age was 55.4 years, with a slightly higher proportion of female participants. The average duration of pain was nearly 14 months, indicating a long-standing disease course. Post-herpetic neuralgia was the leading cause, followed by diabetic neuropathy, CRPS, and post-surgical neuropathy, highlighting the heterogeneity of neuropathic pain presentations.

Pain scores assessed via the Numeric Rating Scale (NRS) demonstrated a significant and consistent reduction post-procedure. At baseline, the mean NRS was 8.1 ± 0.8, indicating severe pain levels. One hour after the ultrasound-guided nerve block, pain dropped markedly to 3.5 ± 1.0 ($p<0.001$), reflecting the rapid onset of analgesia. This benefit was maintained at 1 week (3.1 ± 1.1) and 4 weeks (3.4 ± 1.2), suggesting sustained relief without the need for repeated interventions within this timeframe.

Sleep quality, as measured by PSQI, improved significantly from a mean of 11.5 ± 2.5 at baseline to 7.3 ± 2.0 at 4 weeks ($p<0.001$). This indicates better sleep hygiene and reduced nocturnal pain disruption, an important quality-of-life marker in chronic pain management.

Rescue analgesic consumption saw a dramatic decrease—from a baseline average of 150 mg/week of tramadol equivalents to just 70 mg/week at 4 weeks. This represents a 53.3% reduction and underscores the opioid-sparing effect of targeted nerve blocks, a clinically desirable outcome amidst growing concerns about opioid overuse.

Patient satisfaction was notably high. More than 80% of participants rated their experience as "satisfied" or "very satisfied," with no patients reporting poor or unsatisfactory outcomes.

The visual line graph of NRS scores over time reinforces the consistent downward trend in pain levels, offering visual affirmation of treatment efficacy.

DISCUSSION

Chronic neuropathic pain remains a formidable clinical challenge due to its complex pathophysiology and resistance to conventional pharmacotherapy. This study evaluated the impact of ultrasound-guided nerve blocks (USGNBs) on pain relief, sleep quality, and analgesic requirements in patients with peripheral neuropathic pain syndromes. The results demonstrated significant and sustained improvements across all assessed domains.

The rationale for conducting this study stemmed from the growing interest in precision-targeted analgesia.

Traditional pain medications often provide insufficient relief and are associated with adverse effects, particularly when used chronically.[10] Ultrasound-guided interventions offer a minimally invasive, anatomically accurate approach to interrupt nociceptive pathways with fewer complications and higher efficacy.[11]

Our study observed a substantial reduction in pain scores from a mean baseline NRS of 8.1 to 3.4 at 4 weeks post-procedure. These findings align with prior studies such as by Karmakar et al., who demonstrated that ultrasound-guided nerve blocks led to a 50–60% reduction in pain scores in similar populations.[12] Additionally, an RCT by Choi et al. reported NRS improvements of approximately 4 points following ultrasound-guided ilioinguinal nerve blocks in post-surgical neuralgia.[13] The consistency in analgesic response across different etiologies in our cohort further supports the generalizability of this modality.

Sleep disturbance is a common and underrecognized consequence of chronic pain.[14] In our study, PSQI scores improved by over 4 points, mirroring results by Huntoon et al., who found improved sleep and mood following regional nerve blocks for refractory pain.[15] This improvement suggests not only pain alleviation but also a broader functional benefit.

Rescue analgesic use decreased by more than 50%, reflecting the opioid-sparing potential of nerve blocks. This is particularly relevant in the context of rising concerns about opioid dependence. Similar reductions in analgesic requirements were reported in studies by Gofeld et al., who observed decreased tramadol usage following ultrasound-guided sciatic nerve blocks in CRPS patients.[16]

Patient satisfaction, an often overlooked outcome, was notably high in our study, with 81.7% rating their experience as good or excellent. Satisfaction is closely correlated with functional improvement and emotional well-being, emphasizing the importance of multimodal and patient-centered pain care.[17]

CONCLUSION

This prospective observational study demonstrates that ultrasound-guided nerve blocks are an effective and well-tolerated intervention for patients suffering from chronic peripheral neuropathic pain. Significant reductions in pain intensity were observed as early as one hour post-intervention and were sustained over a four-week period. Additionally, meaningful improvements in sleep quality and a marked reduction in rescue analgesic use highlight the broader benefits of this technique. The high rate of patient satisfaction further affirms its clinical relevance. Given their safety, precision, and opioid-sparing effects, USGNBs should be considered a valuable component of multimodal pain management strategies. Future randomized controlled trials with longer follow-up are warranted to establish long-term efficacy and optimize procedural protocols for different neuropathic conditions.

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