BMC Anesthesiology

STUDY PROTOCOL

Open Access

Efficacy of Pericapsular Nerve Group (PENG) block in preoperative rehabilitation (Prehabilitation) for patients with femoral neck fractures: study protocol for a randomized, placebo-controlled, double-blinded trial

Zhuan Jin[1,2], Daisuke Sugiyama[1*], Fumiya Higo[3], Takahiro Hirata[3], Osamu Kobayashi[1], Hiroshi Morimatsu[2] and Kenichi Ueda[1,4]

Abstract

Background Despite surgery intervention for femoral neck fractures is recommended within 48 h of admission, achieving timely surgery presents challenges for patients with severe comorbidities, or in resource-limited settings. Preoperative rehabilitation (prehabilitation) reduces bedridden time, enhances mobility, and improves postoperative outcomes for patients scheduled for hip arthroplasty due to femoral neck fractures. However, prehabilitation is hindered by insufficient pain control. The pericapsular nerve group (PENG) block provides effective analgesia while preserving motor function. We designed a study to assess the efficacy of PENG block in facilitating prehabilitation for patients with femoral neck fractures who are scheduled for hip arthroplasty.

Methods This prospective randomized placebo-controlled double-blinded trial aims to enroll 100 patients with Garden 3 or 4 femoral neck fractures who are scheduled for hip arthroplasty. Participants will be randomly assigned to receive a PENG block with 0.375% ropivacaine (PENG group) or with normal saline (placebo group) before the initial prehabilitation session. The prehabilitation program comprises five items: Bed-sitting, Edge-sitting, Stand-up, Maintaining-standing, and Wheelchair-transfer, performed with the assistance of a single physical therapist. The primary outcome is the percentage of patients completing the entire prehabilitation program. Secondary outcomes during the initial prehabilitation session are the achievement of each program item and the Numerical Rating Scale (NRS) pain score. Other secondary outcomes include intraoperative bleeding amounts, thromboembolic events during postoperative day 0 to 7, postoperative 3-day cumulative Cumulated Ambulation Score (CAS), and discharge destination. The postoperative outcomes will be compared between subgroups of patients undergoing surgery within 48 h of admission and those undergoing surgery more than 48 h of admission.

Discussion This is the first study aiming to assess the efficacy of PENG block in prehabilitation for patients with femoral neck fractures who are scheduled for hip arthroplasty. PENG block could be beneficial, especially for patients facing delayed surgery, providing a potential treatment option during the waiting period.

*Correspondence:
Daisuke Sugiyama
sugiyama.daisuke@kameda.jp
Full list of author information is available at the end of the article

Trial registration Japan Registry of Clinical Trials, jRCT1031220294, registered on August 26, 2022.

Keywords Femoral neck fracture, Hip fracture, PENG block, Pericapsular nerve group block, Prehabilitation, Preoperative mobilization, Preoperative rehabilitation, Randomized controlled trial, Study protocol

Background

Femoral neck fractures, a common type of hip fracture, primarily affect the elderly population, leading to increased morbidity, mortality, and substantial social costs [1]. Surgical intervention within 48 h of admission is recommended to enhance postoperative recovery by the American Academy of Orthopaedic Surgeons (AAOS) guidelines [2]. However, timely surgery could be challenging for patients with comorbidities, as well as in institutions or areas with limited medical resources [3].

In patients with femoral neck fractures who are scheduled for hip arthroplasty, preoperative rehabilitation (prehabilitation) reduces bedridden time before surgery. It has proven effective in promoting mobilization, preserving muscle strength, and ultimately improving postoperative outcomes [4, 5]. However, inadequate pain control during mobilization impedes effective prehabilitation. The current AAOS guidelines recommend the use of peripheral neural blocks, such as the femoral nerve block (FNB) and the fascia iliaca compartment block (FICB) in the preoperative setting to enhance pain control [2], but these neural blocks induce temporary motor blockade [6], which hinders prehabilitation.

The pericapsular nerve group (PENG) block, first reported by Giron-Arango L et al., targets the articular sensory nerve branches which innervate the anterior capsule of the femoral neck [7]. Previous studies have shown that PENG block provides excellent analgesia, including a meta-analysis that demonstrates the PENG block's non-inferiority to FICB in postoperative pain control [8]. Studies also shows successful utilization of the PENG block with sedation in the anesthetic management especially for high-risk elderly patients [9].

Given its selective targeting of sensory nerves, the PENG block preserves motor function. Previous studies consistently demonstrated significantly less motor blockade in patients who received PENG block compared to those who received an FNB or FICB [10, 11]. Moreover, a recent randomized controlled trial reported that PENG block reduces preoperative dynamic pain score [12], providing additional support for its application in preoperative mobilization. Considering this motor-sparing characteristic, we hypothesize that PENG block can provide sufficient analgesia without impeding mobilization, thereby enhancing prehabilitation for patients with femoral neck fractures who are scheduled for hip arthroplasty.

We conducted a pilot study, currently under publication, to investigate the potential application of PENG block. The pilot study not only unveiled its safety profile but also indicated promising efficacy in prehabilitation. This randomized controlled trial aims to confirm the efficacy of PENG block in prehabilitation for patients with femoral neck fractures who are scheduled for hip arthroplasty.

Methods

Study design

This is a single-centered, randomized, placebo-controlled, double-blinded trial conducted at Kameda Medical Center, Japan. We obtained approval for this study from the hospital's ethics committee (Kameda Medical Center Clinical Research Review Board; approval number: 22–024). This trial was also registered in the Japan Registry of Clinical Trials (register number: jRCT1031220294; first registration: August 26, 2022; https://jrct.niph.go.jp/en-latest-detail/jRCT1031220294). There is no plan to amend the study protocol, including eligibility criteria, outcomes, or analyses. This study has no financial support. All the research members involved in this study have no interests to declare.

The methods and results of this study will be reported according to the Standard Protocol Items: Recommendations for Interventional Trials 2013 statement (Additional file 1). The flow diagram for the trial is presented in Fig. 1.

Recruitment for this study began on November 2, 2022, and will continue through the end of 2025. The anticipated submission date for the primary trial manuscript is set for September 30, 2026.

Eligibility criteria

Inclusion criteria

Patients will be included if they: 1) are adults over the age of 20; 2) have a Garden classification 3 or 4 femoral neck fracture; 3) are scheduled to receive hip arthroplasty at Kameda Medical Center; and 4) have an American Society of Anesthesiologists physical status (ASA-PS) between I and III.

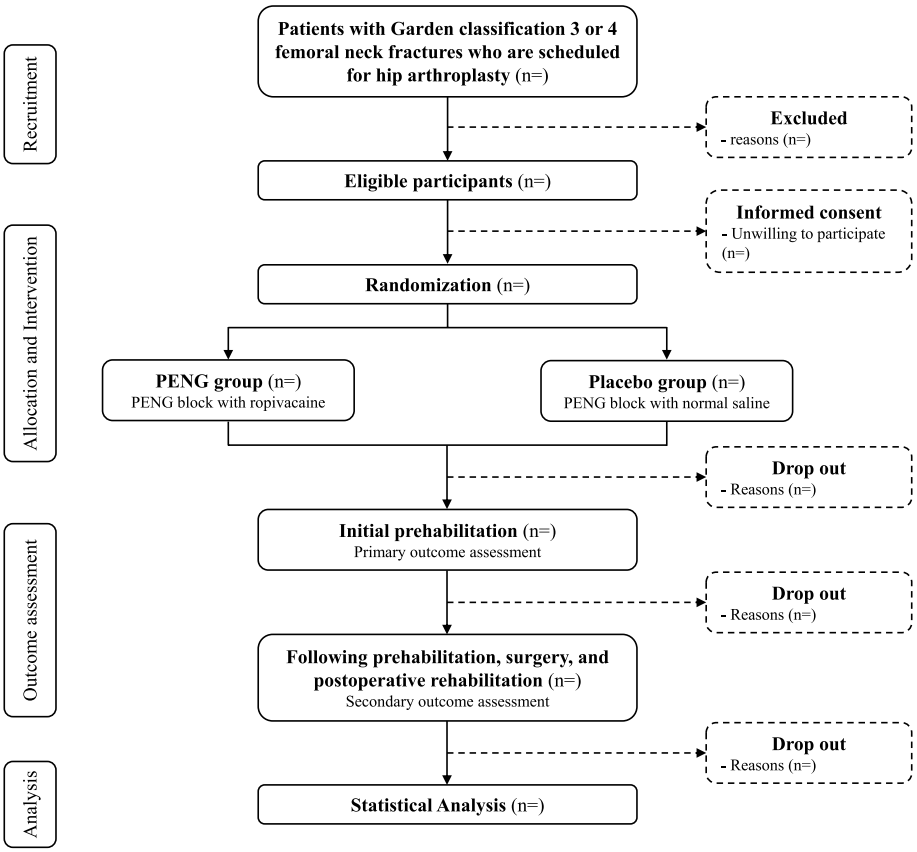

Fig. 1 The flow diagram of the trial. PENG, pericapsular nerve group; Prehabilitation, preoperative rehabilitation

Exclusion criteria

Patients will be excluded if they: 1) have dementia, defined as scoring less than 3 points in the Mini-Cog test [13]; 2) have known allergies to local anesthetics; 3) have a history of hip arthroplasty at the injured extremity; 4) have an infection at the site where the PENG block will be performed; 5) are bedridden prior to the injury; 6) are diagnosed as a pathological femoral neck fracture; or 7) are assessed as inappropriate for participation at the discretion of the orthopedic surgeon.

Informed consent and withdrawal

Patients will be assessed by the research members according to the eligibility criteria. Researcher members will provide full details of the trial both orally and in writing, including implications, possible adverse effects, and any risks to the eligible patients. If patients agree to participate, written consent will be obtained. All participants can withdraw from the trial at any time if they or their families request, or if there are any serious adverse events related to PENG block, including bleeding, infection, neuropathy, and local anesthetic intoxication.

Baseline assessment

After enrolment, all the participants will undergo a pre-intervention assessment that includes a medical record review, and scores of 1) the motor part of the Functional Independence Measure (FIM) [14]; 2) Barthel Index [15]; 3) EuroQol 5 Dimension Self-Report Questionnaire (EQ-5D) [16].

Interventions

PENG group

The patients allocated in the PENG group will receive PENG block with a 20 ml solution of 0.375% ropivacaine. The PENG block will be scheduled at least one hour prior to the initial prehabilitation session. We will perform the blocks at the patient's bedside, using the method described by Giron-Arango L, et al. [7]. We will use a handheld portable ultrasound device (Vscan Air, GE Healthcare, Chicago, USA), consisting of linear (3—12 MHz) and curved (2—5 MHz) array transducer probes on each side of the device. This ultrasound device can be seamlessly connected to an electronic tablet via Bluetooth for real-time visualization.

No sedation will be given to patients during the block procedure. After skin sanitization, the procedure starts with local anesthesia with 2 to 5 ml of 1.0% lidocaine. Using either the linear or curved transducer of the ultrasound device, which is covered with a sterile ultrasound probe cover, we will place the ultrasound probe along the line running from the anterior inferior iliac spine (AIIS) to the pubic ramus. This will visualize the key anatomical structures, including the iliopubic eminence, the iliopsoas muscle, the iliopsoas tendon, and the femoral artery. Subsequently, we will insert a 22-gauge, either 50- or 80-mm needle (Stimuplex Ultra, B. Braun, Melsungen, Germany), placing its tip in the lower musculofascial plane of the iliopsoas muscle just above the pubic ramus. The needle will be inserted from the lateral side of the patient to reduce the risk of inadvertently blocking the femoral nerve, which could occur if the needle tip is placed too close to it. After ensuring negative aspiration, we will inject a 20 ml solution of 0.375% ropivacaine while continuously monitoring the spread of the solution through the real-time ultrasound view on the connected electronic tablet. We will save the images or videos of the solution's distribution for reference.

Every PENG block will be administered by board-certified anesthesiologists, or anesthesiology residents who have substantial expertise in performing PENG blocks. For residents, the whole procedure will be under the direct supervision of an experienced board-certified anesthesiologist, ensuring both the safety and efficacy of the block administration.

Placebo group

The patients allocated in the placebo group will receive the PENG block with a 20 ml solution of normal saline placebo, instead of 0.375% ropivacaine.

Prehabilitation

Following hospitalization, the physical therapy team will promptly schedule prehabilitation sessions, usually on the day of admission or the following day, excluding Sundays and holidays. Daily sessions lasting 40 to 60 min will be conducted until surgery. The prehabilitation program comprises five items, with each subsequent item incrementally more challenging than the preceding one:

1) Bed-sitting: Sitting up on the bed.
2) Edge-sitting: Sitting up on the edge of the bed.
3) Stand-up: Rising from the bed.
4) Maintaining-standing: Maintaining a standing position.
5) Wheelchair-transfer: Transferring to wheelchair.

During each session, a single physical therapist will guide and assist the patient through the program sequentially. Prehabilitation will be terminated and will not proceed to the subsequent item if the patient is unable to perform, requests a stop,

experiences intolerable pain or meets predefined discontinuation criteria [17].

Pain management

All patients will receive a standardized pain management protocol during their hospitalization, including the prescription of common medications such as acetaminophen, nonsteroidal anti-inflammatory drugs, and tramadol. We will not use strong opioids or any form of patient-controlled analgesia.

Surgical intervention

The participants in this study will undergo standard surgical treatment, with the surgery scheduled as early as possible, following the current guidelines. It is crucial to note that this study will not interfere with the surgical schedules.

Anesthesia management

The anesthesia plan will be determined by the anesthesiologists' discretion. Typically, we will employ spinal anesthesia or general anesthesia, with options of preoperative neural blocks including FNB, FICB, PENG block, and lateral cutaneous femoral nerve block.

Postoperative rehabilitation

Patients will receive postoperative rehabilitation from postoperative day 1. Daily sessions, lasting 40 to 60 min, will continue until the patient's discharge. During each session, the physical therapist will provide the same content as prehabilitation, using the predefined prehabilitation program. Postoperative rehabilitation will be discontinued if the patient experiences intolerable pain or meets the predefined discontinuation criteria [17].

Outcome measurement

The primary outcome of this study is the percentage of patients who complete the entire prehabilitation program during the initial prehabilitation session. The secondary outcomes are shown in Table 1.

Sample size calculation

In our pilot study, approximately 70% of the patients received PENG block and 20% of the patients with standard pain management achieved the primary outcome. Considering the potential biases in the pilot study, we hypothesized 50% of those in the PENG group and 20% of those in the placebo group will achieve the primary

Table 1 The secondary outcomes

Outcomes during the initial prehabilitation session	
(1)	Achievement of each item in the prehabilitation program
(2)	NRS pain score
Surgery-related outcomes	
(1)	Intraoperative bleeding amounts
(2)	Thromboembolic events from postoperative day 0 to 7
Postoperative outcomes (i) In patients undergoing surgery within 48 h of admission (ii) In patients undergoing surgery more than 48 h of admission	
(1)	Postoperative 3-day cumulative CAS score
(2)	CAS score at discharge
(3)	Discharge destination (i) Home (ii) Nursing home or other location

NRS Numerical Rating Scale, *CAS* Cumulated Ambulation Score [18, 19]

outcome. By setting a statistical power of 80% and a significance level (α) of 0.05 to identify this difference, we calculated a sample size of 78. Allowing a potential 20% follow-up and data loss, we plan to randomize 100 patients (50 patients in each group).

Recruitment

All participants will be recruited during the period between the time of presentation and the start of the initial prehabilitation session from Kameda Medical Center, a tertiary hospital in Chiba Prefecture, Japan. After prehabilitation is prescribed by the orthopedic surgeons, the physical therapy team will identify potential participants and notify the research team. For potentially eligible patients, a research member will assess the eligibility, provide a detailed explanation of the study, conduct a screening evaluation, and seek written informed consent from the patient to obtain their permission to participate in the study.

Randomization and blinding

Prior to the study, we generated a random allocation sequence using STATA 16.0 statistical software (Stata Statistical Software, College Station, TX, USA) and subsequently incorporated it into the Research Electronic Data Capture (REDCap), an online data management system, to assign the participants to either the PENG group (0.375% ropivacaine) or the placebo group (normal saline placebo) at a 1:1 ratio, in blocks of 4. An independent pharmacist will prepare a 20 ml solution of 0.375% ropivacaine and a 20 ml solution of normal saline, while an independent research staff will unveil the randomization sequence on REDCap and select the designated study drug. This entire process is masked from all the other researchers involved in the study, including the anesthesiologists who perform the block, and the physical therapists who perform the prehabilitation and evaluate the outcomes.

Data management

All study data will be collected promptly through REDCap. The images and videos of the block will be kept on a secured computer without an internet connection. Each patient will be assigned a unique study identifier, facilitating database linkage. Protection of personal health information will be upheld, with its disclosure limited to members of the research team only as required by specific study purposes. The data will be only accessible to authorized personnel through password-protected access. Specific privilege assignments within the database will be employed to restrict data access to the minimum necessary for each individual's role in the trial. The allocation data will be only available to the independent research staff who unveil the allocation sequence. Electronic audit trails will be implemented to automatically capture and record any changes made to database contents.

Statistical analysis

The primary outcome will be analyzed with the Fischer's exact test. The proportion and its 95% confidence interval of the difference between the groups will be obtained.

For secondary outcomes, the analysis will be performed using the Fischer's exact test or the Wilcoxon rank-sum test. The mean values and its 95% confidence interval, or the proportions and its 95% confidence intervals between the groups will be reported.

Baseline characteristics will be summarized as summary statistics (minimum, median, and maximum) for continuous variables and as frequency and proportion for binary variables.

All the data analysis will be performed in the intention-to-treat principle using the R software (R Core Team, Vienna, Austria).

Monitoring

The data monitoring committee (DMC) will consist of members independent from the research team. The DMC will report at defined intervals to assess progress, identify potential issues, and promptly address any concerns that may arise.

Any serious adverse events, in addition to all non-serious adverse events that are both unexpected and determined to be related to the study treatment, will be documented in the study database, and reported as mandated to the hospital's ethics committee, which will decide if the study needs to be stopped.

Dissemination Plans

Dissemination plans include presentations at local, national, and international scientific conferences, and publications in scientific journals. The full protocol will be available with the publications. The participant-level dataset and statistical code will also be disseminated when requested.

Discussion

There is currently a lack of evidence specifically addressing the preoperative use of PENG block in patients with femoral neck fractures who are scheduled for hip arthroplasty. This study will aim to accumulate evidence regarding the efficacy of PENG block in this context.

Our study design has several potential issues. The PENG block will be administered only once in the initial prehabilitation session, utilizing a single-shot approach instead of continuous catheter placement. This decision is made with consideration for the work capacity of our anesthesia team and potential infection risks at the injured site. Given that most participants are anticipated to undergo surgery following current guidelines, the evaluation of the impact of PENG block on extended outcomes, including postoperative recovery, may be limited due to the study design.

The method of outcome evaluation may face constraints due to scarce existing evidence. To address this, we conducted a pilot study to explore potential outcome measurement comparing patients who received standard pain management with those who underwent a PENG block. In our unpublished pilot study, we observed that almost no patients with standard pain management could mobilize beyond sitting, whereas patients who received PENG block demonstrated greater mobility, including wheelchair-transfer. Our original prehabilitation program, featured graded difficulty levels tailored to the patient's daily activities, ranging from basic movements like sitting up on the bed to more complex tasks such as using a wheelchair. We believe that this program could effectively assess the efficacy of PENG block in prehabilitation.

Another major concern is the influence of prehabilitation on perioperative outcomes, specifically with regard to intraoperative bleeding amounts and postoperative thromboembolic events. While the current guidelines do not provide recommendations on preoperative mobilization, it is generally assumed that patients scheduled for hip arthroplasty should be capable of preoperative mobilization, given that the fractured hip will be replaced during the surgical procedure. Additionally, this study also offers opportunities to explore the effect of preoperative mobilization on the risks of perioperative thromboembolic events and bleeding amounts. We intend to address this concern in this study.

This study is meticulously designed to minimize bias using a randomized, placebo-controlled, double-blinded design. Especially for patients unable to undergo prompt surgical intervention, the combination of PENG block and prehabilitation may emerge as a viable treatment option during the waiting period for surgery.

Abbreviations

AAOS	American Academy of Orthopaedic Surgeons
Prehabilitation	Preoperative rehabilitation
PENG	Pericapsular nerve group
FNB	Femoral nerve block
FICB	Fascia iliaca compartment block
ASA-PS	American Society of Anesthesiologists physical status
FIM	Functional Independence Measure
EQ-5D	EuroQol 5 Dimension Self-Report Questionnaire
AIIS	Anterior inferior iliac spine
NRS	Numerical Rating Scale
CAS	Cumulated Ambulation Score
REDCap	Research Electronic Data Capture
DMC	Data monitoring committee

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-024-02620-8.

Additional file 1. SPIRIT 2013 Checklist. Recommended items to address in a clinical trial protocol and related documents.

Acknowledgements
The authors wish to express their great gratitude to all the staff of the physical therapy team and acute pain service team, as well as the surgeons of the Department of Orthopedics at Kameda Medical Center for their generous support.

Authors' contributions
ZJ, DS, OK and KU contributed to the study conception. ZJ, DS, FH, TH, OK and KU were involved in designing the study protocol. Zj, FH and TH collected the data. ZJ wrote the initial draft of the manuscript. All authors reviewed and revised the protocol, contributed to the article's revision, and approved the final version for publication.

Funding
The authors declare that they have no funding.

Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the Kameda Medical Center Clinical Research Review Board (approval number: 22–024). The informed consent will be obtained from patients before participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Anesthesiology, Kameda Medical Center, Kamogawa, Japan. [2]Department of Anesthesiology and Resuscitology, Dentistry and Pharmaceutical Sciences, Okayama University Graduate School of Medicine, Okayama, Japan. [3]Department of Rehabilitation, Kameda Medical Center, Kamogawa, Japan. [4]Department of Anesthesia, University of Iowa Hospitals and Clinics, Iowa City, USA.

Received: 22 January 2024 Accepted: 4 July 2024
Published online: 27 November 2024

References

1. Braithwaite RS, Col NF, Wong JB. Estimating hip fracture morbidity, mortality and costs. J Am Geriatr Soc. 2003;51(3):364–70.
2. American academy of orthopaedic surgeons management of hip fractures in older adults evidence-based clinical practice guideline. 12/03/2021. Available from: https://www.aaos.org/hipfxcpg.
3. Vidan MT, et al. Causes and effects of surgical delay in patients with hip fracture: a cohort study. Ann Intern Med. 2011;155(4):226–33.
4. Sawaguchi A, et al. Effectiveness of preoperative physical therapy for older patients with hip fracture. Geriatr Gerontol Int. 2018;18(7):1003–8.
5. Liu J, et al. Effect of a preoperative mobilization program on perioperative complications and function recovery in older adults with femoral neck fracture. Geriatr Nurs. 2022;44:69–75.
6. Ilfeld BM, Yaksh TL. The end of postoperative pain–a fast-approaching possibility? And, if so, will we be ready? Reg Anesth Pain Med. 2009;34(2):85–7.
7. Giron-Arango L, et al. Pericapsular Nerve Group (PENG) block for hip fracture. Reg Anesth Pain Med. 2018;43(8):859–63.
8. Wang Y, et al. The efficiency of ultrasound-guided pericapsular nerve group block for pain management after hip surgery: a meta-analysis. Pain Ther. 2023;12(1):81–92.
9. Vergari A, et al. PENG block associated with dexmedetomidine sedation for intramedullary femoral fixation in high-risk elderly patients: a case series and review of the literature. Eur Rev Med Pharmacol Sci. 2023;27(20):10061–8.
10. Allard C, et al. Comparison between femoral block and PENG block in femoral neck fractures: A cohort study. PLoS ONE. 2021;16(6): e0252716.
11. Huda AU, Ghafoor H. The use of Pericapsular Nerve Group (PENG) block in hip surgeries is associated with a reduction in opioid consumption, less motor block, and better patient satisfaction: a meta-analysis. Cureus. 2022;14(9): e28872.
12. Lin X, et al. Pericapsular nerve group (PENG) block for early pain management of elderly patients with hip fracture: a single-center double-blind randomized controlled trial. Reg Anesth Pain Med. 2023;48(11):535–9.
13. Borson S, et al. The mini-cog: a cognitive "vital signs" measure for dementia screening in multi-lingual elderly. Int J Geriatr Psychiatry. 2000;15(11):1021–7.
14. Keith RA, et al. The functional independence measure: a new tool for rehabilitation. Adv Clin Rehabil. 1987;1:6–18.
15. Mahoney FI, Barthel DW. Functional Evaluation: The Barthel Index. Md State Med J. 1965;14:61–5.
16. Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. Ann Med. 2001;33(5):337–43.
17. Fletcher GF, et al. Exercise standards for testing and training: a scientific statement from the American Heart Association. Circulation. 2013;128(8):873–934.
18. Parker MJ, Palmer CR. A new mobility score for predicting mortality after hip fracture. J Bone Joint Surg Br. 1993;75(5):797–8.
19. Foss NB, Kristensen MT, Kehlet H. Prediction of postoperative morbidity, mortality and rehabilitation in hip fracture patients: the cumulated ambulation score. Clin Rehabil. 2006;20(8):701–8.

Publisher's Note