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OPIOID-SPARING ANALGESIA IN HIP REPLACEMENT: INSIGHTS FROM THE PERICAPSULAR NERVE GROUP BLOCK

Anaesthesiology

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ABSTRACT

Background- Hip fractures are a major cause of morbidity and hospitalization in the elderly, with surgery being the mainstay of treatment. Effective postoperative pain management is crucial for early mobilization and optimal recovery. Conventional regional techniques such as femoral or fascia iliaca blocks often provide incomplete analgesia and may cause motor weakness, limiting rehabilitation. Due to suboptimal pain control with these methods, higher doses of opioids are frequently required, leading to adverse effects such as respiratory depression, nausea, and delirium. The pericapsular nerve group (PENG) block has emerged as a motor-sparing alternative that may offer superior analgesia while minimizing opioid requirements and related complications. ***Objective-*** To evaluate the effect of PENG block on postoperative opioid consumption and recovery after THA. ***Methods-*** This prospective observational comparative study included 70 adult patients undergoing THA at a tertiary care centre, North India. Group A received ultrasound-guided PENG block plus multimodal analgesia; Group B received multimodal analgesia alone. Postoperative opioid use was recorded in morphine equivalents. Pain scores and quadriceps strength were assessed. ***Results-*** Group A had lower opioid consumption at 0–12h (12.24 ± 14.27 mg vs 36.51 ± 23.54 mg, p=0.001) and 12–24h (17.21 ± 14.44 mg vs 41.26 ± 21.66 mg, p=0.001). Time to first rescue analgesia was longer in Group A (12.31 ± 9.13 h vs 7.03 ± 3.65 h, p=0.002). Pain scores were lower at 8h and 12h. Quadriceps strength was preserved at 24–48h. No complications were observed. ***Conclusion-*** PENG block significantly reduces opioid requirements and improves early pain control in THA without impairing motor function.

KEYWORDS

PENG block, total hip arthroplasty, opioid consumption, postoperative pain

INTRODUCTION

Total hip arthroplasty (THA) remains the standard of care for end-stage hip osteoarthritis, offering substantial pain relief and improved joint function.[1] In the United States, the prevalence of THA among adults aged fifty years and older was estimated to be 2.34% in 2010, with projections indicating a significant rise in demand due to an aging population and the increasing pursuit of improved mobility and quality of life.[2] Despite being one of the most successful and rapidly growing orthopedic procedures, THA can fail due to instability, infection, loosening, or implant wear, imposing a considerable burden on both patients and healthcare systems. Moreover, postoperative pain following hip surgery can be moderate to severe, necessitating effective pain management to ensure early mobilization, faster rehabilitation, and better functional outcomes.[3,4]

Conventional regional anesthetic techniques, such as lumbar plexus and femoral nerve blocks, though effective in providing analgesia, often induce significant motor blockade of the quadriceps, leading to delayed ambulation and rehabilitation. The fascia iliaca compartment block (FICB), while safer and simpler, has demonstrated inconsistent analgesic efficacy for major hip procedures.[5] Consequently, the relative inefficiency of these alternative techniques often necessitates the use of higher opioid doses to achieve adequate analgesia, which in turn increases the risk of opioid-related adverse effects such as respiratory depression, nausea, vomiting, delirium, and constipation.[6]

Advances in the anatomical understanding of hip joint innervation have led to the development of more targeted and motor-sparing regional blocks. The anterior capsule of the hip joint, rich in nociceptors and mechanoreceptors, has been identified as the principal source of pain following hip surgery.[7] The Pericapsular Nerve Group (PENG) block, first described by Girón-Arango et al., specifically targets the articular branches of the femoral, obturator, and accessory obturator nerves that supply the anterior hip capsule.

By selectively blocking these sensory branches while sparing motor fiber, the PENG block provides effective analgesia without compromising quadriceps strength, thereby facilitating early ambulation, improved participation in physiotherapy, and potentially shorter hospital stays.[8]

Rationale And Novelty

Despite its growing clinical adoption, evidence regarding the analgesic efficacy of the PENG block in total hip arthroplasty (THA) remains mixed. Some studies have reported superior pain relief and reduced opioid consumption with PENG block compared to traditional techniques,[9,10] whereas others found no significant difference.[11,12] Moreover, most data are derived from controlled trial settings, with limited real-world evidence assessing its effectiveness in routine clinical practice.

Given these conflicting findings, the present study aims to evaluate whether the implementation of the PENG block, as part of a multimodal analgesic regimen in patients undergoing total hip arthroplasty, effectively reduces postoperative opioid consumption compared to those who do not receive the block.

MATERIALS AND METHODS

Study Design And Ethics- This prospective observational comparative study was conducted in the Department of Anaesthesiology and Postoperative Care Unit at a tertiary care centre in North India between February 2024 and October 2024. Institutional Ethics Committee approval was obtained (Protocol No: 1634/2023; Date: 12.01.2024). Written informed consent was obtained from all participants, and the study adhered to the Declaration of Helsinki principles.

Patient Selection- Seventy adult patients scheduled for elective total hip arthroplasty (THA) under spinal anaesthesia were enrolled. Inclusion criteria were age 18–70 years, ASA physical status I–III, and provision of informed consent. Exclusion criteria included refusal to participate, known allergy to local anaesthetics, infection at the injection site, coagulopathy, pre-existing neurological deficit in the operative limb, inability to use pain scales reliably, or serum creatinine >1.5 mg/dL.

Group Allocation- Based on the study by Pascarella et al, a 30% reduction in opioid consumption was considered clinically significant.[9] With 80% power and a 5% significance level, 35 patients per group were required. Patients were divided into two groups of 35

each. Group A received an ultrasound-guided PENG block with multimodal analgesia, while Group B received multimodal analgesia alone. Participants were allocated to either group using an alternate assignment method.

Anaesthesia And Block Technique- All patients received spinal anaesthesia with 3.5 mL of 0.5% hyperbaric bupivacaine. In Group A, a PENG block was administered preoperatively under aseptic precautions using a curvilinear low-frequency ultrasound probe and a 100-mm echogenic needle. A total of 20 mL of 0.2% ropivacaine was injected in the fascial plane deep to the psoas tendon adjacent to the iliopubic eminence.

Analgesic Regimen- All patients received intravenous paracetamol 1 g every 8 hours, diclofenac 75 mg every 12 hours, and local infiltration with 10 mL of 0.2% ropivacaine at wound closure. Rescue analgesia was intravenous PCA fentanyl (25 mcg demand dose, 15-min lockout). Total opioid doses were converted to oral morphine equivalents (OME) for analysis.

Outcomes- The primary outcome was cumulative opioid consumption in OME during the first 24 hours postoperatively. Secondary outcomes included pain scores [Numerical Rating Scale(NRS) 0–10] at 4, 8, 12, 24, 36, and 48 hours, time to first rescue analgesia, quadriceps strength (Oxford scale 0–5), and adverse effects (nausea, vomiting, respiratory depression, block-related complications).

Statistical Analysis- Data were expressed as frequencies, percentages, and mean±SD. The Chi-square test compared categorical variables, while the Unpaired t-test or Mann–Whitney U test compared continuous variables. A p-value <0.05 was considered statistically significant. Analysis was performed using SPSS version 16.0 (Chicago, Inc., USA).

RESULTS

1. Patient characteristics- The comparison of anthropometric parameters between the groups [Table 1].

Table 1. Baseline Characteristics Of Study Participants.

Anthropometric parameters	Group A (n=35)	Group B (n=35)	t and p-value[1]
Height in cm	165.60±8.12	164.37±6.75	0.68, 0.49
Weight in kg	67.11±8.67	64.77±10.44	1.02, 0.31
BMI in kg/m^2	24.48±2.83	23.84±2.57	0.99, 0.32

[1]Unpaired t-test, n = number of patients

2. Total postoperative opioid consumption- The comparison of post operative opioid consumption in oral morphine equivalents (mg) between the groups [Table 2]. The mean post operative opioid consumption (morphine) at 0-12 h and 12-24 h was significantly (p=0.001) lower among patients of Group A compared to Group B.

Table 2. Postoperative Opioid Consumption (Oral Morphine Equivalents, mg).

Time from PENG Block	Group A (n=35)	Group B (n=35)	U and p-value[1]
0-12 h	12.24±14.27	36.51±23.54	232.50, 0.001*
12-24 h	17.21±14.44	41.26±21.66	189.50, 0.001*

[1]Mann-Whitney U test, *Significant, n = number of patients

3. Pain scores- The comparison of NRS score between the groups across the time periods [Table 3]. NRS pain score was found to be significantly (p<0.05) lower among patients of Group A than Group B at 8 and 12 h postoperatively.

Table 3. Postoperative Pain Scores (NRS).

Time from PENG	Group A (n=35) NRS	Group B (n=35) NRS	U and p-value[1]
4 h	0.23±1.35	0.17±1.01	612.00, 0.98
8 h	3.31±2.24	4.09±1.86	443.00, 0.04*
12 h	3.26±1.37	3.91±1.31	414.50, 0.02*
24 h	3.60±1.06	3.43±1.22	541.50, 0.38
36 h	2.34±1.13	2.31±1.15	569.50, 0.91
48 h	1.77±1.08	2.06±1.13	531.00, 0.30

[1]Mann-Whitney U test, *Significant, n = number of patients; NRS – Numerical rating scale

4. Time to rescue analgesia- The comparison of timing of first dose of opioid between the groups from the time of PENG Block [Table 4]. The mean time of first dose of opioid consumption was significantly (p=0.002) delayed among patients of Group A (12.31±9.13 hours) than Group B (7.03±3.65 hours).

Table 4. Time To Rescue Analgesia.

Groups	Timing Of 1st Dose Of Opioid Consumption In Hours (Mean±SD)
Group A	12.31±9.13
Group B	7.03±3.65
t and p-value[1]	3.17, 0.002*

[1]Unpaired t-test, *Significant,

5. Quadriceps strength- The comparison of Quadriceps muscle strength between the groups [Table 5]. Quadriceps muscle strength was absent at 4 hours in both the groups. However, quadriceps muscle strength was reduced in 5.7% patients in Group A and in 2.9% in Group B at 8 & 12 hours, the difference was insignificant (p>0.05). Quadriceps muscle strength was intact in both the groups at 24, 36 and 48 hours.

Table 5. Comparison Of Quadriceps Muscle Strength Between The Groups

Time from PENG Block	Group A (n=35)		Group B (n=35)		χ^2 and p-value[1]
	No.	%	No.	%	
4 hours					
Absent	35	100.0	35	100.0	-
8 hours					
Intact	33	94.3	34	97.1	0.34, 0.55
Reduced	2	5.7	1	2.9	
12 hours					
Intact	33	94.3	34	97.1	0.34, 0.55
Reduced	2	5.7	1	2.9	
24 hours					
Intact	35	100.0	35	100.0	-
36 hours					
Intact	35	100.0	35	100.0	-
48 hours					
Intact	35	100.0	35	100.0	-

[1]Chi-square test, *Significant, n = number of patients

Complications

No complications such as vascular puncture, haematoma, or local anaesthetic systemic toxicity were observed. Nausea and vomiting were comparable between groups.

DISCUSSION

The pericapsular nerve group (PENG) block is a relatively novel regional anaesthesia technique designed to provide analgesia for hip surgery by targeting the articular branches of the femoral, obturator, and accessory obturator nerves that innervate the anterior hip capsule.[13] A key advantage of the PENG block is its potential to provide effective pain relief without causing significant quadriceps motor weakness, thereby facilitating early mobilization and functional recovery. Despite this theoretical benefit, clinical experience has shown that the PENG block may occasionally result in unanticipated motor weakness.[11] Several explanations have been proposed, including needle misplacement, inadvertent intramuscular injection, or medial spread of local anaesthetic to the femoral nerve.[9]

The role of local anaesthetic volume and concentration is central to the balance between analgesia and motor preservation. Cadaveric and imaging studies have demonstrated that small volumes (10–20 mL) are sufficient to cover the anterior hip capsule,[14] whereas higher volumes increase the likelihood of femoral nerve spread and quadriceps weakness,[15] Clinical studies confirm that lower volumes can achieve comparable analgesia with fewer motor side effects.[16] Similarly, the concentration of ropivacaine may influence motor involvement, as higher concentrations are more likely to affect motor fibres despite being intended for sensory blockade.[17] Thus, titrating both volume and concentration appears critical to achieving the motor-sparing effect that distinguishes the PENG block from other regional techniques.

The current study adds to the growing body of evidence supporting the efficacy of PENG block in the setting of total hip arthroplasty (THA). Patients who received PENG block in addition to multimodal analgesia demonstrated significantly reduced opioid requirements in the first 24 hours postoperatively compared with those receiving multimodal analgesia alone. Moreover, the time to first request for rescue opioid was substantially delayed in the PENG group, reflecting the block's efficacy in prolonging postoperative analgesia.

Pain intensity scores were also lower in the PENG group at early postoperative intervals, particularly at 8 and 12 hours. Importantly, quadriceps strength was preserved, with no significant motor impairment observed at 24, 36, or 48 hours.

Our findings are consistent with reports by Pascarella et al., who observed superior analgesia and reduced opioid use after THA with PENG block compared with controls.[9] Similarly, retrospective analyses have demonstrated meaningful reductions in 24-hour opioid requirements in patients receiving PENG block.[10]

Nevertheless, conflicting data exist. Some randomized controlled trials and meta-analyses have found no significant differences in opioid use, pain scores, or time to rescue analgesia when comparing PENG block with other regional techniques.[18,19] Heterogeneity in study designs, surgical approaches, block techniques, and anaesthetic regimens likely account for this variability. Notably, higher local anaesthetic volumes in some studies may explain the motor weakness observed, undermining the potential motor-sparing advantage.

Strengths of this study include its prospective design, comparable baseline demographics between groups, and systematic evaluation of both analgesic and motor outcomes. The incorporation of multimodal analgesia in both arms reflects contemporary clinical practice, allowing assessment of the incremental benefit of the PENG block.

This study has several limitations. Its observational design and non-randomized allocation may introduce selection bias. The modest sample size and single-centre setting limit generalizability. Long-term outcomes such as functional recovery were not evaluated. Future multicentre randomized trials with larger cohorts are needed to validate these findings and determine optimal dosing strategies.

The results support incorporating the PENG block into multimodal analgesic protocols for total hip arthroplasty (THA). By reducing opioid use and improving pain control without motor impairment, it aligns with ERAS goals, promoting early mobilization, greater satisfaction, and fewer opioid-related adverse effects. However, precise technique, careful selection of anaesthetic volume and concentration, and adequate training in ultrasound guidance are essential for safety and consistency.

CONCLUSION:

Adding the pericapsular nerve group (PENG) block to multimodal analgesia reduced postoperative opioid consumption and improved early pain control after THA without compromising quadriceps strength. These findings highlight its potential as a motor-sparing component of enhanced recovery pathways, warranting confirmation through larger multicentre trials.

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