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Title:

Utilization of pericapsular nerve group (PENG) block in preoperative rehabilitation for patients with femoral neck fractures: a case series

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Running title:

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Abstract

Background

Elderly patients with femoral neck fractures, particularly those with severe comorbidities or living in regions with limited medical resources, may experience delays in surgical treatment. Although the benefits of preoperative rehabilitation (prehabilitation) in hip arthroplasty have been reported, pain management remains a challenge. The pericapsular nerve group (PENG) block, known for its exceptional analgesic effect and motor function preservation, may be a promising intervention during prehabilitation in these patients.

Case

We enrolled ten patients with Garden classification 3-4 femoral neck fractures scheduled for hip arthroplasty. After receiving a PENG block with 20 ml of 0.375% ropivacaine, all patients underwent initial prehabilitation sessions comprising 9 mobility levels, ranging from bed-sitting to walking. One patient was excluded due to experiencing high blood pressure during prehabilitation. Six of the nine remaining patients (66.7%) were successfully transferred from bed to wheelchair.

Conclusions

The PENG block enhanced prehabilitation for patients with femoral neck fractures undergoing hip

arthroplasty.

Keywords: Femoral neck fractures; Hip fractures; Nerve block; Prehabilitation; Preoperative rehabilitation; Regional anesthesia.

Timely surgical intervention for femoral neck fractures can be challenging, particularly in elderly patients with severe comorbidities and in regions with limited medical resources [1]. Preoperative rehabilitation (prehabilitation) has been shown to be effective at enhancing mobilization, preserving muscle strength, and improving postoperative outcomes for patients with femoral neck fractures scheduled for hip arthroplasty [2,3]; however, significant pain during prehabilitation remains a barrier. The pericapsular nerve group (PENG) block, which targets the articular sensory nerve branches of the anterior capsule of the femoral neck, provides excellent postoperative analgesia while preserving motor function [4-6]. This study aims to investigate the feasibility of utilizing the PENG block in prehabilitation for patients with femoral neck fractures scheduled for hip arthroplasty and to offer insights for a future large-scale randomized controlled trial.

This study was approved by the Kameda Medical Center Clinical Research Review Board (approval number: 21-093) and registered in the Japan Registry of Clinical Trials (registration number: jRCT1031220004) prior to patient enrollment.

A total of 16 adult patients diagnosed with Garden classification 3 or 4 femoral neck fractures and scheduled for hip arthroplasty at Kameda Medical Center in Japan between April 2022 and July 2022, were assessed. Patients were excluded if they met any of the following criteria: 1) dementia, defined as scoring less than 23 points on the Mini-Mental Status Examination; 2) known allergies to local anesthetics; 3) a history of hip arthroplasty at the same extremity; 4) an infection at the site

where the PENG block would be performed; 5) those bedridden prior to the injury; and 6) those determined to be inappropriate for participation at the discretion of the orthopedic surgeon. After excluding three patients with dementia, one patient who refused participation, one patient who was bedridden prior to the injury, and one patient who was assessed as inappropriate for participation due to a pathologic fracture, a total of ten eligible patients were enrolled in the study. Written informed consent was obtained from all the enrolled patients.

The study did not interfere with surgical treatment. The surgical procedure was scheduled to be performed as early as possible following current guidelines [7]. All patients were allowed preoperative mobilization with no weight bearing on the injured lower extremity, a practice that has been validated to be safe and effective in this patient cohort: patients with Garden 3-4 femoral neck fractures who are scheduled for a hip arthroplasty [3]. Additionally, each patient received standard preoperative pain management including prescriptions for acetaminophen, non-steroidal anti-inflammatory drugs, and tramadol.

The PENG block was performed at least 1 h before the initial prehabilitation session. Following local anesthesia, we performed a PENG block at the patient's bedside using the technique described by Giron-Arango et al. [4], with 20 ml of 0.375% ropivacaine solution. The procedure was performed using a handheld portable ultrasound device (Vscan Air, GE Healthcare) and a 22-gauge 80-mm needle (Stimuplex Ultra, B. Braun).

After PENG block administration, the initial prehabilitation session was conducted by a single qualified physical therapist. The sessions incorporated a prehabilitation program aimed at enhancing mobilization and preserving muscle strength, designed according to the ICU Mobility Scale (IMS) [8] and the Cumulated Ambulation Score (CAS) [9,10]. The program comprises nine mobility levels, with each subsequent level being progressively more demanding (Table 1). Prehabilitation was performed following this sequence of mobility levels until the patient was unable to perform the exercises, requested to stop, or the discontinuation criteria were met [11]. The same prehabilitation protocol was provided to all patients once daily until surgery; however, only the initial session was conducted under the PENG block. Subsequent sessions were conducted using standard pain management.

Table 2 presents the baseline characteristics of the ten patients enrolled in this study. The outcomes of the prehabilitation program during the initial prehabilitation are shown in Fig. 1. Due to experiencing a high blood pressure exceeding 180/120 mmHg, one patient could not complete the initial prehabilitation [11]. The median Numerical Rating Scale (NRS) pain score during prehabilitation was 6.0 (interquartile range [IQR], 5.0 to 7.0) points.

Four of the nine patients underwent surgery the day after their initial prehabilitation session, while the remaining five had a median wait time of 3.0 (IQR, 2.0 to 4.0) days before surgery.

Regarding postoperative outcomes, patients achieved a median Functional Independence Measure (FIM motor) score of 80.0 (IQR, 66.0 to 83.0) points at discharge [12]. Three out of the nine patients (33.3%) were discharged to rehabilitation hospitals and nursing homes, while six (66.7%) were discharged directly to home. No motor blockade or other adverse events associated with the PENG block were observed.

Discussion

In this study, we investigated the utilization of the PENG block in prehabilitation for patients with femoral neck fractures scheduled for hip arthroplasty. In the preoperative phase, patients often experience intolerable pain, which impedes basic daily activities such as eating and toileting and adversely affects muscle strength maintenance, thereby influencing postoperative outcomes [13]. Incorporating the PENG block in preoperative care resulted in enhanced performance in prehabilitation compared to conventional approaches, with more than half of the patients successfully transferred from bed to wheelchair.

While current guidelines recommend prompt surgical intervention for femoral neck fractures [7], a significant number of elderly patients, particularly those with severe comorbidities, encounter difficulties in adhering to these guidelines. Factors such as the requirement to discontinue anticoagulants or antiplatelets or the need for additional examinations can contribute to delays in surgery for these individuals. As demonstrated in this study, the integration of prehabilitation with the PENG block presents a promising treatment approach, particularly beneficial for individuals experiencing delays in surgical intervention.

Furthermore, although many patients with femoral neck fractures cannot fully regain the ability to perform activities of daily living during their hospital stay, often requiring discharge to rehabilitation hospitals or nursing homes after hospitalization for further care, the patients in this study exhibited

enhanced postoperative outcomes, characterized by a high FIM motor score, and a large proportion were discharged directly to home. Therefore, receiving a PENG block only once during the initial prehabilitation session can have a substantial effect on prehabilitation and preoperative mobilization, with potential promising effects on postoperative outcomes. However, this needs to be further investigated in future studies.

Our study had several limitations. First, the case-series design may introduce potential biases, thereby affecting the generalizability of the findings. Moreover, the use of a single-shot PENG block only in the initial prehabilitation rather than catheter placement for continuous infusion limited our capacity to assess the long-term impact on postoperative outcomes.

Based on the results of this study, we are currently conducting a randomized controlled trial to provide further evidence of the effects of the PENG block in this context.

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Table 1. The prehabilitation program

Level	Item	Explanation
1	Bed-sitting	Sitting up on the bed with the assistance of a single physical therapist.
2	Edge-sitting	Sitting on the edge of the bed with the assistance of a single physical therapist.
3	Stand-up	Standing up from the bed with the assistance of a single physical therapist.
4	Wheelchair-transfer	Transferring to wheelchair with the assistance of a single physical therapist.
5	Marching	Stepping at the bedside with the assistance of a single physical therapist.
6	Walk-with-two	Walking at least 5 meters with the assistance of a single physical therapist and either another physical therapist or a ward nurse.
7	Walk-with-one	Walking at least 5 meters with the assistance of a single physical therapist.
8	Walk-with-device	Walking at least 5 meters with a walking-device.

9	Walk-alone	Walking independently at least 5 meters without a walking-device.

Prehabilitation: preoperative rehabilitation.

Table 2. Patient baseline characteristics*

Characteristics	
Age, yr	75.5 ± 7.1
Female sex, n (%)	10 (100.0)
Asian race, n (%)	10 (100.0)
BMI	19.5 ± 3.6
ASA-PS, n (%)	
I	0 (0.0)
II	6 (60.0)
III	4 (40.0)
Garden classification, n (%)	
III: complete fracture, incompletely displaced	0 (0)
IV: complete fracture, completely displaced	10 (100)
Walking ability before fracture, n (%)	
Independent	9 (90.0)
Walking-device use	1 (10.0)
Preadmission residence, n (%)	
Home	10 (100.0)

Nursing home or other locations	0 (0.0)
FIM motor score†	26.5 [22.3 - 40.3]
Barthel Index‡	30.0 [18.8 - 38.8]

BMI: body mass index, ASA-PS: American Society of Anesthesiology physical status classification system, FIM: Functional Independence Measure.

*The results are expressed as means ± standard deviations or as medians [interquartile ranges] or as number of patients (percentage), as appropriate.

†The FIM motor score comprises 13 activities of daily living (ADL) items. Each item is scored on a scale of 1–7. The total scores range from 13 to 91, with higher scores indicating greater independence.

‡The Barthel Index measures 10 ADL items. The total scores range from 0 to 100, with higher scores indicating greater independence.

Figure legends

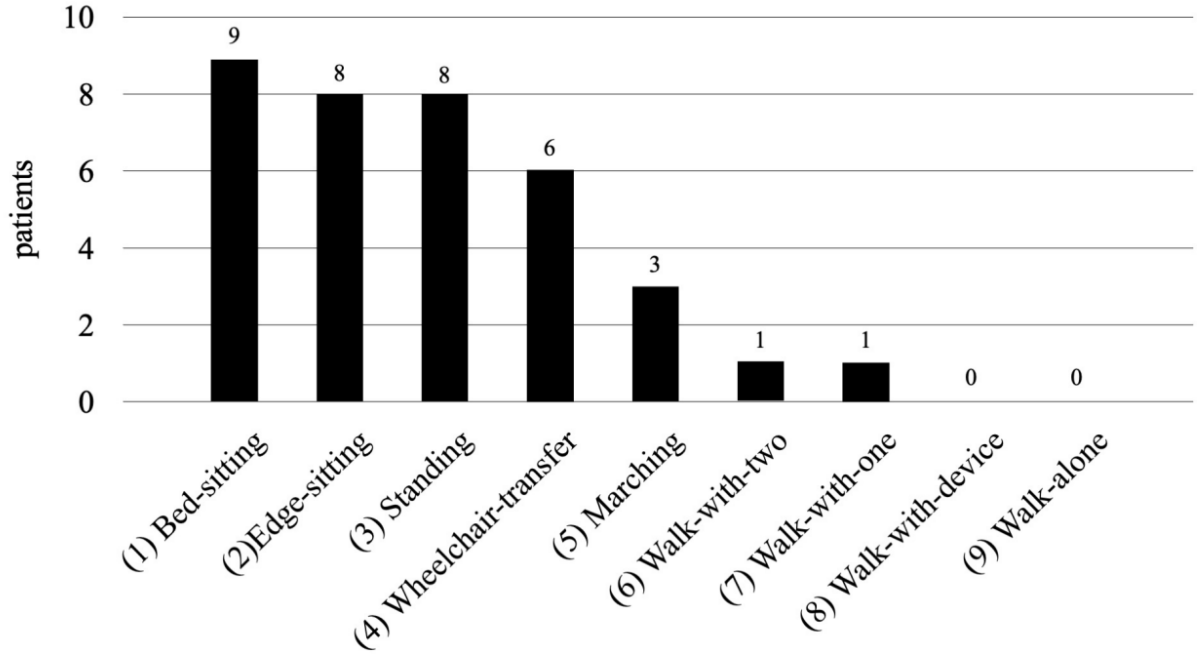

Fig. 1. Prehabilitation program outcomes in the initial prehabilitation session*

*One patient who was unable to participate in prehabilitation due to high blood pressure was excluded from the outcome analysis.