Pericapsular nerve group (PENG) block for early pain management of elderly patients with hip fracture: a single-center double-blind randomized controlled trial

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ABSTRACT

Background The pericapsular nerve group block (PENG) is a novel technique that blocks the articular branches of the hip joint. This study aimed to compare its effectiveness to a sham block in elderly patients with hip fractures.

Method A randomized double-blind controlled trial was conducted in elderly patients with intertrochanteric and neck of femur fractures. Patients were randomized to receive either PENG block or a sham block. Postblock, systemic analgesia was titrated using a standardized protocol of acetaminophen, oral morphine or patient-controlled analgesia. The primary outcome was the dynamic pain score (Numerical Rating Scale 0–10) at 30 min postblock. Secondary outcomes included pain scores at multiple other time points and 24-hour opioid consumption.

Results 60 patients were randomized and 57 completed the trial (PENG n=28, control n=29). Patients in PENG group had significantly lower dynamic pain scores at 30 min compared with control group (median (IQR) 3 (0.5–5) vs 5 (3–10), p<0.01). For the secondary outcomes, dynamic pain scores were lower in PENG group at 1 hour (median (IQR) 2 (1–3.25) vs 5 (3–8), p<0.01) and 3 hours postblock (median (IQR) 2 (0–5) vs 5 (2–8), p<0.05). Patients in PENG group had lower 24-hour opioid consumption (median (IQR) oral morphine equivalent dose 10 (0–15) vs 15 (10–30) mg, p<0.05).

Conclusion PENG block provided effective analgesia for acute traumatic pain following hip fracture. Further studies are required to validate the superiority of PENG blocks over other regional techniques.

Trial registration number NCT04996979.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Pericapsular nerve group block (PENG) block is a novel ultrasound-guided regional anesthetic technique with beneficial effects in postoperative analgesia for patient with hip fractures.

WHAT THIS STUDY ADDS

⇒ PENG block is superior to sham block at reducing acute traumatic pain secondary to hip fractures.

⇒ PENG block also has opioid-sparing effect when used for hip fractures.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ PENG block provides effective early traumatic pain relief compared with systemic analgesics alone in elderly patients with hip fractures.

INTRODUCTION

Hip fracture in the elderly is a common problem worldwide. In many developed societies, the incidence of hip fractures is expected to increase over years in aging population.[1] Patients with hip fractures often have significant pain, particularly with movement.[2] Consequently, these patients are at risk of developing pain and immobility-related complications such as pulmonary infections, venous thromboembolism, and altered mentation.[3 4]

Taken together, the treatment of pain with the use of a multimodal analgesic regimen is a major priority for elderly patients with hip fractures.[3 5] However, this group of patients are often frail and have multiple medical comorbidities. The use of non-steroidal anti-inflammatories drugs and systemic opioids may sometimes be contraindicated or complicated by adverse effects.[6 7] As such, regional anesthetic techniques including femoral nerve blocks (FNB) and fascia iliaca compartment blocks (FICB) are often offered to patients with hip fractures.[8 9]

The Pericapsular nerve group block (PENG) block is a novel technique that was first described by Girón-Arango *et al*.[10] For this block, local anesthetic is deposited between the psoas tendon and the ilium, targeting some (but not, all) of the articular branches of the hip arising from the femoral and accessory obturator nerves.[10] This contrasts with FNB or FICB in which, the blockade of the articular branches of the hip depends on the proximal spread of the local anesthetic within the fascia iliaca compartment.[8]

Previous case series have demonstrated the potential of PENG block to improve analgesia in hip fracture patients.[10–13] Two randomized comparative trials have examined the impact of PENG block on hip fracture perioperative pain control.[14 15] In this study, we aimed to find out whether PENG block compared with a sham block reduced the acute traumatic pain in elderly patients with hip fractures.

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METHODS

This was a randomized double-blind controlled trial conducted in hip fracture patients admitted to Singapore General Hospital, Singapore (ClinicalTrials.gov Identifier: NCT04996979; Date of registration: May 10, 2021. URL: https://clinicaltrials.gov/ct2/show/record/NCT04996979). The study ran from May 24, 2021 to July 2, 2022.

All patients with hip fractures were either admitted or referred to the orthopedics department. Subsequently, details of these patients were shared with study team through the hospital secure messaging system. All these patients were screened by a member of the study team for eligibility. Eligible patients were then approached for the study and informed consent was obtained from patients who agreed to be part of the study.

Participants

The study included patients of age greater than 60 years old who had a solitary hip fracture (intracapsular neck of femur fracture, intertrochanteric fracture). Exclusion criteria were: inability to give consent due to cognitive impairment, multiple fractures, pathological fractures, periprosthetic fracture, or contraindication to block performance.

Randomization, blinding and intervention

Patients were randomly allocated to one of two groups (1:1 ratio) using a computer-generated block randomization list that was generated by a clinical research coordinator (CRC) who was not involved in the patient assessment or block performance. The group allocation was then concealed in a sealed and opaque envelope by the same CRC. On enrolment of a participant into the study, the proceduralist (who was a member of the study team) would be notified of the group assignment. The proceduralist was not blinded to the patient's allocation to the treatment arm, but the patients and the assessors (trained nurses or CRC) of the pain scores were blinded to the group allocation.

The block was performed in the procedure room located within the pain clinic. Standard monitoring (heart rate, blood pressure, and pulse oximetry) was applied to all participants. The procedure was performed by designated study team members who are board-certified anesthesiologists with a minimum of 6 years of training and experience with regional anesthesia techniques.

Intervention group

After prepping and draping, a curvilinear low-frequency ultrasound probe (Fujifilm Sonosite Edge, 2-5MHz transducer) was placed in an oblique plane over the anterior inferior iliac spine and then aligned with the pubic ramus. In this view, the femoral vessels, iliopubic eminence as well as the iliopsoas muscle/tendon were identified. A 100 mm nerve block needle was then inserted from lateral-to-medial in an in-plane fashion until the needle tip was located between the psoas tendon and ilium. Hydrolocalization was then performed to ensure that the injectate was placed in the fascial plane rather than intra-muscularly. Following this, 20 mL of 0.5% Ropivacaine was administered. Following the procedure, a transparent film dressing was applied over the site of the injection.

Control group

In the control group, a sham block was performed using the same skin landmark. The proceduralist performed an ultrasound scan after prepping and draping the injection site. To simulate the sensation of an injection, a blunt needle was used but that did not penetrate the skin. To account for the time taken for the injection, the needle was pressed on the skin for a few minutes. Similar to the intervention group, a transparent film dressing was applied over the site of the injection.

Outcome measures

The primary outcome was the dynamic pain scores reported by the patient 30 min after block performance. Secondary outcomes were pain scores at various time points (1, 3 and 24 hours post-block, pain during positioning for spinal anesthesia), 24-hour opioid consumption, opioid-related side effects (nausea, vomiting, sedation, delirium) as well as block complications (nerve injury, hematoma).

Pain scores were recorded using the Numerical Rating Scale (NRS) ranging from 0 to 10. Dynamic pain was defined as pain experienced during 15° of passive lower limb elevation. Static pain was defined as pain in the patient's chosen position for the best comfort. Pain scores were obtained by nurses or CRC who were blinded to patient allocation. For patients who underwent surgery within 24 hours of the intervention, pain scores during positioning for spinal anesthesia were recorded.

All patients were placed on round-the-clock acetaminophen (PO 1 g every 6 hours). For moderate pain (NRS 4–7), patients would be placed on oral morphine (PO 2.5 mg every 6 hours with a breakthrough dose of 2.5 mg hourly). For persistently severe pain (NRS>7), patients would be initiated on intravenous patient-controlled analgesia. The opioids doses administered to the patients were obtained from the electronic medical records of each patient. Opioids given intraoperatively were not included in the data collection. The 24-hour opioid consumption was converted to oral morphine equivalent dose (OMED) using Opioids Calculator by FPM ANZCA (http://www.opioidscalculator.com.au/).

Power analysis

The sample size calculation was based on previously reported results in the literature. Median dynamic pain scores had been reported to range between 7 and 9 out of 10 and it was estimated that the PENG block would reduce the pain score from hip fracture by 3.[10 11 13] Assuming a SD of 3, to achieve a power (beta value) of 80% and a significance (alpha value) of 5%, with an estimated difference of 3 points in the pain score between the control and intervention group, it was estimated that the total sample size required was 25 individuals per group. To account for a 20% drop-out rate, it was decided to recruit 30 in each group over 1 year.

Statistical analysis

The patient's baseline characteristics were summarized using descriptive statistics. For all continuous variables, the Shapiro-Wilks test was performed to determine if the dataset was normally distributed. All the primary and secondary outcome measures were identified to be non-normally distributed by this measure. Consequently, the static and dynamic NRS scores at all time intervals were compared using the Wilcoxon rank-sum test. For both primary and secondary outcomes, the alpha level was set at 0.05. All statistical analyses were conducted with RStudio V.2022.07.1.

RESULTS

A total of 225 patients were screened for eligibility to participate in this study and 60 patients were enrolled and randomized for the study. During the analysis of the data, it was noted that three patients had fractures that fell outside the inclusion criteria (ie,

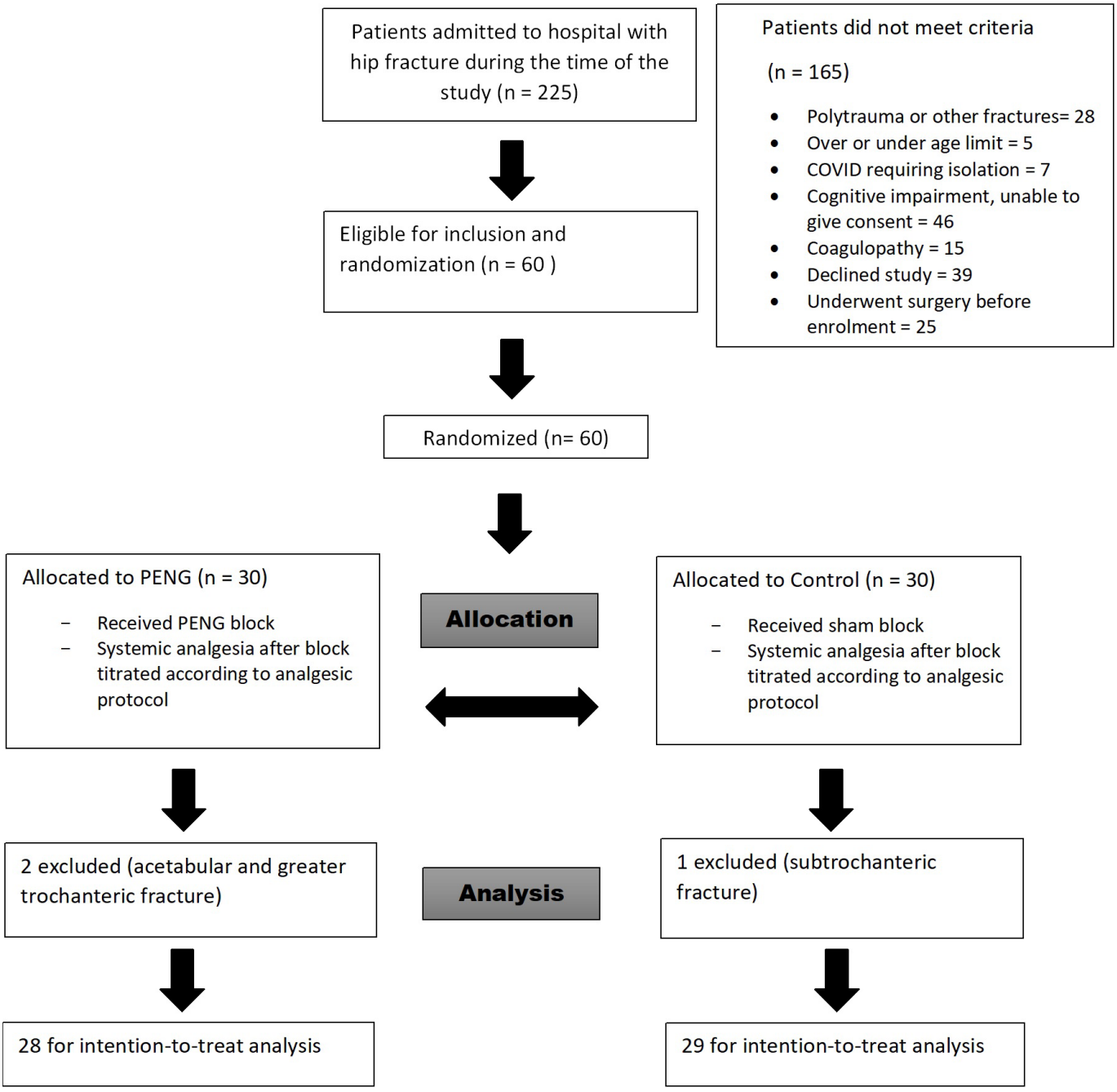

Figure 1 CONSORT study flowchart. CONSORT, Consolidated Standards of Reporting Trials; PENG, pericapsular nerve group.

acetabular, subtrochanteric and greater trochanteric fracture). These patients were excluded from the final analysis (figure 1).

The demographics and baseline characteristics of the 28 patients in the PENG group and 29 patients in the control groups were similar. The two groups were also comparable in terms of the fracture type (ie, neck of femur and intertrochanteric fractures) (table 1).

Primary outcome

Fifty-seven patients were included in the intention-to-treat analysis for the primary outcome: 28 in the PENG block group and 29 in the control group. At 30 min, the dynamic NRS scores in the PENG group were significantly lower than the control group. The median pain score (IQR) of the patients in the PENG group was 3 (0.5–5) compared with 5 (3–10) in the control group ($W=377.5$, $p<0.01$).

Secondary outcomes

Pain scores

To determine the duration of action of the PENG block, a comparison of the pain scores at various time points was made. At all time points, it was noted that the static pain scores were negligible. As such, no differences in the static pain scores were observed at all time points. In contrast, patients in both groups reported severe baseline NRS scores of 7.0 (IQR 4.0–10.0) before block administration. PENG block was found to significantly

Table 1 Baseline characteristics

	PENG	Control
Sample size, n	28	29
Age in years, mean (SD)	80.2 (6.8)	76.3 (7.5)
Sex, n (%)		
Female	20 (71.4)	20 (69.0)
Male	8 (28.6)	9 (31.0)
BMI in kg/m^2, median (IQR)	21.5 (19.2–24.4)	22.4 (19.9–25.2)
Fracture type, n (%)		
Intertrochanteric	10 (35.7)	9 (31.0)
Neck of femur	18 (64.3)	20 (69.0)
Comorbidity		
Cardiovascular, n (%)		
No	10 (35.7)	11 (37.9)
Yes	18 (64.3)	18 (62.1)
Gastrointestinal, n (%)		
No	24 (85.7)	27 (93.1)
Yes	4 (14.3)	2 (6.9)
Genitourinary, n (%)		
No	25 (89.3)	25 (86.2)
Yes	3 (10.7)	4 (13.8)
Musculoskeletal, n (%)		
No	25 (89.3)	26 (89.7)
Yes	3 (10.7)	3 (10.3)
Neurological, n (%)		
No	23 (82.1)	24 (82.8)
Yes	5 (17.9)	5 (17.2)
Endocrine, n (%)		
No	20 (71.4)	22 (75.9)
Yes	8 (28.6)	7 (24.1)
Baseline pain scores (NRS)		
Median static pain score (IQR)	0 (0–1.0)	0 (0–3.0)
Median dynamic pain score (IQR)	7.0 (4.0–10.0)	7.0 (5.0–10.0)

BMI, body mass index; NRS, Numerical Rating Scale; PENG, pericapsular nerve group.

reduce pain scores immediately, 1 hour and 3 hours but not 24 hours postintervention (table 2).

Ten patients went for surgery under spinal anesthesia within the first 24 hours and their pain scores during positioning for spinal anesthesia were recorded. The positioning pain was significantly reduced in the PENG group compared with the control group ($W=5$, $p<0.05$). The median dynamic pain score (IQR) in the PENG group was 4 (0, 4) compared with 10 (6.25, 10) in the control group.

Opioids Consumption

The 24-hour opioid consumption was significantly lower in the PENG block group (OMED median 10 mg, IQR 0–15 mg) compared with the control group (OMED median 15 mg, IQR 10–30 mg, $p<0.05$).

Subgroup analysis

A subgroup analysis was performed based on the type of fracture. For both intracapsular neck of femur and intertrochanteric fractures, dynamic pain was significantly reduced in the PENG group compared with the control group at 30 min (table 3).

Table 2 Static and dynamic pain scores (NRS) of other time points

	PENG	Control	P value*
Immediate postblock			
Sample size, n	28	29	
Median static pain score (IQR)	0 (0)	0 (0)	0.68
Median dynamic pain score (IQR)	4 (0–6.5)	5 (3–7)	0.15
1-hour postblock			
Sample size, n	24	28	
Median static pain score (IQR)	0 (0)	0 (0)	0.41
Median dynamic pain score (IQR)	2 (1, 3.25)	5 (3, 8)	<0.01
3 hours postblock			
Sample size, n	18	25	
Median static pain score (IQR)	0 (0)	0 (0– 2)	0.49
Median dynamic pain score (IQR)	2 (0–5)	5 (2–8)	0.03
24 hours postblock			
Sample size, n	14	17	
Median static pain score (IQR)	0 (0)	0 (0–0.5)	0.82
Median dynamic pain score (IQR)	2 (2–5)	5 (1.75–5.25)	0.70
Positioning pain in OR			
Sample size, n	6	4	
Median static pain score (IQR)	0 (0)	0 (0–1.5)	0.56
Median dynamic pain score (IQR)	4 (0–4)	10 (6.25–10)	0.04

*Wilcoxon rank-sum test used.
NRS, Numerical Rating Scale; OR, operating room; PENG, pericapsular nerve group.

Block complications

Team members involved in the execution of the block were asked to rate whether the block was technically easy or difficult. Ninety-three of the PENG blocks were rated as easy. There were no serious block complications (infection, nerve lesion, hematoma) in any of the patients. There were no significant differences in opioids related side effects (nausea, vomiting, sedation, delirium) between the two groups.

DISCUSSION

This study demonstrated that PENG block reduces dynamic pain scores 30 min following block placement when compared with sham block. This improvement was also observed for the first 3 hours following block performance and during positioning for spinal anesthesia, along with a significant reduction in 24-hour opioid consumption between groups.

Previous publications on the PENG block in patients with hip fractures consist of mainly retrospective case series and a few prospective studies.[16] In a recent randomized comparative trial, Lin *et al* found

Table 3 Pain scores (NRS) 30 min postblock based on type of fractures

	PENG	Control	P value*
Neck of femur fracture			
Sample size, n	18	20	
Median static pain score (IQR)	0 (0)	0 (0)	0.53
Median dynamic pain score (IQR)	3 (0.75–5)	6 (3.75–10)	<0.01
Intertrochanteric fracture			
Sample size, n	10	9	
Median static pain score (IQR)	0 (0)	0 (0)	0.93
Median dynamic pain score (IQR)	2 (0.5–4)	3 (2–8)	<0.01

*Wilcoxon rank-sum test used.
.NRS, Numerical Rating Scale; PENG, pericapsular nerve group.

that PENG block provided superior intraoperative and postoperative analgesia when compared with FNB.[14] In another randomized comparative trial, Mosaffa *et al* reported that the PENG block resulted in a statistically significant reduction in pain (although likely clinically insignificant) when compared with FICB.[15] In contrast to these studies, our study aimed to validate the effectiveness of PENG block for the relief of acute traumatic pain from hip fractures using a sham controlled group.

Multimodal analgesia remains the mainstay of the treatment of hip fracture pain.[3] However, it is known that opioids can have deleterious effects, particularly in this group of patients who are frail and have multiple comorbidities.[3 7] In this study, it was also observed that many patients had inadequate analgesia despite administered opioids before their recruitment. This study, therefore, supports the addition of a PENG block for the management of patients with hip fracture pain. In addition, if there is a possibility of a long wait time to surgery, placement of a continuous catheter should be considered.

Our study has several limitations. First, early surgery has been shown to benefit patients with hip fractures.[17] Given this, patients were allowed to undergo surgery during the study period without standardizing the timing, and results were analyzed using an intention-to-treat approach. For this reason, pain score at 30 min postblock was chosen as the primary endpoint of the study, allowing all patients to be analyzed preoperatively. Secondary outcomes were set as pain scores 1 hour, 3 hours, and 24 hours postblock to determine the duration of the block effect. However, the lack of standardization in block timing before surgery and the large attrition rate introduced potential confounding factors that could affect the results of our secondary outcomes.

Second, although our study showed that patients receiving PENG block required less opioids, there was no statistically significant reduction in opioid-related adverse effects. Possible explanations for this include overall low opioids use in both groups of patients and a lack of power. We postulated that the low opioids use in both groups was because the patients were mostly immobile before surgery and they experienced limited static pain. This may have resulted in nurses not administering opioids to the patients if they did not assess the patient's dynamic pain.

Third, the use of a blunt needle without skin penetration as a sham block to facilitate the blinding of patients was a limitation because it may not fully simulate the actual block performance. However, we chose this method to avoid unnecessary harm to the patient. Although largely safe, the PENG block may carry the risk of serious complications such as accidental harm to the lateral femoral cutaneous nerve.[18]

CONCLUSION

In summary, the PENG block provided effective analgesia for acute traumatic pain following hip fracture. Further multicenter studies are required to confirm our findings and the effectiveness of the PENG block compared with other peripheral nerve blocks.

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Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants and was approved by SingHealth Centralized Institutional Review Board (CIRB) Ref 2021/2152. Participants gave informed consent to participate in the study before taking part.

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