Effect of Ultrasound-Guided Pericapsular Nerve Group Block on Ease of Spinal Positioning during Subarachnoid Blockade in Patients Undergoing Hip Fracture Surgery: A Prospective Observational Study

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ABSTRACT

Background: Hip fractures is an increasing global health burden among elderly persons. Pain is a major intraoperative challenge with difficulty in positioning patients for spinal anaesthesia (SA).

Aim: To assess the efficacy of ultrasound-guided pericapsular nerve group (PENG) block on ease of spinal positioning (EOSP), pain scores, and hemodynamic parameters in patients undergoing hip fracture surgery.

Methods: This prospective observational study included 80 patients (American Society of Anesthesiologists [ASA] physical status I-III) scheduled for intertrochanteric fracture, femoral neck fracture, or total hip arthroplasty. All patients received a single shot PENG block with 20 mL of 0.25% bupivacaine. Visual analogue scale (VAS) scores at rest and with 15 degrees passive straight leg raise (SLR), heart rate (HR), mean arterial pressure (MAP) and oxygen saturation noted at baseline, 15 min and 30 min. EOSP was graded 1 to 4 and the need for rescue analgesia was recorded.

Results: Median VAS at rest was reduced from 8.0 to 0.0 and SLR VAS from 9.0 to 1.0 within 30 minutes ($p < 0.001$ for all pairwise comparisons). HR and MAP decreased significantly ($p<0.001$) but remained within safe physiological limits. 85% of patients achieved Grade 1 EOSP with only 7.5% requiring rescue analgesia.

Conclusion: The PENG block is a safe and effective method for rapid analgesia and allows comfortable positioning of the spine without hemodynamic instability in patients undergoing surgery for hip fracture.

Keywords: *pericapsular nerve group block; hip fracture; spinal anaesthesia; positioning; regional anaesthesia*

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INTRODUCTION

Hip fractures are one of the most important injuries of aging, and their global burden continues to increase with the growth of the elderly population. The global age-standardised incidence of hip fracture has been estimated to have decreased in some high income regions, but the absolute number of hip fractures worldwide is projected to increase by almost twofold from 2018 to 2050 due to demographic ageing [1]. Using the Global Burden of Disease framework, analyses also show a steady rise in both incidence and absolute numbers of hip fractures in adults aged 55 years and older in the last three decades, confirming the burden is substantial across health systems with different resources [2].

In everyday clinical practice, most patients with hip fracture are treated under subarachnoid (spinal) block, which is preferred to general anaesthesia because it reduces peri-operative cardiopulmonary complications in this often elderly and comorbid population. The ability to achieve the flexed lateral or sitting position for placement of the spinal needle is often limited by severe pain from the fracture, and poor positioning can lead to increased procedure time, increased number of needle passes, and increased patient distress [3]. Conventional regional techniques such as the femoral nerve block and fascia iliaca compartment block have been used to relieve this positioning pain. However, both techniques inevitably spread to the femoral nerve trunk and quadriceps motor fibres, resulting in quadriceps weakness that can itself impede safe positioning and delay postoperative mobilisation [4].

The pericapsular nerve group (PENG) block was developed to selectively anaesthetise the sensory articular branches supplying the anterior hip capsule, while avoiding the femoral motor nerve, providing a theoretically favourable analgesic profile for the positioning phase of hip fracture surgery [5]. Recent evidence from randomised and comparative studies, mostly published since 2021, suggests that the PENG block is an effective analgesic technique for reducing positioning pain and improving mobility after hip surgery performed under spinal anaesthesia [6]. However, most published trials have compared the PENG block with an alternative regional technique or a sham/no-block control in tightly controlled randomised settings. Comparatively little observational, real-world data describe how the block performs, and specifically how it affects the ease of spinal positioning, as a stand-alone component of routine anaesthetic care [7]. This gap is of clinical relevance because it is the effectiveness of an intervention under the conditions of everyday practice, without the selection pressures of a randomised trial that finally dictates its uptake at the bedside.

The present study was therefore designed to evaluate the effect of the ultrasound-guided PENG block on the ease of spinal positioning, pain scores and haemodynamic stability in a real-world observational cohort of patients undergoing surgery for hip fracture.

METHODOLOGY

Study Design and Setting

This was a prospective observational study conducted in the Department of Anaesthesiology in a tertiary care teaching hospital with high admission rates of hip fractures. The aim was to report the performance of a pre-existing regional anaesthetic technique in a routine clinical setting, with no randomisation or comparator group; all eligible patients that agreed to consent received the PENG block as part of routine perioperative care. After approval from the institutional ethics committee, the study was conducted for 2 years and was registered prospectively with the Clinical Trials Registry of India (CTRI/2024/09/073855).

Study Population

Patients aged between 18 and 80 years, American Society of Anesthesiologists (ASA) physical status I to III, scheduled for surgical repair of intertrochanteric fracture, femoral neck fracture or total hip arthroplasty under subarachnoid block were included. Exclusion criteria were coagulopathy, known allergy to local anaesthetic agents, cognitive impairment or dementia that would preclude reliable pain assessment, fracture of the femoral shaft, local infection at the proposed site of injection, or any analgesic medication within six hours of the intervention. Eligible patients were identified through purposive sampling of the pre-operative admission records. Written informed consent was obtained from each participant before enrollment.

Sample Size

The minimum sample size was calculated using G*Power software, assuming a two-tailed significance level of 5% and a statistical power of 80%. This led to a required sample size of 80 participants, which was considered sufficient to detect clinically relevant within-subject differences in pain and hemodynamic parameters and to account for potential dropouts.

Study Procedure and Intervention

On arrival to the pre-operative holding area, intravenous access was obtained, crystalloid infusion was started, and standard ASA monitoring (electrocardiography, non-invasive blood pressure and pulse oximetry) was begun. The anaesthesiologist measured baseline VAS scores at rest and during a passive straight-leg raise of the fractured limb to 15° (gently applied). Then the PENG block was performed in the supine position under aseptic precautions and real-time ultrasound guidance using a low-frequency curvilinear transducer by an experienced anaesthesiologist in regional techniques. The transducer was positioned transversely over the anterior inferior iliac spine and rotated to be parallel to the pubic ramus, and a 23-gauge spinal needle was advanced in-plane until the tip was in the

musculofascial plane between the psoas tendon and pubic ramus; then 20 mL of 0.25% bupivacaine was injected in 5 mL aliquots with intermittent negative aspiration. Vital signs were observed every five minutes for 30 minutes after the injection with careful observation for signs of local anaesthetic systemic toxicity. VAS scores at rest and on SLR were reassessed at 15 and 30 minutes. The patients were then moved to the operating room and positioned for subarachnoid block. The ease of spinal positioning was graded by the anaesthesiologist. In patients with Grade 4 positioning difficulty, rescue analgesia with intravenous fentanyl 50 mcg was given before proceeding to spinal anaesthesia.

Outcome Measures

The primary outcome was the grade of ease of spinal positioning, which was categorised from Grade 1 (positioned without pain and with minimal help) to Grade 4 (pain was intolerable and additional analgesia was needed). Secondary outcomes included VAS pain scores at rest and during 15° passive SLR, heart rate, mean arterial pressure and peripheral oxygen saturation at baseline and 15 and 30 minutes after the block. The proportion of patients requiring rescue analgesia and any block related complications were also noted.

Statistical analyses

Continuous variables such as VAS scores and hemodynamic parameters were described as median with interquartile range and compared between three time points with paired-sample tests. Categorical variables such as EOSP grade were analysed with Chi-square test. For each continuous parameter, baseline, 15-minute and 30-minute values were compared pairwise and two-sided p-values <0.05 were considered statistically significant. All analyses were carried out using the SPSS software (version 11).

Ethical Consideration

The study was approved by the institutional ethics committee and conducted as per ICMR National Ethical Guidelines for Biomedical Research (2017). All participants provided written informed consent and had the right to withdraw at any time with no impact on their current clinical care. Patient data were coded and stored securely. Emergency management protocols for local anaesthetic toxicity or haemodynamic instability were kept readily available throughout the study period.

RESULTS

Eighty patients undergoing hip fracture surgery were enrolled and completed the study protocol without dropout.

Baseline Demographic and Clinical Characteristics

The mean age of participants was 63.16 ± 13.90 years (range 21–80 years) and the mean body weight was 60.0 ± 9.08 kg (range 40–80 kg), consistent with the elderly demographic typically affected by fragility hip fractures. Female patients constituted a slightly higher proportion of the cohort (53.8%, n=43) than male patients (46.2%, n=37), in keeping with the higher prevalence of osteoporosis-related fractures among elderly women. Most patients belonged to ASA physical status II (65.0%), followed by ASA III (20.0%) and ASA I (15.0%), indicating that the majority had at least one coexisting systemic comorbidity (Table 1).

Table 1. Baseline demographic and ASA physical status distribution of study participants (N=80)

Variable	n	Value
Age (years), mean ± SD	80	63.16 ± 13.90
Weight (kg), mean ± SD	80	60.0 ± 9.08
Gender, n (%)		
Female	43	53.8%
Male	37	46.2%
ASA physical status, n (%)		
ASA I	12	15.0%
ASA II	52	65.0%
ASA III	16	20.0%

ASA, American Society of Anesthesiologists; SD, standard deviation.

Effect of PENG Block on Pain Scores (VAS at Rest and during Passive SLR)

Following the PENG block, both resting and dynamic pain scores fell sharply and progressively across the observation period. The median VAS at rest declined from 8.0 at baseline to 2.0 at 15 minutes and 0.0 at 30 minutes, while the median VAS during 15° passive SLR fell from 9.0 at baseline to 3.0 at 15 minutes and 1.0 at 30 minutes; the overall change across time points was statistically significant for both measures ($p<0.001$) (Table 2).

Table 2. Median VAS scores at rest and during 15° passive straight-leg raise (SLR) at baseline, 15 minutes, and 30 minutes after the PENG block

Parameter (Median [IQR])	Baseline	15 min	30 min	p value*
VAS at rest	8.0 [1.0]	2.0 [1.0]	0.0 [1.0]	<0.001
VAS during 15° passive SLR	9.0 [1.0]	3.0 [1.25]	1.0 [1.0]	<0.001

*VAS, Visual Analogue Scale (0–10 cm); IQR, interquartile range; SLR, straight-leg raise. *p value for overall change across the three time points.*

Effect of PENG Block on Hemodynamic Parameters

Heart rate declined from a median of 98.5 beats/min at baseline to 92.0 beats/min at 15 minutes and 77.5 beats/min at 30 minutes ($p<0.001$), and mean arterial pressure fell from 112.0 mmHg at baseline to 100.0 mmHg at 15 minutes and 97.0 mmHg at 30 minutes ($p<0.001$), a pattern consistent with attenuation of the pain-related sympathetic response rather than hemodynamic compromise, since both parameters remained within physiologically safe ranges throughout. Peripheral oxygen saturation remained stable (median 99–100%) across all time points (Table 3).

Table 3. Median heart rate, mean arterial pressure, and oxygen saturation at baseline, 15 minutes, and 30 minutes after the PENG block

Parameter (Median [IQR])	Baseline	15 min	30 min	p value*
Heart rate (beats/min)	98.5 [17.75]	92.0 [9.25]	77.5 [9.25]	<0.001
Mean arterial pressure (mmHg)	112.0 [14.50]	100.0 [12.25]	97.0 [8.25]	<0.001
SpO2 (%)	100.0 [1.0]	99.0 [1.0]	100.0 [1.0]	<0.001

*MAP, mean arterial pressure; SpO2, peripheral oxygen saturation; IQR, interquartile range. *p value for overall change across the three time points.*

Ease of Spinal Positioning and Requirement of Rescue Analgesia

The PENG block enabled straightforward positioning for subarachnoid block in the large majority of patients: 85.0% (n=68) achieved Grade 1 EOSP, while 7.5% (n=6), 1.3% (n=1), and 6.2% (n=5) were graded 2, 3, and 4, respectively. Correspondingly, only 7.5% of patients (n=6) required intravenous rescue fentanyl before spinal needle placement, while the remaining 92.5% (n=74) were positioned without any supplemental analgesia (Table 4).

Table 4. Distribution of ease of spinal positioning (EOSP) grade and requirement of rescue analgesia

EOSP grade	Frequency (n)	Percent (%)
Grade 1	68	85.0
Grade 2	6	7.5
Grade 3	1	1.3
Grade 4	5	6.2
Total	**80**	**100.0**
Rescue analgesia required		
No	74	92.5
Yes	6	7.5

EOSP, ease of spinal positioning, graded 1 (sitting without pain and minimal help) to 4 (intolerable pain requiring additional analgesia). Rescue analgesia consisted of intravenous fentanyl 50 mcg administered for Grade 4 EOSP.

Pairwise Comparisons of Pain and Hemodynamic Parameters across Time Intervals

Post-hoc pairwise comparisons confirmed that the reductions observed in Tables 2 and 3 were significant at every interval. For VAS at rest, differences between 15 minutes and baseline, 30 minutes and baseline, and 30 minutes and 15 minutes were all significant ($p<0.001$), as were the corresponding comparisons for SLR VAS ($p<0.001$) and heart rate ($p<0.001$). MAP declined significantly between baseline and 15 minutes and between baseline and 30 minutes (both $p<0.001$), with a smaller but still significant reduction between 15 and 30 minutes ($p=0.009$). SpO2 showed only minor, though occasionally statistically significant, fluctuations ($p=0.006$ and $p=0.018$ for two comparisons; $p=1.000$ for the baseline-to-30-minute comparison), none of which were clinically meaningful (Table 5).

Table 5. Pairwise comparisons of VAS, heart rate, mean arterial pressure, and SpO2 across time intervals following the PENG block

Parameter	Interval compared	Test statistic	p value
VAS at rest	15 min vs Baseline	1.006	<0.001
	30 min vs Baseline	1.994	<0.001
	30 min vs 15 min	0.987	<0.001
VAS during SLR	15 min vs Baseline	1.000	<0.001
	30 min vs Baseline	2.000	<0.001
	30 min vs 15 min	1.000	<0.001
Heart rate	15 min vs Baseline	0.772	<0.001
	30 min vs Baseline	1.829	<0.001
	30 min vs 15 min	1.057	<0.001
Mean arterial pressure	15 min vs Baseline	0.930	<0.001
	30 min vs Baseline	1.405	<0.001
	30 min vs 15 min	0.475	0.009
SpO2	15 min vs Baseline	0.494	0.006
	30 min vs 15 min	-0.437	0.018
	30 min vs Baseline	0.057	1.000

VAS, Visual Analogue Scale; SLR, straight-leg raise; SpO2, peripheral oxygen saturation. Test statistic represents the paired-comparison value (Wilcoxon signed-rank test statistic for VAS and SpO2; paired t-test statistic for heart rate and mean arterial pressure).

DISCUSSION

This prospective observational study demonstrated that a single shot ultrasound-guided PENG block has resulted in a rapid and sustained reduction in resting and dynamic pain scores and was associated with an excellent ease of spinal positioning in the vast majority of patients with maintained hemodynamic stability, findings consistent with a rapidly growing body of literature published since 2021 on the analgesic role of this block in hip fracture surgery.

The magnitude and speed of pain relief observed in this cohort are similar to those reported in comparative trials. Chaudhary et al. similarly reported a significant reduction in positioning related pain after PENG block in patients undergoing spinal anaesthesia for proximal femur fracture with pain scores continuing to fall throughout the 30 minute observation window [3]. Randomised comparisons with fascia iliaca-based techniques have also shown improved or similar analgesia with the PENG block. In comparison with the supra-inguinal fascia iliaca block, the PENG block improved positioning conditions for spinal anaesthesia [7], as shown by Keskes et al. In hip fracture cohorts, Nuthep et al. and Baheti and Yerramshetty demonstrated similar reductions in positioning pain when the PENG block was added to, or compared against fascia iliaca-based analgesia [8,9]. Similarly, a randomised trial by Pavithra et al. found that the pericapsular block offered more favourable conditions for pre-operative positioning compared with a landmark-based fascia iliaca block [10]. These findings are consistent and were derived using distinct comparator techniques and study designs. They have now been replicated in an unselected, real-world cohort in the present study, supporting the generalisability of the analgesic effect of the PENG block for the positioning phase of hip fracture surgery. Mechanistically, this efficacy is due to the selective deposition of local anaesthetic in the musculofascial plane between the psoas tendon and the pubic ramus which anaesthetises the articular branches of the femoral, obturator and accessory obturator nerves supplying the anterior hip capsule – the most densely innervated and nociceptive component of the joint – while sparing the femoral nerve trunk itself and the quadriceps motor function required for safe, active repositioning [5]. A meta-analysis restricted to patients undergoing spinal anaesthesia also demonstrated a significant reduction in pain scores during positioning and earlier postoperative mobilisation following the PENG block [6], which is in direct agreement with the favourable EOSP grades found here, and quality-of-recovery data from randomised trials in hip arthroplasty further suggest that this analgesic advantage translates into meaningful improvement in overall recovery when the block is added to a multimodal regimen [11].

No patient developed clinically important hypotension or bradycardia. The parallel decrease in heart rate and mean arterial pressure after the block is consistent with attenuation of the perioperative stress response after effective regional analgesia in elderly patients undergoing hip surgery. Cui et al. showed that in elderly patients undergoing hip arthroplasty, the PENG block was more effective than the suprainguinal fascia iliaca block in preserving intraoperative hemodynamic stability and in reducing markers of the surgical stress response [12], a mechanism that plausibly explains the smooth hemodynamic trend observed in the present cohort, rather than any adverse cardiovascular effect. As unrelieved fracture pain is a potent sympathetic stimulus and a recognised precipitant of delirium and adverse cardiac events in older adults, the reduction in heart rate and blood pressure is most likely a reflection of successful analgesia, rather than a safety concern [13,14]. This interpretation is consistent with opioid-sparing data from placebo-controlled trials, in which the PENG block was associated with a significant reduction in opioid consumption over 24 hours, without increased hypotension or nausea [15,16]. Similarly, meta-analytic evidence confirms a consistent, moderate-quality reduction in perioperative opioid requirement across multiple randomised trials [16,17,18,19,20]. This is especially relevant in this elderly comorbid population where opioid-related sedation, respiratory depression and delirium carry a disproportionate risk [14].

Together, these results support the inclusion of the ultrasound-guided PENG block in routine preoperative pathways for hip fracture surgery, particularly in resource-poor settings where it can be performed rapidly, with only one needle pass, and without the motor blockade associated with femoral nerve-based techniques. There are some limitations to consider. The observational, single-arm design and absence of a randomised comparator or placebo control preclude definitive causal attribution of the observed improvements to the PENG block alone. The single-centre setting limits generalisability to institutions with a different case-mix or operator experience. While the sample size was relatively small but adequate for the primary observational objectives, it limits statistical power for subgroup analyses by fracture type or ASA class, and postoperative outcomes such as opioid consumption, ambulation and delirium were not assessed, representing an important direction for future controlled trials.

CONCLUSION

In this prospective observational study, a single ultrasound-guided PENG block produced rapid and sustained reductions in resting and dynamic pain scores, enabled Grade 1 ease of spinal positioning in the majority of patients, minimised the need for rescue analgesia, and preserved hemodynamic stability throughout the pre-spinal period. These findings, consistent with the expanding post-2021 literature on the PENG block, support its routine use as a safe and effective analgesic adjunct for facilitating spinal positioning in patients undergoing hip fracture surgery.

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