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Comparison between pericapsular nerve group block and morphine infusion in reducing pain of proximal femur fracture in the emergency department: A randomized controlled study

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ABSTRACT

Background: This study aimed to assess the safety and efficacy of analgesia with pericapsular nerve group (PENG) block as an adjuvant to morphine infusion for the management of preoperative pain in patients with proximal femur fractures.

Methods: This single-blinded, parallel-group, randomized trial enrolled 36 adult patients with proximal femur fractures who were prepared for surgery. The patients were randomly allocated to two groups. In the PENG group, 18 patients received a US-guided PENG block as an adjuvant to patient-controlled morphine analgesia (PCA), while in the PCA group, 18 patients received PCA only. The primary outcome was the total morphine consumption in 24 hours before the surgery. The secondary outcomes included the visual analogue scale (VAS), need for rescue analgesia, total sleep hours, incidence of respiratory depression, hemodynamic stability, and incidence of nausea and vomiting during the first 24 hours post-procedure.

Results: The PENG block significantly decreased the total dose of morphine, VAS score at one-hour post-procedure, need for rescue analgesia, incidence of respiratory depression and nausea but increased the sleeping hours. Vomiting was comparable in the two groups ($p = 0.121$). Significantly higher mean arterial pressures from 8 to 20 hours after the block as well as heart rates immediately after the block were observed in the PENG group compared to the PCA group.

Conclusion: In patients with proximal femur fractures, preoperative PENG block can be used as an adjuvant to morphine infusion for controlling the pain and the total dose of morphine usage.

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Analgesia; morphine; pericapsular nerve group block; proximal femur fracture

1. Introduction

Proximal femoral fractures are commonly traumatic in elderly females aged more than 50 years [1]. Numerous studies have reported severe pain in the perioperative period, which can lead to a series of related complications, which not only increases the perioperative risk but also compromises the long-term prognosis of patients. Optimal perioperative analgesia can greatly facilitate the patient's postoperative recovery [2,3].

Safe and effective pain management may be challenging for patients with acute femur fractures. The most popular analgesic treatment for pain is opioids. However, Bijur et al. [4] demonstrated that the standard analgesic doses of morphine were not effective in controlling severe pain. Furthermore, respiratory depression, nausea, vomiting, hemodynamic instability, and cognitive dysfunction are common adverse effects [5]. In addition, elderly patients have been demonstrated to be more likely to develop oligoanalgesia in emergency rooms [6]. Hence, other adjuvants to morphine should be used to control severe pain, particularly in elderly patients with femur fractures [7].

Regional anesthesia is a multimodal analgesic strategy used to limit the need for opioid drugs [8]. Lumbar plexus, fascia iliaca, and femoral nerve blocks are frequently used as regional analgesic methods. These approaches have only partial success in reducing pain. Moreover, patients with these blocks are liable to fall due to muscle weakness [9].

The pericapsular nerve group (PENG) block is an ultrasound-guided regional anesthetic method that was created in 2018. Pericapsular nerve group block is used for pain control in total hip arthroplasties or fractures of the proximal femur/femoral head. It gives quick and efficient alleviation of hip pain without motor affection. The PENG block targets the nerve connected to the anterior hip capsule, by injecting local anesthetic into the psoas muscle and superior pubic ramus' myofascial plane [10]. The PENG block can be administered alone as the primary analgesic or in combination with other types of anesthesia. A supplementary lateral femoral cutaneous nerve block offers further protection for lateral surgical incisions [11].

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The aim of this study was to assess the safety and efficacy of analgesia with preoperative PENG block as an adjuvant to morphine for control of preoperative pain in patients with proximal femur fractures.

2. Methods

2.1. Ethical considerations

The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Suez Canal University, Egypt. The study was registered at the ClinicalTrials.gov (ID: NCT05023473). Written informed consents were obtained from the study participants after explanation of the purpose and technique of the study. All data were kept confidential.

2.2. Study design, setting, and date

This single-blind, parallel-group, randomized, controlled trial was conducted at the Suez Canal University Hospital, Egypt, between April and August 2022.

2.3. Eligibility criteria

The present study included 36 adult patients (aged more than 18 years) with unilateral fracture of the proximal femur who were American Society of Anesthesiologists (ASA) physical status I or II and were scheduled for surgery.

We excluded patients with body mass index greater than 35 Kg/m^2, bleeding tendency, chronic liver or kidney disease and heart block greater than first degree. Patients who had history of allergy to the drugs used and those who refused to participate were also excluded.

2.4. Randomization, allocation concealment, and blinding

Randomization was done by a computer software program (www.Randmizer.org), and allocation concealment was performed using the sequentially numbered, opaque, sealed envelope method [12]. The envelopes were impermeable to intense light, and the allocation sequence was concealed from the physician assessing and enrolling participants. To prevent subversion of the allocation sequence, the name and hospital admission number of the participants were written on the envelopes. The corresponding envelope was opened only after the enrolled participant completed all baseline assessments, and it was time to allocate the intervention. The study participants were kept blinded to the allocation.

2.5. Interventions

Thirty-six patients were randomly allocated to two groups (18 patients each). The PENG group underwent US-guided pericapsular nerve group block with bupivacaine 0.5% plus patient-controlled morphine analgesia (PCA). The PCA group received PCA only.

All patients were subjected to detailed history taking and thorough physical examination. Routine preoperative investigations were performed including complete blood count, prothrombin time, partial thromboplastin time, international normalized ratio, liver function tests, serum creatinine, and random blood sugar.

Immediately after diagnosis and stabilization in the emergency department before shifting to the ward, morphine analgesia was given by PCA. Once visual analogue scale (VAS) was more than or equal to four, the patient pressed a button on the PCA pump (Graseby 3300 PUMP; Smith Medical International, Ashford, Kent, UK), which was programmed to deliver a bolus of 1 ml (1 mg morphine), 30 minutes lockout interval, and a maximum dose of 2 mg/hour. Paracetamol (1 gm) was given by infusion every 6 hours for 24 hours. Ketorolac (30 mg) was given as a rescue analgesia. Basic monitoring, using Datex-Ohmeda™, was applied for the heart rate, non-invasive blood pressure, oxygen saturation, and ECG.

2.6. Block performance

With the patient in the supine position, the ultrasound curvilinear (2.5–5 MHz) probe was placed on a transverse plane over the anterior superior iliac spine. Once the spine was identified, the transducer was aligned with the pubic ramus and rotated at approximately 45 degrees, parallel to the inguinal crease. The transducer was then slid medially along this axis until the anterior inferior iliac spine, iliopubic eminence, and the psoas tendon were identified, serving as anatomic landmarks. The head of the femur was exposed through sliding the probe distally or gently tilting caudally. After returning to the initial starting position, a standard B-Braun Stimuplex 22 G × 100 mm needle was inserted in-plane under ultrasound guidance, from lateral to medial, in the plane between the psoas tendon and the pubic ramus. All the blocks were performed in an aseptic setting with the patient observed.

2.6.1. The pericapsular nerve group block group

The allocated patient to PEBG block received 20 mL of 0.5% bupivacaine local anesthetic by injection in a plane block between the psoas fascia and superior pubic rami and continued with PCA.

2.6.2. The patient-controlled morphine analgesia group

The allocated patient to PCA continued with PCA only.

The total morphine consumption was recorded for the 24 hours after the block. The VAS for pain was assessed immediately post-procedure and at 1, 4, 8, 12, 16, 20, and 24 hours after the procedure [13]. The

VAS ranges from 0, indicating no pain, to 10, indicating severe intolerable pain, with variable degrees of ascending pain in between. The VAS was assessed at rest by an anesthesia resident who is blinded to the performed technique. The incidence of analgesia (ketorolac) requests was recorded. The total sleeping hours were recorded for 24 hours after the block by the observing nurses. The incidence of respiratory depression was assessed and recorded when the oxygen saturation dropped below 92%. The hemodynamic parameters including respiratory rate, heart rate (HR), and mean arterial blood pressure (MAP) were recorded immediately post-procedure and at 1, 4, 8, 12, 16, 20, and 24 hours after the procedure. Any adverse effects, including the nausea and vomiting, were recorded and managed according to the usual protocols. All patients were transported to the operation theater 24 hours or more following the block.

2.7. Outcomes

The primary outcome was the total amount of morphine during the first 24 hours post-procedure. Secondary outcomes included the post-procedure pain that was assessed using the VAS score, the need for rescue analgesia, the total sleep hours, the incidence of respiratory depression, the hemodynamic stability, and the incidence of nausea and vomiting during the first 24 hours post-procedure.

2.8. Sample size calculation

The sample size was calculated using the G power 3.1.9.2 software after setting the used statistical test to the Independent Samples t Test, with an α error probability of 0.05, power of 0.85, and allocation ratio of 1:1. According to Pascarella et al. [14], a Cohen's effect size of 1.15 was calculated regarding the total opioid consumption between the control and the PENG block groups. Based on these assumptions, the calculated sample size was 16 patients per group. We added 10% to account for the possible dropouts. The final sample size was then 18 subjects per group (the total sample size was 36 patients).

2.9. Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (IBM SPSS Statistics) for Windows, version 22 (IBM© Corp., Armonk, NY, USA) and GraphPad Prism (GraphPad Software), version 8.0.1 (San Diego, California, U.S.). For quantitative data, the Shapiro–Wilk test for normality was performed. Normally distributed data were summarized as mean ± standard deviation (SD), and the studied groups were compared using the Student's t-test or the Mann–Whitney U-test. Qualitative data were summarized as frequencies, and associations were tested using the Pearson's Chi-square test or Fisher's exact test. All tests were two-tailed. A p-value <0.05 was considered significant.

3. Results

Forty-three patients were recruited; two patients refused to participate, and two patients were excluded due to coagulation disorders, three patients were omitted because they did not complete the 24-hour period between the block performance and the shift to the operating room. Thirty-six patients were enrolled in the study and were randomly allocated to two groups (18 patients each). The PENG group received PENG block with bupivacaine 0.5% as adjuvant to PCA. The PCA group underwent US-guided placebo block and the PCA (Figure 1).

Baseline characteristics including age, gender, body mass index, and ASA physical status were comparable in both groups. The total morphine consumption was significantly lower in the PENG group than in the PCA group ($p < 0.001$). The total morphine reduction was 3.6 mg less in the PENG group than in the PCA only group. Only one patient in the PENG group required rescue analgesia, while nine patients in the PCA group needed rescue analgesia with statistically significant difference ($p = 0.007$). The median value of the sleeping hours was 8 hours in the PENG group compared with 7 hours in the PCA group with a statistically significant difference ($p = 0.01$). The PCA group developed significantly greater respiratory center depression in comparison with the PENG group (61% vs 11%, respectively; $p = 0.005$). The incidence of nausea was significantly lower in the PENG group than the PCA group (17% vs 56%, respectively; $p < 0.05$). Meanwhile, vomiting was comparable in both groups ($p = 0.121$) (Table 1).

t different time points along 24 hours after the block, the VAS score revealed significantly higher score in the PCA group compared to the PENG group just at the 1st hour after the block. The rest of the 23 hours revealed no significant difference between both groups (Figure 2).

At 8 hours and till 20 hours following the block, the MAP was significantly higher in the PENG group compared to the PCA group. At the end of 24 hours following the block, the MAP was comparable in both groups (Figure 3).

The HR was significantly higher in the PENG group than the PCA group immediately after completion of the block. However, during follow-up of the rest of the 24 hours, the values were comparable in both groups (Figure 4).

4. Discussion

For the past 20 years, opioids have been dominating the global market for effective analgesia of hip fractures

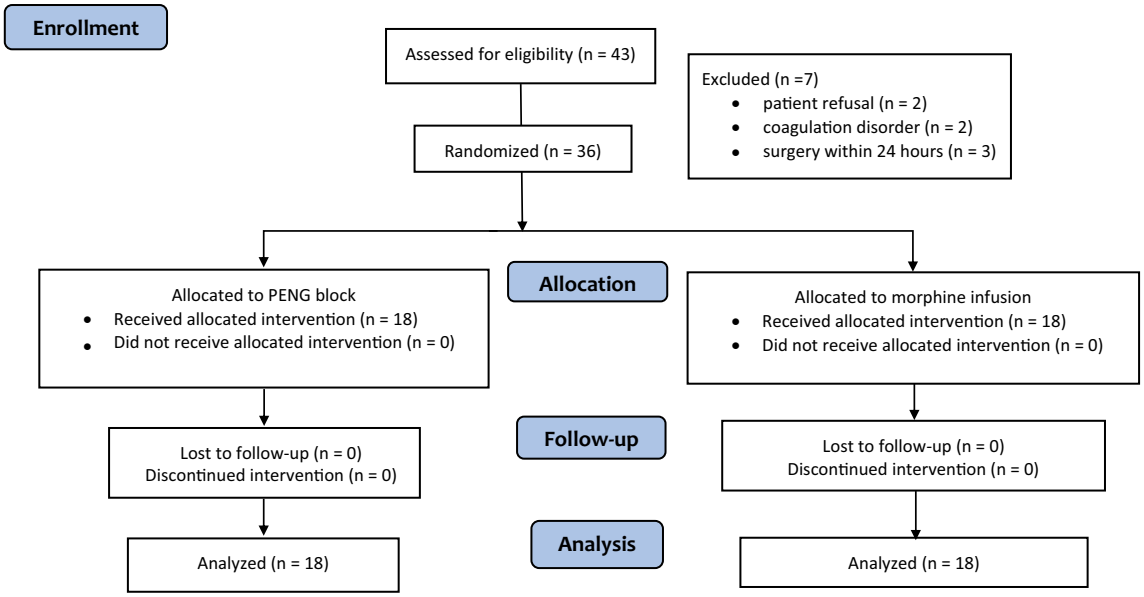

Figure 1. The trial flow chart.

Table 1. Demographic, baseline patients' characteristics, total morphine consumption, rescue analgesic request, total sleeping hours, respiratory depression, nausea, and vomiting.

		PENG N = 18	PCA N = 18	p-value
Age (years)		57 (55–58)	56 (47–61)	0.743
Gender (females)		10 (56%)	9 (50%)	1.00
BMI (Kg/m^2, mean ± SD)		28.44 ± 3.68	29.99 ± 3.69	0.654
ASA	I	7 (39%)	6 (33%)	1.00
	II	11 (61%)	12 (67%)	
Total morphine consumption (Within the first 24 h in milligrams)		5 (4–8)	18 (15.5–22.5)	**<0.001***
Rescue analgesia (ketorolac)		1 (6%)	9 (50%)	**0.007***
Total sleeping hours (Within the first 24 hours)		8 (7–9)	7 (6–8)	**0.010***
Incidence of respiratory depression		2 (11%)	11 (61%)	**0.005***
Nausea		3 (17%)	10 (56%)	**0.035***
Vomiting		2 (11%)	7 (39%)	0.121

Data are presented as mean ± SD, median (range) or number (%). ASA: American Society of Anesthesiologists; BMI: body mass index; h: hours; n: number; SD: standard deviation. P-values are based on the independent-t-test, Mann Whitney U test, or chi-square test. *Significant.05.

[15,16]. Opioids could reduce pain at rest, but they were ineffective in controlling pain on movement. Patients with hip fractures frequently employ fascia iliaca block and femoral nerve block for pain management because they are generally safe and can offer a reasonable level of analgesia with an opioid-sparing effect. However, these blocks might not offer enough analgesia in hip fractures. Pericapsular nerve group block is a novel approach with scarce scientific support [17]. The aim of this study was to assess the safety and efficacy of PENG block as an adjuvant to morphine for management of preoperative pain in patients with proximal femur fractures.

In the present study, baseline characteristics were comparable in both groups. During the preoperative 24 hours, patients who received PENG block had significantly lower total dose of morphine consumption, VAS score, need for rescue analgesia, and incidence of respiratory depression and nausea as well as longer sleep hours compared to patients who received morphine only. In addition, those patients had significantly higher MAP, and HR at certain times compared to patients who received morphine only, but it was comparable to the baseline measurements and the sedating effect of morphine may be the cause of lower records in morphine group.

Our findings were in accordance with earlier studies denoting that PENG block provided better analgesia than other modalities during hip arthroplasty. Aliste at al. [18], Hua et al. [19], and Mostaffa et al. [20] have reported that PENG block was more effective than the iliac fascia block.

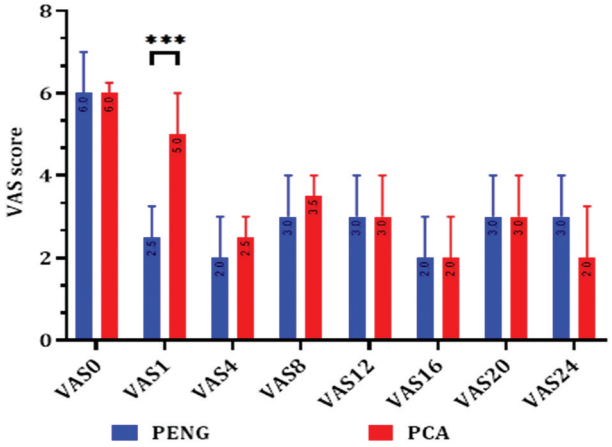

Figure 2. Visual analogue scale (VAS). ***Statistical significance at P < 0.001.

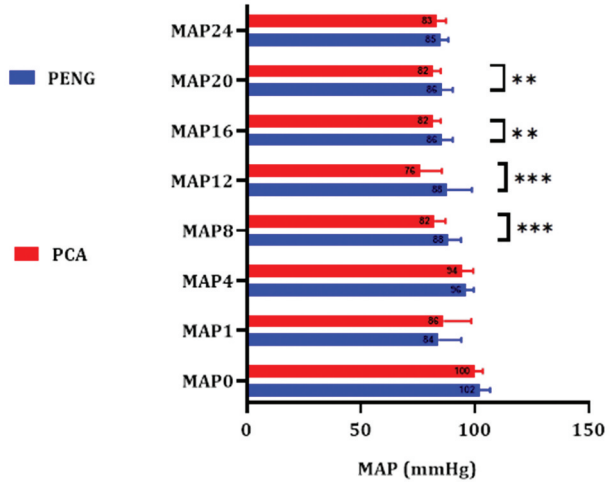

Figure 3. Heart rate (HR). ***Statistical significance at P < 0.001.

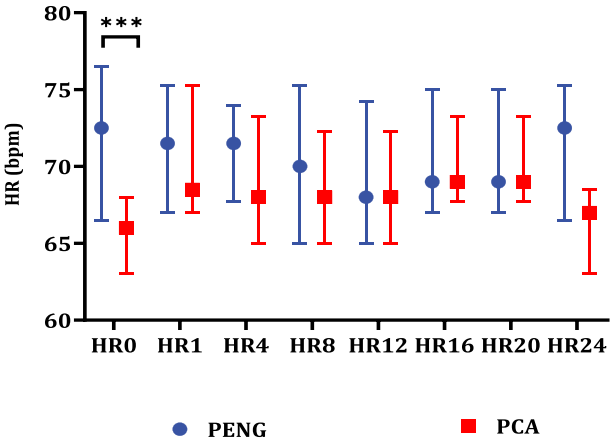

Figure 4. Mean arterial blood pressure (MAP). **Statistical significance at P < 0.01; ***Statistical significance at P < 0.001.

Allard et al. [21] and Lin et al. [22] have found that PENG block was more effective than femoral nerve block in the management of hip fractures' pain. Fascia iliaca compartment block and femoral nerve block have moderate analgesic effect as these blocks spare the obturator nerve. Meanwhile, PENG block relieves pain by blocking branches from the femoral nerve, obturator nerve, and accessory obturator nerve that mainly innervate the anterior hip joint [10]. Reasonably speaking, PENG block did not include sensory branches of the femoral nerve that are distal to the groin. As a result, it can provide an ideal analgesia without reducing the patient's muscle strength, enabling the patient's postoperative functional recovery [23]. In addition, the supine position, which is essential for patients with acute femur fractures is a specific benefit of the PENG block [11].

A recent retrospective study [14] reported a significantly lowered postoperative opioid usage with PENG block after 24 hours. Another retrospective study [24] discovered that PENG block was associated with a 2.4 mg reduction in the 24-hour hydromorphone use among patients with total hip arthroplasty. A randomized controlled trial by Pascarella et al. [25] reported that PENG block lowered the total amount of morphine during the first 48 hours after total hip arthroplasty. This reduction in morphine consumption was associated with lowered respiratory depression, nausea, vomiting, and hemodynamic instability with the PENG block. Compared to PCA, pericapsular nerve group block was considered a safer procedure, as the MAP and HR were relatively more stable with this procedure. Mears and Kates [26] reported that the preoperative analgesic effect of PENG block added a benefit in alleviation of the patient's stress that was heightened by the body position placement excruciating movement, also tended to stabilize the abnormalities in circulatory function and decreased the risk of anesthesia.

Contrary to our finding, Lin et al. [9] reported that the use of opiate was comparable with both PENG block and local infiltration analgesia. This might be because the included patients were older and had lower baseline opiate use. Furthermore, this study lacked the necessary statistical power to distinguish between the two groups in terms of either opiate usage or patient-reported outcome measures. Also, Allard et al. [21] found that PENG block was not associated with a significant change in postoperative morphine consumption compared to femoral block in the management of hip fractures. Allard et al. used 20 ml of ropivacaine at 3.5 mg/ml without any adjuvants, which could have prolonged the duration of postoperative analgesia. The original local anesthetic consisted of 20 ml of bupivacaine and 2.5 mg/ml of adrenaline or 20 ml of ropivacaine and 5 mg/ml of adrenaline combined with dexamethasone [10].

4.1. Limitation

The current research was a single-center study with a small sample size. Hence, larger, multicenter randomized controlled trials are needed.

4.2. Conclusions

In proximal femur fractures, preoperative PENG block is an effective analgesic modality that can lower the total morphine consumption. It is a safe approach that reduces the respiratory and hemodynamic depression induced by morphine. Thus, the use of PENG block may be advantageous as adjuvant to morphine infusion among patients with proximal femur fractures.

Disclosure statement

No potential conflict of interest was reported by the authors.

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