

CASE REPORT

Hemodynamic-Protective and Neuromonitoring-Preserving Pericapsular Nerve Group Regional Analgesia for Cemented Hip Hemiarthroplasty in an Elderly Patient with Coexisting Traumatic Intracerebral Hemorrhage and Bundle Branch Block: An Observational Analytic Case Study

Sugeng Budi Santoso¹, Septian Adi Permana¹, Algi Iskandar^{1*}¹ Department of Anesthesiology and Intensive Care Therapy, Faculty of Medicine, Universitas Sebelas Maret / Dr. Moewardi Regional General Hospital, Surakarta, Indonesia.

ARTICLE INFO

Article history

Received: August 12, 2026
Revised: September 9, 2026
Accepted: September 28, 2026
Available online: October 3, 2026
Published: October 5, 2026

Keywords

Arthroplasty
Conduction block
Intracerebral hemorrhage
Nerve block
Opioid-sparing analgesia

DOI

<https://doi.org/10.37275/jacr.v7i2.974>

Corresponding author

Algi Iskandar
algiiskandar6909@gmail.com

ABSTRACT

Background. Pain control after hip fracture surgery is difficult when intracranial injury and cardiac conduction disease limit systemic opioids. Opioids can raise intracranial pressure through hypoventilation. They can also obscure serial neurological examination.

Objective. To describe an opioid-sparing multimodal analgesic course centered on an ultrasound-guided pericapsular nerve group (PENG) block in cemented hip hemiarthroplasty.

Methods. A 64-year-old man (ASA III) fell from two meters. He had a displaced right intertrochanteric fracture, a minimal traumatic right frontal intracerebral hemorrhage (ICH score 0) and right bundle branch block. Cemented hemiarthroplasty was done under general anesthesia. After induction, a PENG block was placed with 20 mL of 0.25% bupivacaine, and scheduled intravenous paracetamol followed. Pain, quadriceps strength, Glasgow Coma Scale, hemodynamics and delirium were recorded at six time points.

Results. On arrival in the High-Care Unit, resting pain was 1/10 (7/10 before surgery) and movement pain 2/10 (9/10 before). No rescue opioid was needed over 72 hours; fentanyl 100 mcg was given at induction. The Glasgow Coma Scale stayed 15. Mean arterial pressure fell 19.4% to 82.0 mmHg at cementation and recovered within four minutes without a vasopressor or arrhythmia. Quadriceps strength was MRC 4/5 on arrival and 5/5 on day 1. No delirium occurred, and he went home on day 3.

Conclusion. A PENG block within a multimodal regimen was followed by low pain scores, no postoperative opioid use and a clear sensorium. One case cannot show causation. Fracture fixation, paracetamol and anesthesia acted at the same time.

Access licence: Open access. This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International Licence (CC BY-NC-SA 4.0), which permits non-commercial use, sharing, adaptation and reproduction in any medium, provided the original author and source are credited and derivative works are licensed under identical terms.

Copyright: © 2026 The Author(s). Published by HM Publisher in collaboration with CMHC Research Center. e-ISSN 2745-9497.

1. Introduction

Fragility fractures of the proximal femur are a major public health and economic problem. Early projections put the worldwide number at 6.26 million hip fractures a year by 2050 as populations age.¹ These fractures are seldom just a local injury to bone, because they signal systemic frailty, declining organ reserve and existing multimorbidity, and frail patients have more complications and higher mortality.² Mortality is high. It was traditionally quoted as about 10% at one month and 30% at one year, and recent registries report lower figures.³ In a large Canadian cohort the 30-day mortality was 7.0%.⁴ Hospital mortality is also higher than after elective hip replacement.⁵ Timing matters. Surgery within 48 hours is associated with lower mortality and fewer complications,⁶ and the risk of pneumonia and venous thromboembolism rises with waiting time.⁴ In older adults with a displaced intracapsular or extracapsular fracture, prompt surgical

stabilization is therefore the cornerstone of care, because it limits the harm of prolonged recumbency: deconditioning, hypostatic pneumonia, pressure ulcers and thromboembolism.^{6,7}

Surgery for comminuted or unstable proximal femoral fractures, especially cemented bipolar hemiarthroplasty or total joint replacement, produces intense somatic and visceral nociceptive input. Pain matters. Poorly controlled pain afterwards is more than a comfort problem in older patients. It contributes to the surgical stress response, with sympathoadrenal activation, excess catecholamines, vasoconstriction and higher myocardial oxygen consumption.⁸ The chest suffers too. Severe persistent pain around the incision and joint limits diaphragmatic movement and tidal volume, and analgesic technique can influence postoperative pulmonary function in older patients with hip fracture.⁹ Systemic opioids, given as intravenous patient-controlled analgesia or intermittent boluses, were long the mainstay of analgesia after arthroplasty. In frail older patients their therapeutic

window is narrow. Respiratory depression, somnolence, nausea, ileus, urinary retention and delirium can all follow.^{10,11} These adverse events have driven a move toward opioid-sparing multimodal regimens. Regional anesthesia has a central role in them.^{12,13} Complete avoidance of intraoperative opioids is not itself proven to add benefit.¹⁴

Within ultrasound-guided regional anesthesia, the pericapsular nerve group (PENG) block has emerged as an anatomically targeted technique designed for hip surgery.^{15–17} Girón-Arango and colleagues described it in 2018.¹⁵ The technique places local anesthetic in the deep musculofascial plane between the psoas major tendon and the iliopubic eminence of the pelvic brim.^{15,18} Cadaveric dissections map the sensory supply of the anterior hip joint capsule. It comes from articular branches of the femoral and obturator nerves in all specimens and of the accessory obturator nerve in about half.¹⁹ These branches cross the anterior pelvic surface beneath the psoas tendon, so a single ultrasound-guided depot at the iliopubic eminence is intended to cover the anterior capsule.^{19,20} The local anesthetic stays deep to the psoas tendon and superficial to the periosteum. The block therefore acts on articular sensory branches and is meant to spare the main motor trunks of the femoral nerve, which run in a more superficial and lateral plane. In trials, quadriceps motor block was less frequent than after a suprainguinal fascia iliaca block, and quadriceps strength recovered better.^{21,22}

Bone quality shapes the surgical situation in older patients with proximal femoral trauma. Intertrochanteric fractures, particularly Boyd-Griffin type II comminuted fractures, often occur in bone weakened by senile osteoporosis.²³ The Singh index grades the sequential loss of trabecular stress groups in the proximal femur on radiographs and so gives a semi-quantitative measure of bone loss, and grade IV indicates marked rarefaction of the tensile and compressive trabecular arches.²⁴ Internal fixation, usually with an intramedullary device, is generally preferred for intertrochanteric fractures. Fixation can fail. In osteoporotic or comminuted fractures it carries a risk of mechanical failure, including femoral head cut-out, non-union and loss of fixation. Arthroplasty is then considered in carefully selected patients, because it gives immediate implant stability and allows full weight-bearing straight away.²³ Cementation has its own hazard, however. Pressurizing the femoral canal and inserting the stem with polymethylmethacrylate (PMMA) can cause bone cement implantation syndrome (BCIS), with hypoxia, hypotension and loss of consciousness.^{25,26} Fat, marrow elements and cement monomer are thought to embolize into the pulmonary circulation, and the result can range from transient hypotension to cardiac arrest.²⁵ In a series of 208 patients with cemented hemiarthroplasty for proximal femoral fracture, 37% had symptoms of BCIS, and those patients had more cardiovascular complications and higher in-hospital mortality.²⁷

The anesthetic picture becomes much harder when a frail older patient with a hip fracture also has acute neurotrauma and pre-existing conduction disease. Choices narrow. Each condition on its own complicates the choice between opioid-based, general and neuraxial techniques.^{28–30} Even a sub-centimetre contusion in acute traumatic intracerebral hemorrhage (ICH) calls for close neurological vigilance.³¹ Systemic opioids are a concern here. Opioid-induced hypoventilation raises arterial

carbon dioxide, which dilates cerebral vessels and expands cerebral blood volume, so that intracranial pressure (ICP) can rise and threaten cerebral perfusion pressure (CPP).^{32,33} Opioid-related somnolence and miosis can also mask serial Glasgow Coma Scale (GCS) and pupillary examinations, the noninvasive tools that reveal an expanding intracranial mass. Right bundle branch block (RBBB) adds a cardiac problem. It reflects structural or degenerative damage to the ventricular conduction system, and in cohort studies it is associated with higher cardiac and all-cause mortality.³⁴

Randomized trials and meta-analyses of the PENG block in hip arthroplasty give mixed results. Most are favorable, with some studies showing less opioid use or better recovery and others showing no difference from fascia iliaca block.^{35–41} In hip fracture the evidence comes from small randomized trials and case series.^{42–46} That combination is the reason for this report. Systemic opioids risk neurological obscuration and hypercapnic ICP surges. Neuraxial sympathectomy risks hypotension during cementation. This case report describes the clinical course, hemodynamic behavior, serial GCS and opioid use under an ultrasound-guided PENG block-centered multimodal analgesic strategy. The patient is a 64-year-old man with a displaced Boyd-Griffin II fracture, a minimal traumatic frontal ICH and baseline RBBB.

2. Methods

2.1. Report design and reporting guideline

This is a single case report prepared according to the CARE guideline.⁴⁷

2.2. Setting

The patient was managed in the emergency department, the operating room, the High-Care Unit (HCU) and the ward of Dr. Moewardi Regional General Hospital, Surakarta, Indonesia, the teaching hospital affiliated with the Faculty of Medicine, Universitas Sebelas Maret.

2.3. Patient information and case selection

The patient was a 64-year-old man who presented acutely after a fall from a scaffold about two meters high. He had severe right hip pain, could not bear weight, and had a persistent headache with a brief initial loss of consciousness. He was classified ASA III. He weighed 51 kg and measured 155 cm (body mass index 21.2 kg/m²).

The case is reported because a displaced intertrochanteric fracture, a minimal traumatic intracerebral hemorrhage and right bundle branch block coexisted. Each of them limits the usual analgesic and anesthetic options.

2.4. Case timeline

Six time points were defined (Table 1). T0 was the emergency department presentation baseline, T1 was preoperative multidisciplinary clearance and stabilization, T2 was intraoperative stem cementation and bone cement implantation, and T3 was admission to the HCU within one hour of extubation. T4 was the morning of postoperative day 1, 24 hours after the block, during initial assisted mobilization. T5 was the morning of postoperative day 3 at readiness for discharge, 72 hours after the block. Percentage change ($\Delta\%$) from T0 was calculated as $[(T_n - T_0) / T_0] \times 100$ for each later time point (T1 to T5).

Table 1. Clinical timeline of the case with relative time points.

Time point	Clinical event	Investigation and result	Intervention
T0, day 0 (emergency department, about 3 h after the fall)	Right hip pain, headache, brief loss of consciousness	GCS 15 (E4V5M6); BP 129/88 mmHg (MAP 101.7); HR 61/min; SpO ₂ 97%; pain 7/10 rest, 9/10 movement. Pelvic radiograph: Boyd-Griffin II. Head CT: right frontal ICH ≈ 0.01 cc, ICH score 0. ECG: RBBB, QRS 124 ms. WBC 13,400 /μL; glucose 173 mg/dL	Multidisciplinary assessment
T1, day 0 (preoperative clearance)	Clearance by neurosurgery, cardiology and orthopedics	MAP 96.0 mmHg; HR 64/min; pain 6/10 rest, 8/10 movement; WBC 12,800 /μL; glucose 158 mg/dL	Mannitol 100 mL every 8 h; 2 units PRBC cross-matched
T2, day 0 (surgery)	General anesthesia, PENG block, cemented hemiarthroplasty	At cementation: BP 108/69 mmHg (MAP 82.0, −19.4%); HR 68/min; SpO ₂ 99% (FiO ₂ 0.50); no ST change	Fentanyl 100 mcg, propofol 75 mg, rocuronium 40 mg, sevoflurane; PENG block 20 mL 0.25% bupivacaine (50 mg); PMMA cement; neostigmine 2.5 mg + atropine 1.0 mg
T3, day 0 (HCU, ≤ 1 h after extubation)	Awake, oriented, calm	GCS 15; BP 122/78 mmHg (MAP 92.7); pain 1/10 rest, 2/10 movement; quadriceps MRC 4/5; WBC 11,200 /μL; glucose 136 mg/dL	Paracetamol 1,000 mg every 8 h; rescue tramadol or morphine if NRS > 4 (none used)
T4, day 1	Bed-to-chair transfer and walking with a walker	Pain 1/10 rest, 2/10 movement; MRC 5/5; CAM-ICU negative; WBC 9,400 /μL; glucose 118 mg/dL	Paracetamol
T5, day 3	Discharge to outpatient orthopedic rehabilitation	Pain 0/10 rest, 1/10 movement; MAP 89.3 mmHg; WBC 7,600 /μL; glucose 106 mg/dL; no complications	—

Notes: BP, blood pressure; CAM-ICU, Confusion Assessment Method for the ICU; CT, computed tomography; GCS, Glasgow Coma Scale; HCU, high-care unit; HR, heart rate; ICH, intracerebral hemorrhage; MAP, mean arterial pressure; MRC, Medical Research Council scale; PENG, pericapsular nerve group; PMMA, polymethylmethacrylate; PRBC, packed red blood cells; RBBB, right bundle branch block; WBC, white blood cell count. Δ% is the change from T0.

2.5. Clinical findings and diagnostic assessment

Diagnosis rested on imaging and laboratory work-up. (i) Pelvic radiography showed an acute, complete, displaced intertrochanteric fracture of the right proximal femur, classified as Boyd-Griffin type II (ICD-10 S72.14). It came with trabecular rarefaction that was graded Singh index IV. (ii) Non-contrast multislice computed tomography (MSCT) of the head showed acute traumatic brain injury. There was a sub-centimetre right frontal traumatic intracerebral hemorrhage with a calculated volume of about 0.01 cc (10 mm³) and bilateral chronic lacunar infarcts at the genu of the internal capsule. The ICH score was 0, which for spontaneous hemorrhage predicts a 30-day mortality of 0%; the score was not developed for traumatic hemorrhage.⁴⁸ (iii) The 12-lead electrocardiogram showed sinus rhythm at 75 beats/min with complete right bundle branch block (RBBB, QRS duration 124 ms, positive rSR' morphology in leads V1–V2). (iv) Laboratory tests showed leukocytosis from systemic trauma (13,400 /μL) and stress hyperglycemia (173 mg/dL). Coagulation was normal (PT 12.1 s, INR 1.02, aPTT 29.4 s). Deep fascial needle puncture was therefore safe.

2.6. Therapeutic intervention

A perioperative conference brought together attending specialists in anesthesiology, neurosurgery, cardiology and orthopedic surgery. Neurosurgery cleared the patient for urgent orthopedic neurosurgery under strictly conservative cranial management. It recommended intravenous mannitol (Totilac) 100 mL every eight hours against post-traumatic cerebral edema, continuous serial GCS and pupillary monitoring, and avoidance of sedation-induced hypercapnia. Cardiology stressed the limited ventricular conduction reserve that goes with RBBB, and it required continuous ST-segment and conduction surveillance, a mean arterial pressure within 20% of baseline, avoidance of vagal surges and vigilance during cement application. Advanced bone loss and comminuted fracture geometry argued against stable internal fixation, so the orthopedic team chose cemented right hip hemiarthroplasty with greater trochanteric tension-band reattachment. Blood was ready. Two units of packed red blood cells were cross-matched and held on standby (blood group B Rhesus positive).

Strict physiological targets were applied through anesthesia and recovery. They protect cerebral perfusion and myocardial oxygen balance. Cerebral perfusion pressure follows the relation $CPP = MAP - ICP$.³¹ ICP was assumed at 10 to 15 mmHg because no mass effect was present. A mean arterial pressure (MAP) above 80 mmHg was therefore targeted to keep an estimated CPP above 65–70 mmHg. MAP was also kept under 110 mmHg, above which the hematoma could expand.⁴⁹ In view of the right bundle branch block, heart rate was kept between 55 and 80 beats/min to preserve diastolic ventricular filling time and coronary perfusion and to avoid rate-dependent conduction worsening. Alarms sounded at once if systolic pressure moved more than ±20% from the pre-induction baseline.

General endotracheal anesthesia (GA-ETT) was chosen to guarantee immobility and controlled ventilation and to prevent coughing and ICP spikes. After preoxygenation with 100% oxygen, anesthesia was induced smoothly with intravenous fentanyl 2 mcg/kg (100 mcg), titrated propofol 1.5 mg/kg (75 mg) and rocuronium bromide 0.8 mg/kg (40 mg). Intubation was atraumatic. It succeeded at the first attempt with a video laryngoscope and a 7.5-mm internal diameter cuffed tube fixed at 21 cm at the incisors. Ventilation was volume-controlled with a tidal volume of 360 mL (about 7 mL/kg predicted body weight) and positive end-expiratory pressure of 5 cmH₂O. Minute ventilation was adjusted for strict normocapnia, with an end-tidal carbon dioxide (ETCO₂) of 35 to 38 mmHg. Anesthesia was maintained with sevoflurane (minimum alveolar concentration 1.0–1.2) in an oxygen-air mixture (FiO₂ 0.50).

After intubation and before surgical positioning, the ultrasound-guided PENG block was performed under strict asepsis with the patient supine (Figure 1). A low-frequency curvilinear transducer (2–5 MHz) was placed transversely over the right anterior inferior iliac spine (AIIS). It was then rotated about 45 degrees counterclockwise to line up with the pubic ramus. This showed the AIIS laterally, the iliopubic eminence (IPE) medially, the psoas major tendon and the nearby femoral neurovascular bundle. Under real-time guidance, a 22-gauge, 80-mm echogenic block needle was advanced in-plane from lateral to medial through the deep fascia. The target was the musculofascial plane between the posterior surface of the psoas tendon and the

anterior surface of the iliopubic eminence. Aspiration for blood was negative. A volume of 20 mL of 0.25% bupivacaine hydrochloride (50 mg) was injected in divided

aliquots, and hypoechoic hydrodissection appeared beneath the psoas major tendon, with spread along the anterior periosteal surface of the hip capsule.

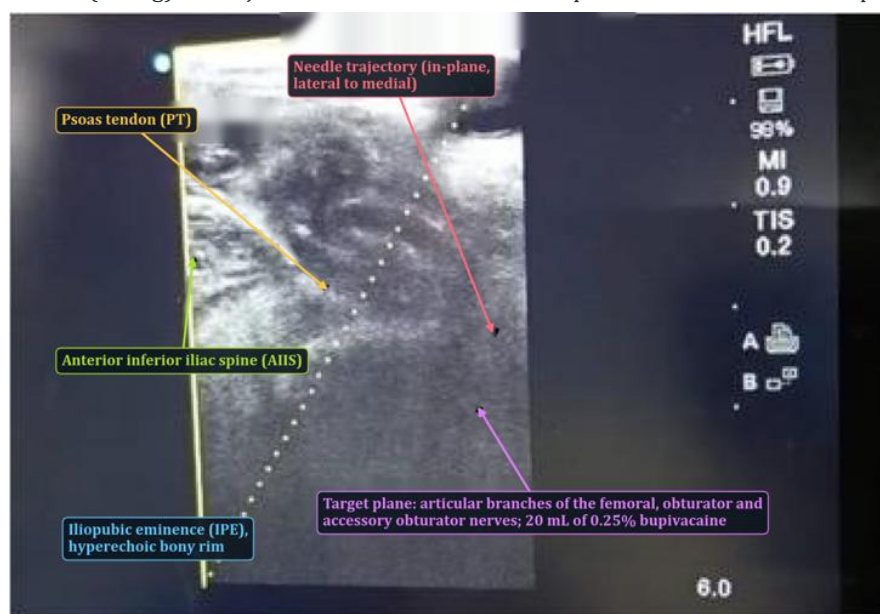


Figure 1. Real-time ultrasound sonography and target plane for the PENG block. The right anterior pelvic brim is shown with a low-frequency curvilinear transducer, with the anterior inferior iliac spine (AIIS), iliopubic eminence (IPE), psoas tendon (PT) and the in-plane needle path (dotted line) from lateral to medial. A volume of 20 mL of 0.25% bupivacaine was deposited in the plane deep to the psoas tendon.

Positioning followed. The patient was turned to the left lateral decubitus position with the spine aligned and the head and neck positioned to avoid compressing jugular venous outflow. Through a posterolateral Moore approach the femoral head was excised, the acetabulum was inspected and cleared, and the femoral canal was prepared with sequential rasps. Before PMMA bone cement was

implanted, high-volume pulsed lavage cleared marrow fat and debris, retrograde vacuum suction was applied and a distal intramedullary cement restrictor was placed. Vigilance for BCIS was raised during cement pressurization and stem insertion. The bipolar prosthesis was reduced, the greater trochanter was reattached with tension-band wiring, and the wound was closed in layers (Figure 2).

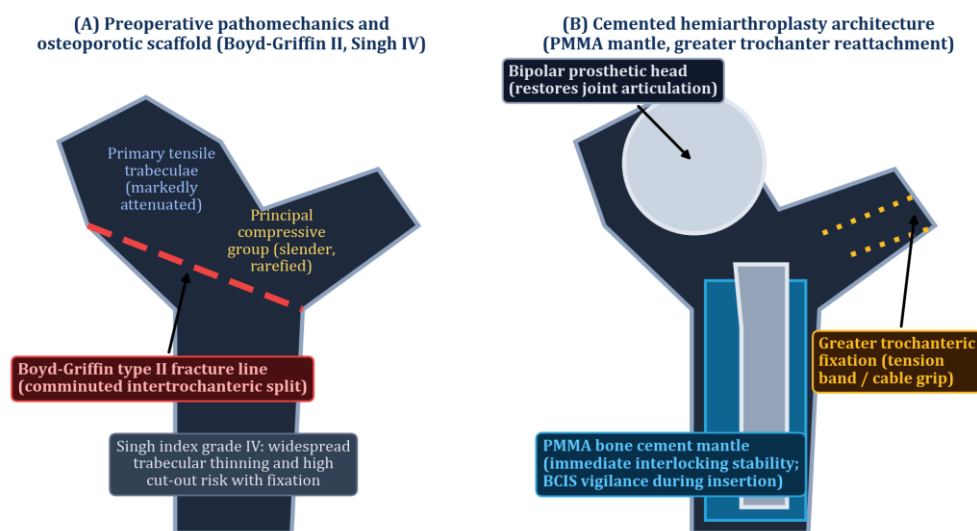


Figure 2. Cemented hemiarthroplasty in an osteoporotic femur. (A) Preoperative schematic of the Boyd-Griffin type II comminuted fracture line and the reduced trabecular pattern (Singh index IV). (B) Postoperative schematic with the PMMA cement mantle, femoral stem, bipolar head and greater trochanteric tension-band reattachment.

Neuromuscular blockade was reversed with intravenous neostigmine 2.5 mg and atropine 1.0 mg after the train-of-four ratio exceeded 0.90, and the patient was extubated in the operating room. The postoperative regimen was multimodal. It consisted of scheduled intravenous paracetamol 1,000 mg every eight hours. Intravenous tramadol 50 mg or morphine 2 mg was prescribed as rescue for breakthrough pain above NRS 4/10.

2.7. Outcome measures and follow-up

Physiological data were collected continuously. Continuous five-lead electrocardiography ran in the operating room and the HCU, following heart rate, rhythm and QRS stability to detect any new atrioventricular conduction delay or ischemia. Arterial blood pressure was recorded continuously, and MAP (mmHg) was calculated as diastolic pressure plus one third of the difference

between systolic and diastolic pressure. Neurological status was followed with serial GCS scores,⁵⁰ pupillary light reflex and symmetry every 15 minutes during recovery and hourly thereafter. Pain intensity was rated on the 11-point Numeric Rating Scale (NRS, 0 = no pain, 10 = worst imaginable pain),⁵¹ separately at rest and during passive 15-degree hip flexion (dynamic pain). Quadriceps function was graded on the Medical Research Council (MRC) muscle strength scale (0 to 5),⁵² with emphasis on active knee extension against gravity and manual resistance. Delirium was screened twice daily with the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU).⁵³ Systemic opioid use was recorded as intravenous morphine milligram equivalents (MME).¹¹

Because $n = 1$, no inferential statistics were calculated. Values are described over time, with $\Delta\%$ as defined above. Follow-up ended with discharge on postoperative day 3.

2.8. Ethics and consent

CMHC Research Center Ethics Committee, Indonesia, gave protocol approval (Protocol Approval Reference Number: 2026/0419), and Dr. Moewardi Regional General Hospital, Surakarta, Indonesia, authorized the work. The protocol followed the Declaration of Helsinki and the recommendations of the International Committee of Medical Journal Editors.⁵⁴ Written informed consent was

Table 2. Baseline clinical, anthropometric, laboratory and radiological findings.

Category	Variable	Admission value	Reference interval	Comment
Demographics	Age / sex	64 years / male	N/A	Older adult
Anthropometry	Weight / height / BMI	51 kg / 155 cm / 21.2 kg/m ²	18.5–24.9 kg/m ²	Normal nutritional status
Trauma	Mechanism	Fall from about 2 meters	N/A	High-energy impact with femoral and cranial injury
Trauma	Symptoms	Right hip pain, headache	N/A	Severe acute musculoskeletal pain
Neurological state	Glasgow Coma Scale	E4V5M6 (15/15)	15/15	Intact sensorium; transient loss of consciousness after the fall
Hemodynamics	Blood pressure (MAP)	129/88 mmHg (101.7 mmHg)	90–120 / 60–80 mmHg	Normotensive
Hemodynamics	Heart rate / rhythm	61 beats/min / sinus rhythm	60–100 beats/min	Normal rate
Respiration	Respiratory rate / SpO ₂	19 breaths/min / 97% (room air)	12–20 / $\geq 95\%$	Normal ventilation and oxygenation
Hematology	White blood cell count	13,400 / μ L (1.34×10^4 / μ L)	4,500–11,000 / μ L	Leukocytosis; stress-inflammatory response
Hematology	Hemoglobin / hematocrit	13.8 g/dL / 41.2%	13.0–17.0 g/dL / 40–50%	No acute anemia
Hematology	Platelet count	248,000 / μ L	150,000–450,000 / μ L	Normal
Metabolic	Random blood glucose	173 mg/dL (9.60 mmol/L)	70–140 mg/dL	Transient stress hyperglycemia
Renal	Blood urea nitrogen / creatinine	14.2 mg/dL / 0.88 mg/dL	7–20 / 0.6–1.2 mg/dL	Normal renal function
Coagulation	PT / INR / aPTT	12.1 s / 1.02 / 29.4 s	11–14 s / 0.8–1.2 / 25–35 s	Normal
Immunohematology	ABO / Rhesus	B / positive	N/A	2 units PRBC cross-matched
Chest radiograph	AP film	Normal; CTR 46%	Normal	No cardiac enlargement or pulmonary edema
Orthopedic imaging	Pelvic and femur radiograph	Displaced right intertrochanteric fracture	Intact bone	Boyd-Griffin type II (ICD-10 S72.14)
Bone quality	Singh index (contralateral proximal femur)	Grade IV	Grade 6 (normal)	Reduced trabecular pattern
Neuroimaging	Non-contrast head MSCT	Right frontal traumatic ICH (≈ 0.01 cc)	No hemorrhage	Minimal hemorrhage; bilateral lacunar infarcts
Neurological score	ICH score ⁴⁸	0 (GCS 15, volume < 30 cc, no IVH)	0–6	Developed for spontaneous ICH
Electrocardiography	12-lead ECG	Sinus rhythm 75 beats/min, RBBB (QRS 124 ms)	Normal conduction	Right bundle branch block
Anesthetic status	ASA physical status	Class III	Class I–VI	Severe systemic disease

Notes: Reference ranges are those of the laboratory of Dr. Moewardi Regional General Hospital. ASA, American Society of Anesthesiologists; BMI, body mass index; CTR, cardiothoracic ratio; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; INR, international normalized ratio; MAP, mean arterial pressure; MSCT, multislice computed tomography; PRBC, packed red blood cells; PT, prothrombin time; aPTT, activated partial thromboplastin time; RBBB, right bundle branch block; SpO₂, peripheral oxygen saturation.

obtained from the patient and his legal surrogate for recording, analysis and publication of clinical variables, laboratory results, radiographs and sonographic images, with de-identification and privacy protection.

3. Results

3.1. Presentation and baseline findings

The patient reached the emergency department about three hours after the fall. He had severe right hip pain with marked external rotation and shortening of the right leg and a dull frontal headache. He had lost consciousness briefly, for about two minutes. There was no post-traumatic vomiting, seizure or focal weakness. On first examination he was in moderate distress from musculoskeletal pain. He was fully conscious and cognitively intact, with a Glasgow Coma Scale of E4V5M6 (15/15) and round, isocoric, 3-mm pupils with a brisk light reaction. Blood pressure was 129/88 mmHg (calculated MAP 101.7 mmHg). Heart rate was 61 beats/min in regular sinus rhythm. Respiratory rate was 19 breaths/min and peripheral oxygen saturation (SpO₂) was 97% on room air. Pain was 7/10 at rest and 9/10 on minimal passive movement of the limb. Table 2 shows the baseline clinical, anthropometric, laboratory and radiological findings.

Admission laboratory tests showed marked stress-inflammatory and metabolic responses to the trauma. The white blood cell count was raised at 13,400 / μ L (reference range 4,500–11,000 / μ L), with neutrophil-predominant leukocytosis. Random blood glucose was 173 mg/dL (reference range 70–140 mg/dL), in keeping with acute post-traumatic stress hyperglycemia. Hemoglobin was normal at 13.8 g/dL (reference range 13.0–17.0 g/dL), hematocrit was 41.2% and platelets were 248,000 / μ L. Renal function was normal: blood urea nitrogen was 14.2 mg/dL and serum creatinine 0.88 mg/dL. Coagulation tests were normal: prothrombin time 12.1 seconds, international normalized ratio (INR) 1.02 and activated partial thromboplastin time 29.4 seconds.

3.2. Diagnostic findings

Anteroposterior radiographs of the pelvis and right femur showed a complete, comminuted, displaced intertrochanteric fracture of the right proximal femur (Boyd-Griffin type II). The contralateral proximal femur showed advanced rarefaction, graded Singh index IV: the principal tensile trabecular group was markedly resorbed, and the principal compressive trabeculae were thinned. The chest was normal. The anteroposterior chest radiograph showed clear lung fields without infiltrate, pneumothorax or consolidation, and a cardiothoracic ratio of 46%, measured on an anteroposterior film (Figure 3).

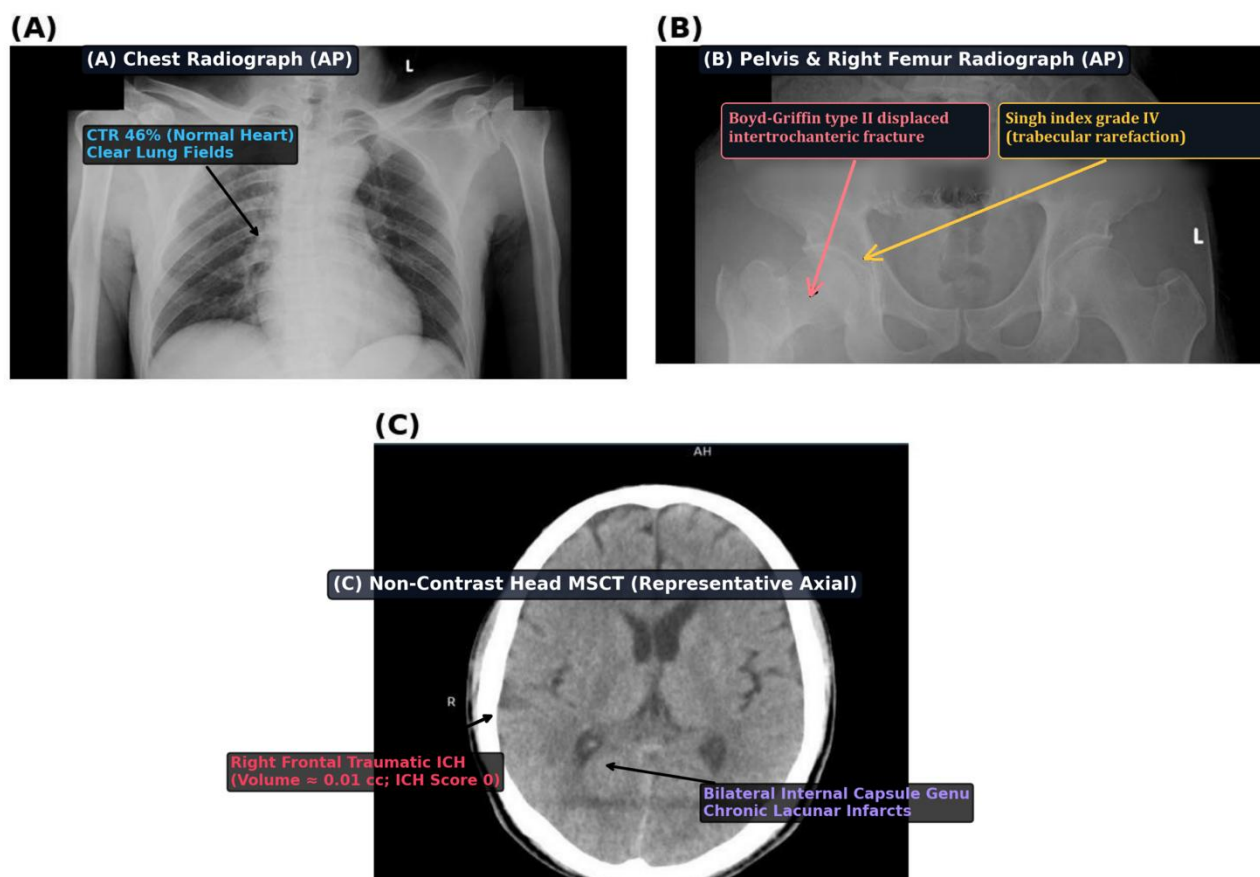


Figure 3. Admission imaging. (A) Chest radiograph (anteroposterior) with a normal cardiothoracic ratio (CTR 46%) and clear lung fields. (B) Anteroposterior pelvic radiograph showing a complete displaced right intertrochanteric fracture (Boyd-Griffin type II) with reduced trabecular pattern (Singh index IV). (C) Representative axial slice of non-contrast head MSCT showing a minimal right frontal traumatic intracerebral hemorrhage (ICH score 0) and chronic lacunar infarcts at the genu of the internal capsule.

Emergency non-contrast MSCT of the head on day 0 showed a hyperdense focus under 8 mm in the right frontal subcortical white matter, an acute minimal traumatic intracerebral hemorrhage with a calculated volume of about 0.01 cc (10 mm³). There was no midline shift. Mass effect, ventricular compression and subarachnoid extension were also absent. Bilateral chronic lacunar infarctions were seen at the genu of the internal capsule. The calculated ICH score was 0 (GCS 15 = 0 points, volume < 30 cc = 0, no intraventricular hemorrhage = 0, supratentorial location = 0, age < 80 years = 0). A 12-lead electrocardiogram was recorded on day 1. It showed normal sinus rhythm at 75 beats/min and a prolonged QRS duration of 124 ms. Positive rSR' complexes were present in V1–V2, and slurred S waves were wide in leads I and V6. These findings confirmed complete right bundle branch block. There was no pathological ST-segment elevation or depression, and ventricular hypertrophy was absent.

3.3. Treatment course and outcome

During cement pressurization and stem insertion (T2), blood pressure fell briefly from 124/82 mmHg to a nadir of 108/69 mmHg (MAP 82.0 mmHg, a –19.4% change from the admission baseline). Heart rate rose slightly to 68 beats/min. There was no ST deviation, no progression of conduction block and no hypoxemia (SpO₂ 99% on FiO₂ 0.50). The pressure drop resolved by itself within four minutes without a vasopressor, and clinically significant BCIS was absent.

Emergence was smooth, without agitation, bucking or hemodynamic surges. The patient arrived in the HCU (T3) alert, oriented and calm. GCS was E4V5M6 (15/15), the pupils were isocoric at 3 mm with brisk bilateral light reactivity, and there was no focal neurological deficit. Vital signs were stable. Blood pressure was 122/78 mmHg (MAP 92.7 mmHg), heart rate 66 beats/min in regular sinus

rhythm, respiratory rate 16 breaths/min and SpO₂ 98% on room air. Resting pain at the surgical hip was 1/10, against 7/10 at admission ($\Delta\%$ = -85.7%). Dynamic pain on passive 15-degree flexion was 2/10, against 9/10 ($\Delta\%$ =

Table 3. Physiological, neurological, analgesic and laboratory trajectory across six time points.

Parameter	T0	T1	T2	T3	T4	T5	$\Delta\%$ T5 vs T0
Systolic BP (mmHg)	129	124 (-3.9%)	108 (-16.3%)	122 (-5.4%)	120 (-7.0%)	118 (-8.5%)	-8.5%
Diastolic BP (mmHg)	88	82 (-6.8%)	69 (-21.6%)	78 (-11.4%)	75 (-14.8%)	75 (-14.8%)	-14.8%
MAP (mmHg)	101.7	96.0 (-5.6%)	82.0 (-19.4%)	92.7 (-8.8%)	90.0 (-11.5%)	89.3 (-12.2%)	-12.2%
Heart rate (beats/min)	61	64 (+4.9%)	68 (+11.5%)	66 (+8.2%)	64 (+4.9%)	62 (+1.6%)	+1.6%
Respiratory rate (breaths/min)	19	18 (-5.3%)	12 (ventilated)	16 (-15.8%)	15 (-21.1%)	14 (-26.3%)	-26.3%
SpO ₂ (%)	97 (room air)	98 (room air)	99 (FiO ₂ 0.5)	98 (room air)	98 (room air)	99 (room air)	+2.1%
GCS (/15)	15 (E4V5M6)	15 (E4V5M6)	General anesthesia	15 (E4V5M6)	15 (E4V5M6)	15 (E4V5M6)	0.0%
Pupils	3 mm, isocoric	3 mm, isocoric	Not assessed	3 mm, isocoric	3 mm, isocoric	3 mm, isocoric	Unchanged
Resting pain (NRS 0–10)	7	6 (-14.3%)	Not rated (GA)	1 (-85.7%)	1 (-85.7%)	0 (-100.0%)	-100.0%
Dynamic pain (NRS 0–10)	9	8 (-11.1%)	Not rated (GA)	2 (-77.8%)	2 (-77.8%)	1 (-88.9%)	-88.9%
Quadriceps power (MRC 0–5)	Not testable (fracture)	Not testable (fracture)	Neuromuscular blockade	4	5	5	Not calculated
Systemic opioid (MME)	0	0	10 (fentanyl at induction)	0	0	0	10 intraoperative; 0 postoperative
Delirium (CAM-ICU)	Negative	Negative	Not assessed	Negative	Negative	Negative	Negative
WBC (/μL)	13,400	12,800 (-4.5%)	Not measured	11,200 (-16.4%)	9,400 (-29.9%)	7,600 (-43.3%)	-43.3%
Blood glucose (mg/dL)	173	158 (-8.7%)	142 (-17.9%)	136 (-21.4%)	118 (-31.8%)	106 (-38.7%)	-38.7%
Lactate (mmol/L)	1.8	1.6 (-11.1%)	1.4 (-22.2%)	1.2 (-33.3%)	1.0 (-44.4%)	0.9 (-50.0%)	-50.0%

Notes: T0, emergency department; T1, preoperative clearance; T2, intraoperative cementation; T3, high-care unit (1 h after extubation); T4, postoperative day 1; T5, postoperative day 3. $\Delta\%$ = $[(T_n - T_0) / T_0] \times 100$. CAM-ICU, Confusion Assessment Method for the ICU; GA, general anesthesia; GCS, Glasgow Coma Scale; MAP, mean arterial pressure; MME, morphine milligram equivalents; MRC, Medical Research Council scale; NRS, numeric rating scale; WBC, white blood cell count.

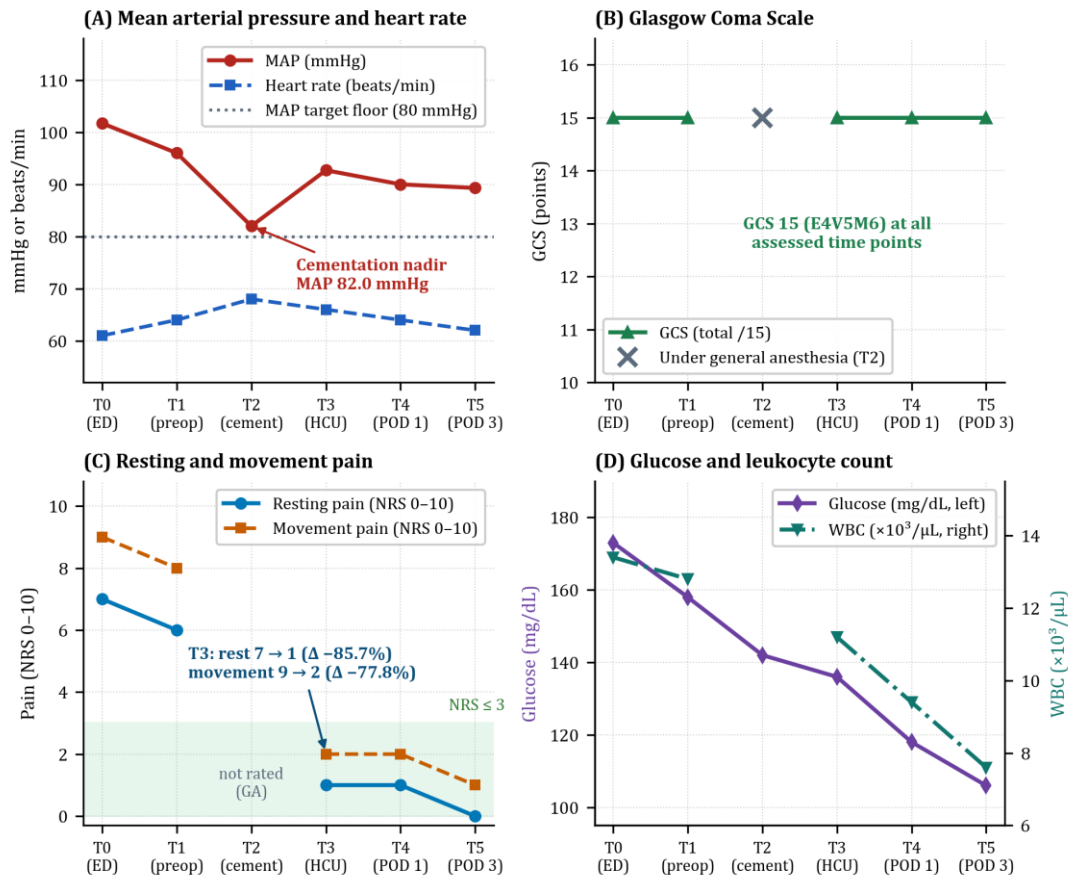


Figure 4. Longitudinal trajectories across six time points (T0 to T5). (A) Mean arterial pressure (MAP) and heart rate; the dotted line marks the MAP target floor of 80 mmHg. (B) Glasgow Coma Scale (T2 under general anesthesia). (C) Resting and dynamic pain (NRS 0–10); pain was not rated under general anesthesia (T2). (D) Blood glucose and white blood cell count.

Pain stayed controlled for the whole 72-hour postoperative period, with resting NRS between 0/10 and 1/10 and dynamic pain between 1/10 and 2/10. No rescue was needed. The patient took no tramadol or morphine, so cumulative postoperative systemic opioid use was 0 MME; the only opioid exposure was fentanyl 100 mcg (about 10 MME) at induction. On postoperative day 1 (T4) he moved from bed to chair and walked with a walker with early assisted support. Quadriceps strength was MRC grade 5/5. CAM-ICU assessments were negative at every evaluated interval, so there was no postoperative delirium.

Serial biochemical tests showed steady normalization of the trauma-related stress markers. The leukocyte count fell from 13,400 / μ L at T0 to 11,200 / μ L at T3 and 9,400 / μ L at T4. It reached the normal range at 7,600 / μ L on POD 3 (T5, $\Delta\%$ = -43.3% from admission). Random blood glucose fell from 173 mg/dL at presentation to 136 mg/dL at T3 and 118 mg/dL at T4. It normalized to 106 mg/dL at T5 ($\Delta\%$ = -38.7%). Serial lactate stayed low (0.9–1.2 mmol/L) from T3 onward, against 1.8 mmol/L at T0. Continuous ECG telemetry in the HCU showed persistent baseline RBBB. No new conduction delay, progression of the block or ventricular ectopy appeared. No seizure, arrhythmia, metallic taste or hemodynamic collapse followed the block, and no adverse event attributable to the block or to the multimodal regimen was recorded. The patient was discharged to outpatient orthopedic rehabilitation on POD 3 without neurological, cardiovascular or wound complications.

4. Discussion

4.1. Principal lesson of the case

In a 64-year-old man with a hip fracture, a minimal traumatic intracerebral hemorrhage and right bundle branch block, a PENG block within an opioid-minimizing multimodal regimen was followed by low pain scores, no postoperative opioid requirement, a clear sensorium and

Table 4. Published reports used for comparison.

Report	Design and sample	Population or intervention	Main findings as reported
Yu et al. 2023 ³⁵	Meta-analysis, 9 studies	Hip surgery; PENG block vs control or other nerve blocks	No significant difference in 24-h morphine use (MD -2.57 mg, 95% CI -5.42 to 0.27) or in static and dynamic pain at 6 and 24 h versus other nerve blocks; PENG proposed as an alternative multimodal option
Andrade et al. 2023 ⁵⁵	Meta-analysis, 8 RCTs, 384 patients	Hip surgery; PENG vs fascia iliaca block	Lower static pain at 12 h and lower 24-h morphine use (MD -6.93 mg, 95% CI -13.60 to -0.25); no difference in dynamic pain at 6 or 24 h
Li et al. 2024 ⁵⁶	Meta-analysis, 15 RCTs, 890 patients	Hip fracture surgery under spinal anesthesia; PENG block	Lower pain at positioning (SMD -0.35), less postoperative hypokinesia (RR 0.11) and earlier first walking
Aliste et al. 2021 ²¹	RCT, 40 patients	Primary total hip arthroplasty; PENG (20 mL levobupivacaine 0.5%) vs suprainguinal fascia iliaca block	Quadriceps motor block 25% vs 85% at 6 h
Lin et al. 2023 ⁴²	RCT, 60 randomized (57 analyzed)	Hip fracture; PENG vs sham block	Dynamic NRS at 30 min 3 vs 5; 24-h opioid 10 vs 15 mg oral morphine equivalents
Cui et al. 2024 ⁵⁷	RCT, 74 patients	Older patients, hip surgery under general anesthesia; PENG vs suprainguinal fascia iliaca block	Fascia iliaca block gave stronger analgesia, more stable intraoperative hemodynamics and less stress response
Kukreja et al. 2023 ³⁸	RCT, 112 patients	Primary total hip arthroplasty under spinal anesthesia; PENG vs none	24-h QoR-15 132 vs 103 (median difference 26); less opioid use
Snapp et al. 2024 ⁶¹	Quality-improvement project, retrospective data	Hip fracture; fascia iliaca blocks given in the emergency department	Preoperative opioid use 38 → 16.9–18 MME; delirium 6% → 0%
Weingärtner et al. 2022 ²⁷	Retrospective series, 208 patients	Cemented hemiarthroplasty for proximal femur fracture	BCIS symptoms in 37%; more cardiovascular complications (27.3% vs 13.7%) and higher in-hospital mortality (15.6% vs 4.6%) with BCIS
Kim et al. 2023 ⁵⁸	Cadaver study, 18 cadavers	PENG block with 10, 20 or 30 mL	Femoral nerve stained in 50% (20 mL) and 100% (30 mL); authors found no reliable motor sparing
Yeoh et al. 2022 ⁶⁰	Scoping review	Quadriceps weakness after PENG block	Quadriceps weakness in 25% or more; possible bursal injection
Chassery et al. 2024 ¹⁴	RCT, ambulatory total hip arthroplasty	Opioid-free vs opioid-sparing anesthesia	Complete intraoperative opioid avoidance gave no benefit over opioid-sparing anesthesia

stable hemodynamics. The case shows that this approach is feasible. It cannot show that the block caused these results. There were five main observations. (i) Pain was low after surgery: resting pain was 1/10 on unit arrival (Δ -85.7%) and dynamic pain 2/10 (Δ -77.8%). (ii) No postoperative systemic rescue opioid was needed (0 MME over 72 hours). (iii) GCS stayed 15 throughout, so an evolving traumatic hemorrhage could be watched without interruption. (iv) MAP fell by 19.4% at cementation and recovered without treatment, with no change in conduction. (v) Quadriceps power was MRC 4/5 one hour after extubation and 5/5 on day 1, which allowed early ambulation without delirium.

4.2. Comparison with the published literature

Published evidence on the PENG block is mixed (Table 4). In a meta-analysis of nine studies in hip surgery, the PENG block gave no significant difference in 24-hour morphine use or pain scores compared with other nerve blocks, and the authors regarded it as an alternative multimodal option.³⁵ A pooled analysis of eight randomized trials (384 patients) against fascia iliaca block found lower static pain at 12 hours and lower 24-hour morphine use, with no difference in dynamic pain.⁵⁵ In hip fracture surgery under spinal anesthesia, pooled data from 15 trials (890 patients) showed lower pain at positioning and earlier first walking.⁵⁶ A randomized trial in hip fracture found lower dynamic pain at 30 minutes and lower 24-hour opioid use than with a sham block (10 vs 15 mg oral morphine equivalents), and this agrees with the low pain and opioid use seen here.⁴² Other trials give less favorable or neutral results. After hip arthroplasty or fracture surgery, suprainguinal fascia iliaca block was better than PENG for analgesia, hemodynamics and stress response in one trial,⁵⁷ and PENG did not reduce fentanyl use or pain scores in another.⁴⁰ A trial in total hip arthroplasty found better quality of recovery and less opioid use with PENG.³⁸

Report	Design and sample	Population or intervention	Main findings as reported
This case	Single patient	64-year-old man, hip fracture, minimal traumatic ICH, RBBB; PENG 20 mL 0.25% bupivacaine + paracetamol	Pain 1/10 rest and 2/10 movement on unit arrival; 0 MME postoperative; GCS 15; quadriceps MRC 4/5 then 5/5

Notes: Values are those reported by the authors; designs and populations differ, and no pooled or head-to-head comparison is intended. BCIS, bone cement implantation syndrome; CI, confidence interval; MD, mean difference; MME, morphine milligram equivalents; NRS, numeric rating scale; PENG, pericapsular nerve group; RCT, randomized controlled trial; RR, relative risk; SMD, standardized mean difference.

Motor sparing is a particular point of difference. In cadavers, 20 mL stained the femoral nerve itself in 6 of 12 specimens and 30 mL in all of them, and the authors concluded that single-injection PENG blocks of 10, 20 or 30 mL do not reliably spare motor function or selectively block the anterior capsule.⁵⁸ With 10 mL, femoral nerve staining occurred in 2 of 6 specimens.⁵⁹ A scoping review reports quadriceps weakness in 25% or more of patients after PENG block, possibly from injection into the iliopsoas bursa.⁶⁰ Randomized comparisons with suprainguinal fascia iliaca block show less quadriceps block with PENG (25% vs 85% at 6 hours),²¹ and strength recovered better with continuous PENG than with continuous fascia iliaca block.²² Our protocol used 20 mL of 0.25% bupivacaine (50 mg). Quadriceps strength was MRC 4/5 an hour after extubation and 5/5 on day 1. This is compatible with little or no femoral nerve involvement, but it cannot exclude it, because strength could not be graded before the block.

For the other elements of the case, the literature is limited. BCIS is a frequent complication of cemented hemiarthroplasty, with symptoms in 37% of 208 patients in one series and higher cardiovascular complications and in-hospital mortality in those affected.²⁷ Preoperative regional blocks given in the emergency department reduced opioid use and delirium in hip fracture patients (preoperative opioid use fell from 38 to about 17 MME, and delirium from 6% to 0%) in a quality-improvement project.⁶¹ A randomized trial found that a preoperative fascia iliaca block reduced postoperative morphine use.¹³

4.3. Pathophysiological or mechanistic interpretation

The rationale for the block rests on the anatomy of hip joint nociception. The anterior capsule is supplied by articular branches of the femoral, obturator and accessory obturator nerves, which run in a narrow fascial corridor along the anterior pelvic brim, deep to the iliopsoas complex and over the iliopubic eminence and anterior inferior iliac spine.¹⁹ Real-time ultrasound lets the operator place local anesthetic between the deep surface of the psoas tendon and the iliopubic eminence. The articular branches can then be reached before they enter the fibrous capsule.²⁰ The conventional femoral nerve block or suprainguinal fascia iliaca block places the drug around the main femoral trunk, whereas the PENG block works deep to the psoas tendon.^{18,21} What was observed here is a low pain score after surgery. What is inferred, and not shown, is that the block contributed to it. The comparison is between a fractured hip before surgery and a replaced hip after surgery, so fixation of the fracture, paracetamol and the anesthetic itself relieve pain in parallel, and analgesia given before surgery was not described.

Acute traumatic brain injury raises the stakes of opioid analgesia. Secondary brain injury is driven by hypoxia, hypoperfusion and rises in intracranial pressure.³¹ Opioids act on mu-opioid receptors in the pontomedullary respiratory complex and cause dose-dependent hypoventilation. The resulting rise in arterial carbon dioxide (PaCO₂) dilates cerebral arterioles, and because the skull is rigid (the Monro-Kellie doctrine), greater cerebral blood volume can raise intracranial pressure

sharply.^{32,33} In our patient the sensorium remained clear (GCS 15) after a single dose of fentanyl 100 mcg at induction and with no postoperative opioid. This was observed, but it is not proof that the absence of opioids was responsible, because propofol and sevoflurane were also given.

Right bundle branch block adds a cardiac concern. Conduction through the right bundle branch relies on rapid Phase 0 depolarization by voltage-gated cardiac sodium channels (Nav1.5), and in complete RBBB the right ventricle is activated late, by trans-septal spread from the left bundle branch. This widens the QRS complex and creates ventricular dyssynchrony.³⁴ Under surgical stress, strong sympathetic surges cause tachycardia and greater myocardial oxygen demand. Large opioid boluses or deep neuraxial sympathectomy, on the other hand, can cause marked vagal predominance or arterial hypotension, which lowers coronary perfusion pressure. In this patient, MAP stayed between 82.0 and 101.7 mmHg and heart rate between 61 and 68 beats/min at all time points. The drop in MAP at cementation (−19.4%) is consistent with the combined effect of general anesthesia, positioning and cement implantation. During PMMA polymerization and stem impaction, intramedullary pressure is high, and cement monomer, fat globules and marrow elements can enter the venous circulation, causing pulmonary vasoconstriction, higher right ventricular afterload and hypotension.^{25,26} Neuraxial anesthesia was avoided because of the risk of sympathetic block-related hypotension. This is a hypothesis. Spinal anesthesia is commonly used in hip fracture surgery and has been reported as feasible in patients at high cardiovascular risk.²⁹ A propensity-matched study found fewer 30-day complications with spinal than with general anesthesia and judged both acceptable,⁶² a review favors regional anesthesia,²⁸ and a block with total intravenous anesthesia has been used in ASA IV patients.³⁰ No comparison with neuraxial anesthesia was made in this case.

Local anesthetic systemic toxicity (LAST) is a concern in older patients, in whom the risk is raised by lower plasma protein binding, reduced cardiac output and slower hepatic clearance.⁶³ In the PENG block the drug goes into a deep musculofascial pocket between the psoas tendon and the pubic ramus, where microvascular density is lower than in highly vascular compartments, so systemic absorption may be slow and blunted. Peak plasma concentrations after fascial plane blocks with 20 mL of 0.25% bupivacaine (50 mg) are reported to occur 30 to 45 minutes after injection, at mean levels of 0.35 to 0.65 mcg/mL, below the accepted toxicity threshold of 2.0 to 4.0 mcg/mL. The dose of 50 mg corresponded to about 0.98 mg/kg in this 51-kg patient, below the commonly cited maximum of 2.0 mg/kg, although recommended maximum doses are not evidence-based thresholds.⁶⁴ Serial electrocardiographic and neurological evaluations showed no sign of toxicity.

Delirium affects a large share of patients after hip fracture surgery and is linked with mortality and disability.^{10,65} Uncontrolled pain and drugs such as opioids and anticholinergics are recognized triggers.^{10,61} Regional blocks that lower opioid use may reduce delirium.⁶¹ CAM-

ICU was negative throughout and no delirium occurred, and bed-to-chair transfer was possible within 24 hours of surgery.

Figure 5 summarizes the pathways that guided the plan. It is a conceptual diagram, not a result: it contrasts the hazards expected with systemic opioids or neuraxial

sympathectomy in this patient with the course that followed the PENG-centered regimen. The regional technique was chosen with these physiological constraints in mind. Regional block adds to, and does not replace, careful anesthetic and perioperative management. Table 5 compares the main regional options qualitatively.

Table 5. Qualitative comparison of regional and systemic analgesic options for proximal femoral fracture surgery.

Modality	Target and plane	Sensory coverage	Quadriceps effect	Hemodynamic and sympathetic effect	Relevance in traumatic ICH
PENG block (this case)	Articular branches of the femoral, obturator and accessory obturator nerves; plane between the psoas tendon and the iliopectic eminence	Anterior hip capsule	Intended to spare the quadriceps; weakness has been reported	No sympathectomy	Does not sedate; GCS can be followed
Suprainguinal fascia iliaca block	Femoral, lateral femoral cutaneous and obturator nerves (variable); deep to the fascia iliaca above the inguinal ligament	Anterior hip and lateral thigh	Quadriceps block is more frequent than with PENG ²¹	No sympathectomy	Provides opioid sparing; motor block can limit mobilization
Femoral nerve block	Femoral nerve trunk in the femoral triangle	Anterior thigh, knee and part of the anterior capsule	Substantial quadriceps block	No sympathectomy	Acceptable sensorium; motor block limits rehabilitation
Lumbar plexus block	Lumbar plexus roots (L2–L4) within the psoas compartment	Ipsilateral lower limb	Complete motor block in the femoral and obturator territories	Possible unilateral sympathetic effect; retroperitoneal hematoma is a rare risk	Positioning difficulty after trauma
Spinal or epidural analgesia	Spinal nerve roots	Bilateral lower limbs, autonomic block	Dose-dependent motor block	Sympathectomy with vasodilation, hypotension and bradycardia	Hypotension lowers CPP; epidural hematoma risk with antithrombotics
Systemic opioids	Central and peripheral mu-opioid receptors	Systemic analgesia without anatomical targeting	No motor block	Bradycardia, vasodilation and histamine release possible	Sedation and hypoventilation can obscure GCS and raise PaCO ₂ and ICP

Notes: CPP, cerebral perfusion pressure; GCS, Glasgow Coma Scale; ICP, intracranial pressure; PENG, pericapsular nerve group.

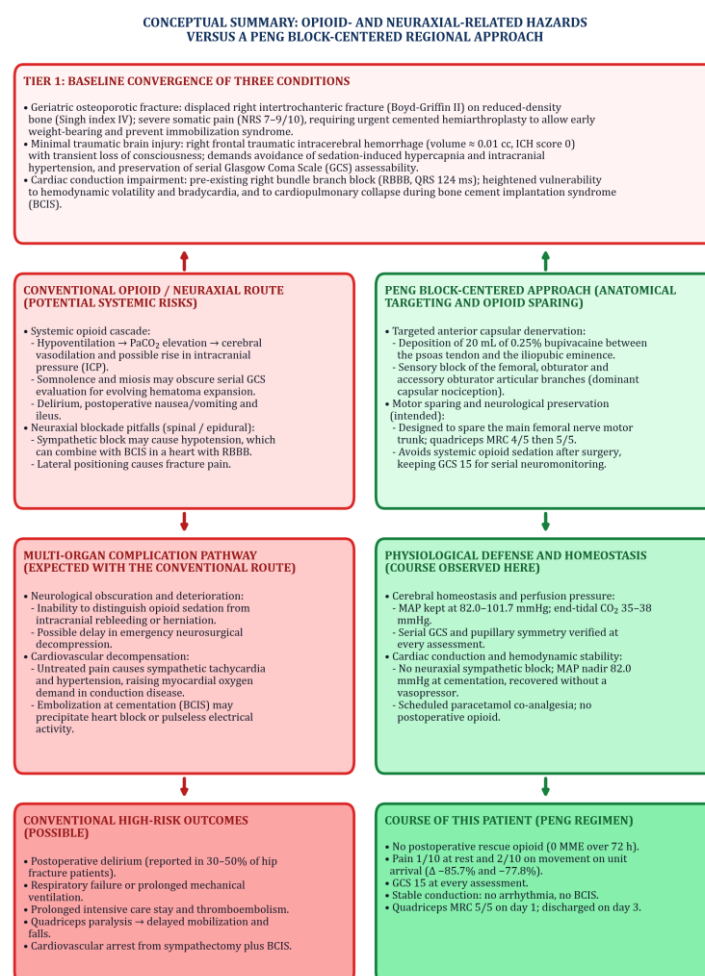


Figure 5. Conceptual summary of the pathways considered in planning analgesia: the hazards expected with systemic opioids or neuraxial block (left) and the course followed with the PENG-centered regimen (right) across four tiers. The diagram is conceptual and is not a measured result.

4.4. Implications for practice

Several practical points follow, with limited transferability from a single patient. (i) In older orthopedic trauma patients with acute traumatic brain injury, limiting systemic opioids and using a sensory-selective regional technique is a reasonable plan, provided that neurological monitoring is maintained. (ii) An ultrasound-guided PENG block with 20 mL of 0.25% bupivacaine gave low pain scores here, but injectate volume and quadriceps strength should be assessed in each patient, since cadaveric and clinical data show that motor sparing is not guaranteed. (iii) In patients with cardiac conduction disease undergoing cemented arthroplasty, general anesthesia with a PENG block after induction was followed by acceptable hemodynamics. Whether it is better than neuraxial techniques is not known. (iv) Coordination between anesthesiology, neurosurgery, orthopedics and cardiology is essential. It reconciles competing perioperative priorities in one management plan.

4.5. Strengths

The case has a detailed record. Six time points were documented, with explicit hemodynamic and neurological targets, a reproducible description of the block, weight-based doses and a complete baseline and laboratory profile. Derived values (MAP, BMI, $\Delta\%$, mg/kg dose) could be recalculated from the printed data.

4.6. Limitations

First, this is a single patient, so the findings are descriptive. They cannot show that the block was effective or safe in general, and they do not allow claims that PENG is superior to other regional techniques. Second, the pain comparison is between a fractured hip before surgery and a replaced hip afterwards. Fracture fixation, paracetamol and general anesthesia may all have contributed, and analgesia given before surgery was not described. Third, ICP and cardiac output were not measured, because the hematoma was minimal (ICH score 0) and there was no shock, so cerebral perfusion pressure was estimated and not measured. Fourth, a single-shot PENG block lasts a limited time, usually 18 to 24 hours; later pain scores of 0–1/10 reflect paracetamol and healing as well. A continuous catheter or adjuvants such as liposomal bupivacaine might be needed for longer surgical pain.⁶⁶ Fifth, strength could not be graded before the block, no follow-up head CT is described, and follow-up ended on day 3.

4.7. Recommendations for future work

Prospective studies of regional analgesia in older patients with hip fracture and coexisting intracranial or cardiac disease are needed. A registry or a randomized comparison of PENG block with other regional techniques, with standard measurement of pain, quadriceps strength, opioid use, delirium and hemodynamics, would test the hypothesis that this case generates.

5. Conclusion

In this 64-year-old man with a displaced intertrochanteric fracture, a minimal traumatic intracerebral hemorrhage and right bundle branch block, an ultrasound-guided PENG block within an opioid-minimizing multimodal regimen was followed by low pain scores (resting 1/10 and dynamic 2/10 on unit arrival). No opioid was needed after surgery over 72 hours. The Glasgow Coma Scale stayed 15 throughout, and mean arterial pressure recovered without

treatment after cementation. This answers the objective of describing the course. One case cannot show that the block caused these outcomes. The approach should be tested in prospective studies of comparable patients.

6. Declarations

Ethical approval and consent to participate. This case report was approved by the CMHC Research Center Ethics Committee, Indonesia, under reference number 2026/0419, with institutional authorization from Dr. Moewardi Regional General Hospital, Surakarta, Indonesia. The study followed the Declaration of Helsinki. Written informed consent to participate was obtained from the patient and his legal surrogate.

Consent for publication. Written informed consent for publication of this case and of the accompanying de-identified clinical, radiological and sonographic images was obtained from the patient and his legal surrogate. All direct personal identifiers were removed.

Availability of data and materials. The clinical datasets, radiological examinations and physiological trajectory data supporting the conclusions of this article are available from the corresponding author on reasonable request, subject to institutional data governance standards.

Artificial intelligence (AI) use statement. The authors declare that no generative artificial intelligence tool was used in the preparation of this manuscript.

Author contribution statement. S.B.S. and S.A.P. managed the patient, collected the data and drafted the manuscript (Investigation, Data curation, Writing – original draft). A.I. conceived the report, designed the analysis, revised the manuscript, approved the final version and supervised the work (Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision, Project administration). All authors read and approved the final manuscript.

Funding statement. This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflict of interest (competing interests) statement. The authors declare that they have no competing interests.

Acknowledgements. The authors thank the multidisciplinary clinical and nursing staff of the Department of Anesthesiology and Intensive Care Therapy and the Departments of Orthopedic Surgery, Neurosurgery and Cardiology at Dr. Moewardi Regional General Hospital, Surakarta, Indonesia, for their collaborative expertise and patient care.

7. References

1. Cooper C, Campion G, Melton LJ. Hip fractures in the elderly: a world-wide projection. *Osteoporos Int.* 1992;2(6):285–9. doi:10.1007/bf01623184
2. Dong X, Zhang X, Hu F, et al. Association of frailty with adverse outcomes in surgically treated geriatric patients with hip fracture: a meta-analysis and trial sequential analysis. *PLoS One.* 2024;19(6):e0305706. doi:10.1371/journal.pone.0305706
3. Downey C, Kelly M, Quinlan JF. Changing trends in the mortality rate at 1-year post hip fracture - a systematic review. *World J Orthop.* 2019;10(3):166–75. doi:10.5312/wjo.v10.i3.166
4. Pincus D, Ravi B, Wasserstein D, et al. Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. *JAMA.* 2017;318(20):1994–2003. doi:10.1001/jama.2017.17606
5. Le Manach Y, Collins G, Bhandari M, et al. Outcomes after hip fracture surgery compared with elective total hip replacement. *JAMA.* 2015;314(11):1159–66. doi:10.1001/jama.2015.10842

6. Klestil T, Röder C, Stotter C, et al. Impact of timing of surgery in elderly hip fracture patients: a systematic review and meta-analysis. *Sci Rep.* 2018;8:13933. doi:10.1038/s41598-018-32098-7
7. HIP ATTACK Investigators. Accelerated surgery versus standard care in hip fracture (HIP ATTACK): an international, randomised, controlled trial. *Lancet.* 2020;395(10225):698-708. doi:10.1016/S0140-6736(20)30058-1
8. Cusack B, Buggy DJ. Anaesthesia, analgesia, and the surgical stress response. *BJA Educ.* 2020;20(9):321-8. doi:10.1016/j.bjae.2020.04.006
9. Wang S, Xu Y, Kang Y, et al. Effect of different analgesic treatments on the pulmonary function in elderly hip fracture patients: a prospective study. *Medicine (Baltimore).* 2023;102(33):e34505. doi:10.1097/MD.00000000000034505
10. Marcantonio ER. Delirium in hospitalized older adults. *N Engl J Med.* 2017;377(15):1456-66. doi:10.1056/NEJMcP1605501
11. Dowell D, Ragan KR, Jones CM, et al. CDC clinical practice guideline for prescribing opioids for pain: United States, 2022. *MMWR Recomm Rep.* 2022;71(3):1-95. doi:10.15585/mmwr.r7103a1
12. Anger M, Valovska T, Beloel H, et al. PROSPECT guideline for total hip arthroplasty: a systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia.* 2021;76(8):1082-97. doi:10.1111/anae.15498
13. Thompson J, Long M, Rogers E, et al. Fascia iliaca block decreases hip fracture postoperative opioid consumption: a prospective randomized controlled trial. *J Orthop Trauma.* 2020;34(1):49-54. doi:10.1097/bot.0000000000001634
14. Chassery C, Athar V, Marty P, et al. Opioid-free versus opioid-sparing anaesthesia in ambulatory total hip arthroplasty: a randomised controlled trial. *Br J Anaesth.* 2024;132(2):352-8. doi:10.1016/j.bja.2023.02.031
15. Girón-Arango L, Peng PWH, Chin KJ, et al. Pericapsular nerve group (PENG) block for hip fracture. *Reg Anesth Pain Med.* 2018;43(8):859-63. doi:10.1097/aap.0000000000000847
16. Del Buono R, Padua E, Pascarella G, et al. Pericapsular nerve group block: an overview. *Minerva Anesthesiol.* 2021;87(4):458-66. doi:10.23736/s0375-9393.20.14798-9
17. Nájera Losada DC, Pérez Moreno JC. Pericapsular nerve group block in hip surgery. An alternative that goes beyond what we know?. *Rev Esp Anesthesiol Reanim (Engl Ed).* 2022;69(10):654-62. doi:10.1016/j.redare.2021.10.002
18. Elhamrawy A, Kerbage J, Veneziano G, et al. Pericapsular nerve group (PENG) block in pediatric patients undergoing hip and pelvic surgical procedures: an educational focused review. *J Pain Res.* 2024;17:3697-705. doi:10.2147/jpr.s481273
19. Short AJ, Barnett JGG, Gofeld M, et al. Anatomic study of innervation of the anterior hip capsule: implication for image-guided intervention. *Reg Anesth Pain Med.* 2018;43(2):186-92. doi:10.1097/AAP.0000000000000701
20. Girón-Arango L, Peng P. Pericapsular nerve group (PENG) block: what have we learned in the last 5 years?. *Reg Anesth Pain Med.* 2025;50(5):402-9. doi:10.1136/rapm-2024-105427
21. Aliste J, Layera S, Bravo D, et al. Randomized comparison between pericapsular nerve group (PENG) block and suprainguinal fascia iliaca block for total hip arthroplasty. *Reg Anesth Pain Med.* 2021;46(10):874-8. doi:10.1136/rapm-2021-102997
22. Duan L, Zhang L, Shi CG, et al. Comparison of continuous pericapsular nerve group (PENG) block versus continuous fascia iliaca compartment block on pain management and quadriceps muscle strength after total hip arthroplasty: a prospective, randomized controlled study. *BMC Anesthesiol.* 2023;23(1):233. doi:10.1186/s12871-023-02190-1
23. Nie B, Wu D, Yang Z, et al. Comparison of intramedullary fixation and arthroplasty for the treatment of intertrochanteric hip fractures in the elderly. *Medicine (Baltimore).* 2017;96(27):e7446. doi:10.1097/md.00000000000007446
24. Singh M, Nagrath A, Maini P. Changes in trabecular pattern of the upper end of the femur as an index of osteoporosis. *J Bone Joint Surg Am.* 1970;52(3):457-67. PMID: 5425640
25. Donaldson AJ, Thomson HE, Harper NJ, et al. Bone cement implantation syndrome. *Br J Anaesth.* 2009;102(1):12-22. doi:10.1093/bja/aen328
26. Rassir R, Schuiling M, Siersevelt IN, et al. What are the frequency, related mortality, and factors associated with bone cement implantation syndrome in arthroplasty surgery?. *Clin Orthop Relat Res.* 2021;479(4):755-63. doi:10.1097/corr.0000000000001541
27. Weingärtner K, Störmann P, Schramm D, et al. Bone cement implantation syndrome in cemented hip hemiarthroplasty—a persistent risk. *Eur J Trauma Emerg Surg.* 2021;48(2):721-9. doi:10.1007/s00068-020-01587-8
28. Li P, Li X, Peng G, et al. Comparative analysis of general and regional anesthesia applications in geriatric hip fracture surgery. *Medicine (Baltimore).* 2025;104(2):e41125. doi:10.1097/md.00000000000041125
29. Çağırn Z, Vahabi A, Özgül KK, et al. Unilateral spinal anesthesia in hip fracture surgery for geriatric patients with high cardiovascular risk due to aortic stenosis is safe and effective. *Geriatr Orthop Surg Rehabil.* 2024;15:21514593241280908. doi:10.1177/21514593241280908
30. Huang YY, Hui CK, Lau NC, et al. Total intravenous anesthesia for geriatric hip fracture with severe systemic disease. *Eur J Trauma Emerg Surg.* 2023;49(5):2139-45. doi:10.1007/s00068-023-02291-z
31. Carney N, Totten AM, O'Reilly C, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery.* 2017;80(1):6-15. doi:10.1227/NEU.0000000000001432
32. Siebers NW, Steiner LA. Anesthesia for traumatic brain injury. *Curr Opin Anaesthesiol.* 2024;37(5):486-92. doi:10.1097/ACO.0000000000001404
33. Citerio G, Robba C, Rebora P, et al. Management of arterial partial pressure of carbon dioxide in the first week after traumatic brain injury: results from the CENTER-TBI study. *Intensive Care Med.* 2021;47(9):961-73. doi:10.1007/s00134-021-06470-7
34. Xiong Y, Wang L, Liu W, et al. The prognostic significance of right bundle branch block: a meta-analysis of prospective cohort studies. *Clin Cardiol.* 2015;38(10):604-13. doi:10.1002/clc.22454
35. Yu L, Shen X, Liu H. The efficacy of pericapsular nerve group block for postoperative analgesia in patients undergoing hip surgery: a systematic review and meta-analysis of randomized controlled trials. *Front Med (Lausanne).* 2023;10:1084532. doi:10.3389/fmed.2023.1084532
36. Kim E, Shin WC, Lee SM, et al. Efficacy of pericapsular nerve group block for pain reduction and opioid consumption after total hip arthroplasty: a meta-analysis of randomized controlled trials. *Hip Pelvis.* 2023;35(2):63-72. doi:10.5371/hp.2023.35.2.63
37. Liang L, Zhang C, Dai W, et al. Comparison between pericapsular nerve group (PENG) block with lateral femoral cutaneous nerve block and supra-inguinal fascia iliaca compartment block (S-FICB) for total hip arthroplasty: a randomized controlled trial. *J Anesth.* 2023;37(4):503-10. doi:10.1007/s00540-023-03192-6
38. Kukreja P, Uppal V, Kofskey AM, et al. Quality of recovery after pericapsular nerve group (PENG) block for primary total hip arthroplasty under spinal anaesthesia: a randomised controlled observer-blinded trial. *Br J Anaesth.* 2023;130(6):773-9. doi:10.1016/j.bja.2023.02.017
39. Vamshi C, Sinha C, Kumar A, et al. Comparison of the efficacy of pericapsular nerve group block (PENG) block versus suprainguinal fascia iliaca block (SFIB) in total hip arthroplasty: a randomized control trial. *Indian J Anaesth.* 2023;67(4):364-9. doi:10.4103/ijia.ija_311_22
40. Vichainarong C, Kampitak W, Ngarmukos S, et al. Comparison of analgesic efficacy between ultrasound-guided supra-inguinal fascia iliaca block and pericapsular nerve group block following total hip arthroplasty: a randomized controlled trial. *Hip Pelvis.* 2024;36(4):290-301. doi:10.5371/hp.2024.36.4.290
41. Mostafa TAH, El Mourad MB, Mohamed NK. Pericapsular nerve group block in hip arthroplasty: a prospective randomized trial. *J Opioid Manag.* 2023;19(4):313-20. doi:10.5055/jom.2023.0788
42. Lin X, Liu CW, Goh QY, 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. doi:10.1136/rapm-2022-104117
43. Yoo SH, Lee MJ, Beak MH, et al. Efficacy of supplemental ultrasound-guided pericapsular nerve group (PENG) block combined with lateral femoral cutaneous nerve block in patients receiving local infiltration analgesia after hip fracture surgery: a prospective randomized controlled trial. *Medicina (Kaunas).* 2024;60(2):315. doi:10.3390/medicina60020315
44. Sahnoun N, Keskes M, Ali Mtibaa M, et al. Pericapsular nerve group block versus fascia iliaca block for perioperative analgesia in hip fracture surgery: a prospective randomized trial. *Pan Afr Med J.* 2023;46:93. doi:10.11604/pamj.2023.46.93.41117
45. Morrison C, Brown B, Lin DY, et al. Analgesia and anesthesia using the pericapsular nerve group block in hip surgery and hip fracture: a scoping review. *Reg Anesth Pain Med.* 2020;46(2):169-75. doi:10.1136/rapm-2020-101826
46. Tang Y, Zhang X, Yi S, et al. Ultrasound-guided pericapsular nerve group (PENG) block for early analgesia in elderly patients with hip fractures: a single-center prospective randomized controlled study. *BMC Anesthesiol.* 2023;23(1):383. doi:10.1186/s12871-023-02336-1
47. Riley DS, Barber MS, Kienle GS, et al. CARE guidelines for case reports: explanation and elaboration document. *J Clin Epidemiol.* 2017;89:218-35. doi:10.1016/j.jclinepi.2017.04.026
48. Hemphill JC, Bonovich DC, Besmertis L, et al. The ICH score: a simple, reliable grading scale for intracerebral hemorrhage. *Stroke.* 2001;32(4):891-7. doi:10.1161/01.str.32.4.891
49. Greenberg SM, Ziai WC, Cordonnier C, et al. 2022 guideline for the management of patients with spontaneous intracerebral hemorrhage: a guideline from the American Heart Association/American Stroke Association. *Stroke.* 2022;53(7):e282-361. doi:10.1161/str.0000000000000407
50. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. *Lancet.* 1974;2(7872):81-4. doi:10.1016/S0140-6736(74)91639-0
51. Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short-Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken).* 2011;63(Suppl 11):S240-52. doi:10.1002/acr.20543
52. Paternostro-Sluga T, Grim-Stieger M, Posch M, et al. Reliability and validity of the Medical Research Council (MRC) scale and a modified scale for testing muscle strength in patients with radial palsy. *J Rehabil Med.* 2008;40(8):665-71. doi:10.2340/16501977-0235

53. Ely EW, Inouye SK, Bernard GR, et al. Delirium in mechanically ventilated patients: validity and reliability of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU). *JAMA*. 2001;286(21):2703-10. doi:10.1001/jama.286.21.2703
54. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191-4. doi:10.1001/jama.2013.281053
55. Andrade PP, Lombardi RA, Marques IR, et al. Pericapsular Nerve Group (PENG) block versus fascia iliaca compartment (FI) block for hip surgery: a systematic review and meta-analysis of randomized controlled trials. *Braz J Anesthesiol*. 2023;73(6):794-809. doi:10.1016/j.bjane.2023.07.007
56. Li S, An J, Qian C, et al. Efficacy and safety of pericapsular nerve group block for hip fracture surgery under spinal anesthesia: a meta-analysis. *Int J Clin Pract*. 2024;2024:6896066. doi:10.1155/2024/6896066
57. Cui X, Cheng Z, Zhang T, et al. Effect of pericapsular nerve group block and suprainguinal fascia iliaca block on postoperative analgesia and stress response in elderly patients undergoing hip arthroplasty: a prospective randomized controlled double-blind trial. *BMC Anesthesiol*. 2024;24(1):220. doi:10.1186/s12871-024-02604-8
58. Kim JY, Kim J, Kim DH, et al. Anatomical and radiological assessments of injectate spread stratified by the volume of the pericapsular nerve group block. *Anesth Analg*. 2023;136(3):597-604. doi:10.1213/ane.0000000000006364
59. Smits RJH, Tan ECTH, Van den Bersselaar LR, et al. The comparison of spread of methylene blue after the pericapsular nerve group block and a double injection selectively targeting the articular branches to the anterior hip capsule in human cadavers. *Pain Pract*. 2025;25(2):e70002. doi:10.1111/papr.70002
60. Yeoh SR, Chou Y, Chan SM, et al. Pericapsular nerve group block and iliopsoas plane block: a scoping review of quadriceps weakness after two proclaimed motor-sparing hip blocks. *Healthcare (Basel)*. 2022;10(8):1565. doi:10.3390/healthcare10081565
61. Snapp C, Byrd B, Porter M. Reduction of postoperative delirium and opioid use in hip fracture patients through utilization of emergency department physician administered regional nerve blocks. *Geriatr Orthop Surg Rehabil*. 2024;15:21514593241228073. doi:10.1177/21514593241228073
62. Rodkey DL, Pezzi A, Hymes R. Effects of spinal anesthesia in geriatric hip fracture: a propensity-matched study. *J Orthop Trauma*. 2022;36(5):234-8. doi:10.1097/bot.0000000000002273
63. Neal JM, Barrington MJ, Fettiplace MR, et al. The Third American Society of Regional Anesthesia and Pain Medicine practice advisory on local anesthetic systemic toxicity. *Reg Anesth Pain Med*. 2018;43(2):113-23. doi:10.1097/aap.0000000000000720
64. Rosenberg PH, Veering BT, Urmev WF. Maximum recommended doses of local anesthetics: a multifactorial concept. *Reg Anesth Pain Med*. 2004;29(6):564-75. doi:10.1016/j.rapm.2004.08.003
65. Wu J, Yin Y, Jin M, et al. The risk factors for postoperative delirium in adult patients after hip fracture surgery: a systematic review and meta-analysis. *Int J Geriatr Psychiatry*. 2021;36(1):3-14. doi:10.1002/gps.5408
66. Peng H, Wen J, Chen M, et al. Preoperative analgesia efficacy of liposomal bupivacaine following pericapsular nerve group (PENG) block in patients with hip fracture: a randomized controlled observer-blinded study. *Pain Ther*. 2024;14(1):283-96. doi:10.1007/s40122-024-00683-6