

# Pericapsular Nerve Group Block in Combination with Lateral Femoral Cutaneous Nerve and Sacral Plexus Blocks for Hip Fracture: A Case Series

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**Background:** Regional anesthetic techniques for hip fracture are critical for pain control, reducing perioperative adverse events, and minimizing postoperative opioid use. This case series investigates the use of a novel triple-block protocol—ultrasound-guided pericapsular nerve group (PENG) block, lateral femoral cutaneous nerve (LFCN) and sacral plexus blocks—in patients with hip fractures, focusing on its feasibility as an anesthetic strategy for high-risk hip fracture patients.

**Case Presentation:** Five frail elderly patients with significant comorbidities and contraindications to neuraxial anesthesia underwent bipolar femoral head replacement surgery. Primary outcomes included anesthesia quality (0-3 scale: poor, acceptable, good, excellent) and postoperative analgesia. Secondary outcomes encompassed surgical conditions, complications, and patient satisfaction.

**Results:** These combined blocks provided effective analgesia (Visual Analog Scale, [VAS] scores of 0-1 at PACU discharge) and preserved quadriceps motor function (Medical Research Council [MRC] scale 4-5). Surgical conditions were rated “excellent” in four cases and “acceptable” in one. Postoperative sufentanil consumption was low (36-83 µg via patient-controlled analgesia [PCA]). Complications included one case of surgical site dehiscence (requiring reoperation) and transient dizziness.

**Conclusion:** This triple-block technique offers comprehensive analgesia for high-risk hip fracture patients or those with contraindications to neuraxial anesthesia, enabling early mobilization and reducing opioid reliance. Larger randomized trials are warranted to confirm these findings.

**Keywords:** pericapsular nerve group block, lateral femoral cutaneous nerve block, sacral plexus block, hip fractures, geriatric anesthesia

## Introduction

With over 2 million hip fractures (HF) annually worldwide and 1-year mortality rates exceeding 20%,<sup>1</sup> optimizing perioperative anesthesia is critical for this vulnerable population. While regional anesthesia is recommended,<sup>2</sup> contemporary multimodal regimens demonstrate 23–35% failure rates in achieving adequate surgical anesthesia for hip fracture patients with the American Society of Anesthesiologists (ASA) physical status  $\geq$ III, particularly those requiring lateral positioning.<sup>3</sup> General anesthesia in geriatric patients is associated with risks such as postoperative delirium,<sup>3</sup> hemodynamic instability,<sup>4</sup> and prolonged recovery, while neuraxial anesthesia carries contraindications in anticoagulated patients due to the risk of spinal hematoma.<sup>5</sup> These risks are amplified in elderly patients, 30–40% of whom receive chronic anticoagulant therapy.<sup>6</sup> In recent years, peripheral nerve blocks have increasingly been used in HF surgeries as an important component of analgesia approach for frail elderly patients or those on anticoagulants.

Hip joint innervation is complex, involving not only the lumbar plexus but also the sciatic nerve and branches of the sacral plexus, including superior gluteal nerve, inferior gluteal nerve and an articular branch from the quadratus femoris nerve.<sup>7</sup> The pericapsular nerve group (PENG) block is a novel ultrasound-guided nerve block. Case reports and limited clinical studies have reported PENG block as being effective in managing acute fracture-related pain, neuraxial anesthesia positioning pain, and postoperative pain in hip fracture patients.<sup>8</sup> However, isolated PENG blocks may inadequately address lateral and posterior sensory pathways, limiting their utility in complex surgeries.<sup>9</sup>

Similarly, the lateral femoral cutaneous nerve (LFCN) block is an effective technique for providing pain relief in the hip and thigh region, often used in combination with other nerve blocks to ensure comprehensive pain management. The sacral plexus block is considered to provide additional analgesia by targeting the nerve roots innervating the posterior hip joint and surrounding muscles. This combined approach helps address pain via multiple pathways, improving overall pain control and reducing reliance on systemic analgesics.<sup>10</sup>

While PENG and LFCN blocks have been studied individually, their combination as a single anesthetic technique represents a novel approach. Recent studies highlight that combining anterior (PENG) and lateral (LFCN) blocks reduces opioid consumption compared to single block,<sup>11</sup> but posterior coverage remains inadequate. Our protocol addresses this gap by integrating sacral plexus blockade, which enhances posterior analgesia without motor impairment. This case series demonstrates that combining these three blocks provides more comprehensive analgesia targeting multiple pain pathways, including the anterior, lateral, and posterior aspects of the hip joint, particularly beneficial for high-risk elderly patients with contraindications to neuraxial anesthesia. The innovative aspect of this method lies in its ability to provide targeted and effective pain relief while minimizing the risks and systemic side effects associated with general or neuraxial anesthesia.

The objective of this case series was to evaluate the efficacy and safety of combining PENG, LFCN, and sacral plexus blocks as the primary anesthetic technique for five high-risk elderly patients undergoing bipolar femoral head replacement surgeries.

## Case Presentation

### Patient Consent for Publication and Ethical Approval

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Ethical Committee of The Second People's Hospital of Dongying (approval number ID 202404223). Prior to the surgery, written informed consent for all procedures and publication of the data were obtained from all patients.

### Patient Characteristics

This case series included five elderly patients with poor general health status. Their demographic data, including age, gender, body mass index (BMI), ASA status, fracture type, comorbidities, significant test abnormalities, and preoperative use of anticoagulants or antiplatelet drugs, are shown in [Table 1](#).

### Anesthetic Technique

On the day of surgery, all patients received oral acetaminophen 1 g, celecoxib 400 mg and gabapentin 400 mg 1–2 hours before operation, and then were transferred to the operating room. 500 mL of Ringer's solution was infused, and oxygen was given 4 L/min via face mask. Pulse oximeter, non-invasive blood pressure (NIBP) and electrocardiogram (ECG) monitors were connected.

Prior to block placement, dexmedetomidine was titrated based on hemodynamic responses (targeting a Ramsay Sedation Scale [RSS] score of 2–3), with an initial infusion of 0.4–0.6 µg/kg over 15 minutes, followed by a maintenance rate of 0.2–0.5 µg·kg<sup>-1</sup>·h<sup>-1</sup>. Intravenous sufentanil 0.1 µg/kg (Yichang Humanwell Pharmaceutical Co., China) was administered as rescue analgesia. All ultrasound-guided nerve blocks were performed using a Huason Clover 60 Color Doppler Ultrasound System (Huason Medical, Shenzhen, China) with a high-frequency linear probe (5–12 MHz) and a low-frequency convex probe (2–5 MHz).

**Table 1** Patient Demographics, Block Parameters, and Outcomes

	Case One	Case Two	Case Three	Case Four	Case Five
Age(years)	88	94	78	83	66
Sex	Male	Male	Male	Female	Female
BMI (kg/m <sup>2</sup> )	22	28	27	25	29
ASA status	IV	III	III	III	III
Fracture type	Left FNF	Right FNF	Left FNF 3 months Left hip mass	Left FNF	Left FNF
Comorbidities	COPD(pulmonary arterial hypertension 61 mmHg) Emphysema and bullae in both lungs Cerebral infarction Hearing loss Complete right bundle branch block Anticoagulation with low-molecular-weight heparin 5000 U 6h before surgery	Alzheimer's disease and memory loss Surgery for lumbar spine compression fracture 6 years	Alzheimer's disease Ankylosing spondylitis, more than 10 years Mild bronchiectasis in the upper lobes of both lungs, emphysema and bullae in both lungs esophageal hiatal hernia	Hypertension Coronary heart disease Old bilateral multiple rib fractures with Malunion Old T8 and L1/L2 compression fractures	Hypertension Type 2 diabetes mellitus CK-MB 19.01 ng/mL BG:15.19mmol/L HbA1c:11.3% Neuraxial anesthesia failed
Surgery type	Left BFHR	Right BFHR	Left BFHR	Left BFHR Left hip mass resection	Left BFHR
Blockerformance Time(minutes)	17	18	19	17	18
Block coverage	L1-S3	T12-S3	T12-S2	L1-S3	L1-S3
VAS (rest/dynamic)					
Baseline	7/10	8/10	9/10	6/9	9/10
30min	0/0	0/0	0/0	0/0	0/0
PACU discharge	0/0	0/0	0/0	0/0	0/1
6h	0/0	0/0	0/1	0/2	1/2
24h	2/4	2/3	2/3	2/4	2/4
48h	1/2	1/2	2/3	1/2	2/3
Anesthesia quality	3	3	2	3	2
Surgery duration (minutes)	60	57	63	115	79
Blood loss(mL)	200	200	100	200	300
Opioid consumption	45 µg sufentanil with PCA	36 µg sufentanil with PCA	72 µg sufentanil with PCA	62µg sufentanil with PCA	83 µg sufentanil with PCA
Hospital stay (days)	17	14	11	26	23
Max Dexmedetomidine Dose (µg kg <sup>-1</sup> h <sup>-1</sup> )	0.5	0.4	0.5	0.3	0.5
Muscle Relaxation Rating	5	5	4	5	4

**Abbreviations:** BMI, body mass index; ASA, American Society of Anesthesiologists; FNF, femur neck fracture; BFHR, bipolar femoral head replacement; VAS, visual analog scale; PACU, postanesthesia care unit; PCA, patient controlled analgesia; NT-proBNP, N-terminal pro-B-type natriuretic peptide; BG, blood glucose; HbA1c, glycated hemoglobin.

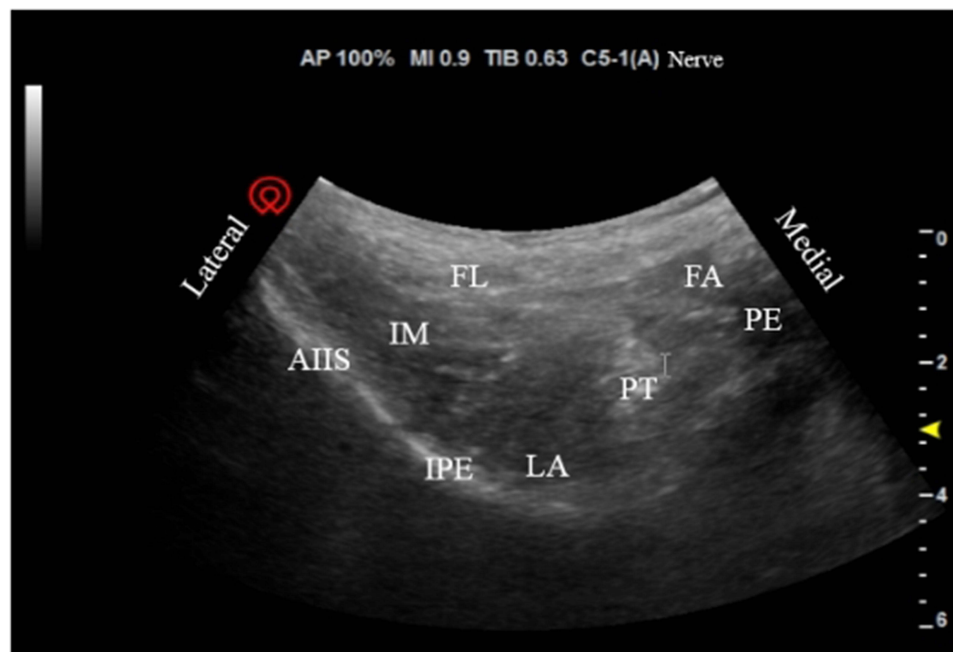
All peripheral nerve block procedures were performed by the first author, an anesthesiologist with expertise in regional anesthesia. The PENG block was performed as described by Andrade et al.<sup>9</sup> A low-frequency convex array probe (2–5 MHz) was used to acquire images from lateral to medial of the anterior inferior iliac spine, iliopubic eminence, psoas tendon, and femoral artery. After negative aspiration, 20 mL of 0.4% ropivacaine with 4 mg dexamethasone (except Case 5) was injected in 5 mL increments into the space between the psoas tendon and the iliopubic eminence following the principle of sterility and using an “in-plane” technique (Figure 1). The LFCN was then performed when the needle was withdrawn to the plane between sartorius muscle, tensor fasciae lata, covered by the fascia lata and injected 5 mL of 0.4% ropivacaine using a high-frequency linear array probe (5–12 MHz) (Figure 2).

Fifteen minutes after blockade placement, once movement-related pain was reduced, the patient was positioned in lateral decubitus with the surgical side up. The sacral plexus block was performed via the parasacral approach.<sup>12</sup> The same low-frequency convex array probe was used to identify the greater sciatic foramen, piriformis muscle and sacral plexus. In the deep of the piriformis, the sacral plexus was identified as a hyperechoic structure. When the needle tip reached the sacral plexus, 20 mL of 0.4% ropivacaine with 4 mg dexamethasone (except Case 5) was injected (Figure 3). Block performance time, from probe-skin contact to end of injection was recorded (Table 1).

## Outcome Measurement

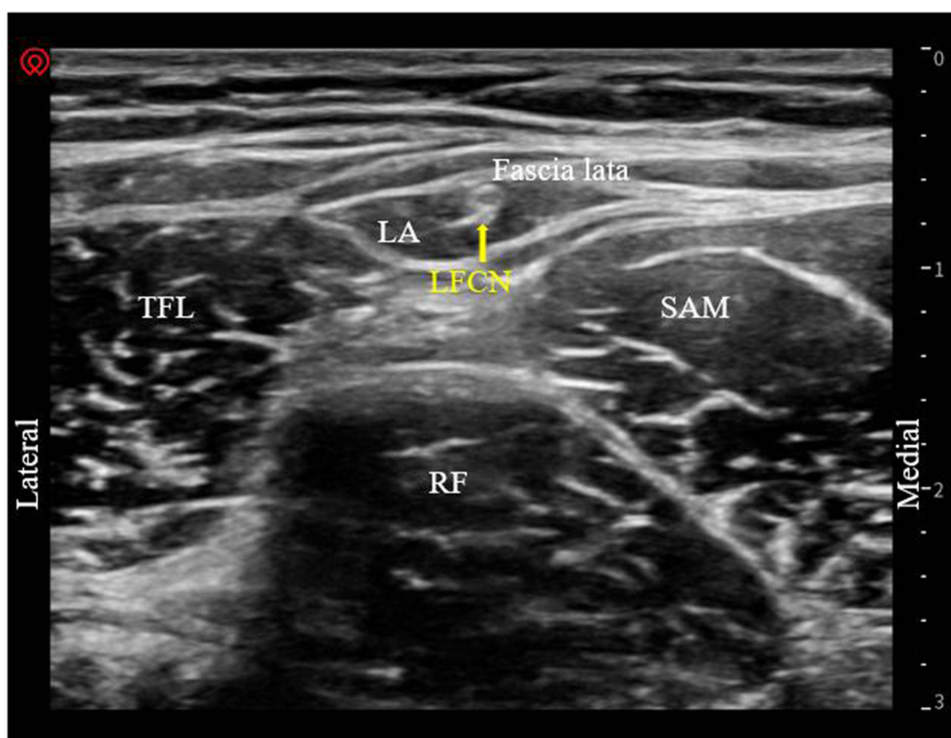
Pain intensity was assessed using Visual Analog Scale (VAS, 0–10) at rest and during movement by the attending anesthesiologist and a trained research nurse at the following time points: preoperatively, within 30 minutes post-block, in the post-anesthesia care unit (PACU) and at 6, 18, 24 and 48 hours postoperatively (Table 1). Pain management was adjusted to maintain comfort and minimize systemic analgesics.

The primary outcome measurement was anesthesia quality, assessed by the performing anesthesiologist on a 0–3 scale (“poor”, “acceptable”, “good” or “excellent”). Anesthetic efficacy was defined as: (1) complete abolition of pain perception in the target area (VAS=0) or significant pain reduction (VAS≤2); (2) no requirement for supplemental opioids beyond the predefined protocol; (3) surgeon satisfaction score  $\geq 2$ . Quadriceps motor function was assessed using



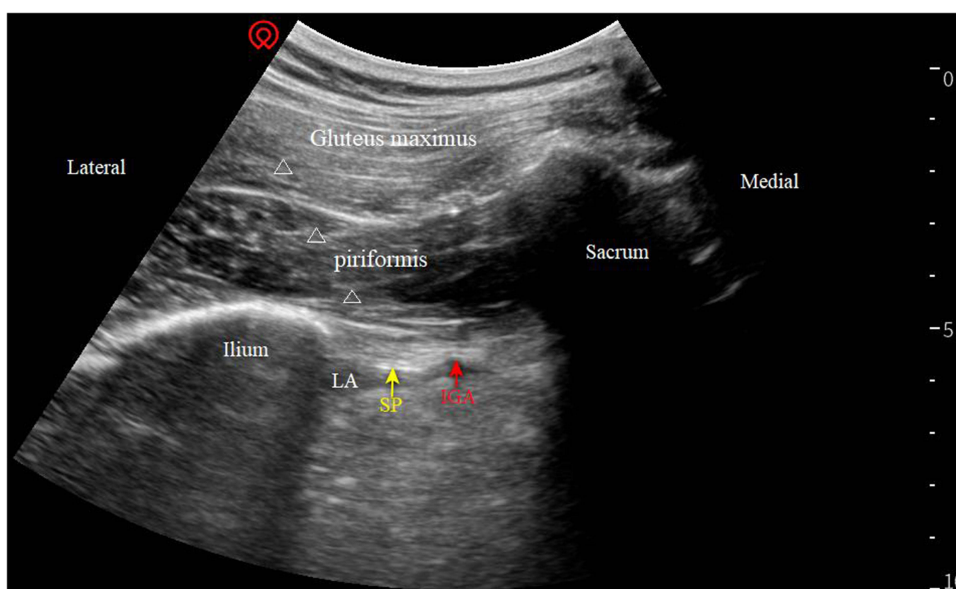
**Figure 1** The post-injection sonogram of the PENG block with a low-frequency curvilinear probe.

**Abbreviations:** AIIS, anterior inferior iliac spine; IPE, iliopubic eminence; PT, psoas tendon; IM, iliacus muscle; FL, fascia iliaca; FA, femoral artery; PE, pectineal muscle; LA, local anesthetic.



**Figure 2** The post-injection sonogram of the LFCN block when the PENG block completed and the needle withdrawn to the plane between sartorius muscle, tensor fascia lata, covered by the fascia lata using a high-frequency linear probe.

**Abbreviations:** TFL, tensor fascia lata muscle; SAM, sartorius muscle; RF, rectus femoris; LA, local anesthetic; LFCN, lateral femoral cutaneous nerve.



**Figure 3** The post-injection sonogram of the sacral plexus block with parasacral approach using a low-frequency curvilinear probe.

**Abbreviations:** LA, local anesthetic; SP, sciatic plexus; IGA, inferior gluteal artery; Gmax, gluteus maximus; Gmed, gluteus medius; Gmin, gluteus minimus; Triangle, needle.

the Medical Research Council (MRC) scale (0–5) 30 minutes post-block. Surgical conditions (e.g., muscle relaxation, patient positioning stability) were rated by the surgeon on a 0–3 scale as “poor”, “acceptable”, “good” or “excellent”.

The secondary outcomes included VAS scores at rest and during movement at predefined time points, patient satisfaction, intraoperative rescue analgesia use, postoperative sufentanil consumption, quadriceps motor block rate,

block-related complications and postoperative adverse effects (e.g., nausea, vomiting, hematoma, puncture site infection, postoperative delirium).

The postoperative analgesic regimen included acetaminophen 1 g p.o. every 8 hours, and celecoxib 200 mg p.o. every 12 hours. After block fade, patients received patient-controlled analgesia (PCA) with sufentanil (0.1 µg/kg, 10-minute lockout) for 48 hours (Table 1).

All patients had the same discharge criteria: no fever, resumed a normal diet, and well-healed incisions.

## Results

Sensory blockade levels, assessed via pinprick testing within 30 minutes post-block, spanned from L1 to S3 in Case 1, Case 4 and Case 5, from T12 to S3 in Case 2, and from T12 to S2 in Case 3. This demonstrated anatomical variability in sacral plexus innervation, with no block-related complications occurred (Table 1).

All patients achieved complete motor blockade (MRC 0–1) in the operative limb, and surgeons rated surgical conditions as “excellent” in four cases and “acceptable” in Case 5 due to intraoperative discomfort. Quadriceps motor function was preserved (MRC 4–5) in all patients, confirming minimal motor blockade. Surgeons rated intraoperative muscle relaxation as “excellent” (n=3) or “good” (n=2), facilitating stable positioning and surgical manipulation.

Surgeries were performed via a lateral-posterior approach with the patient in lateral decubitus position. Except for Case 5 who felt pain and discomfort at the upper part of the incision and was treated with 0.5 mg/kg of esketamine, the other patients did not complain of pain and only used dexmedetomidine 0.2–0.5 µg·kg<sup>-1</sup>·h<sup>-1</sup> for sedation, with no need for additional opioids or incision infiltration (Table 1).

Dexmedetomidine infusion rates were titrated intraoperatively based on hemodynamic stability and RSS scores, targeting light to moderate sedation (RSS 2–3). The maximal infusion dose for each patient was as follows: Case 1 (0.5 µg·kg<sup>-1</sup>·h<sup>-1</sup>), Case 2 (0.4 µg·kg<sup>-1</sup>·h<sup>-1</sup>), Case 3 (0.5 µg·kg<sup>-1</sup>·h<sup>-1</sup>), Case 4 (0.3 µg·kg<sup>-1</sup>·h<sup>-1</sup>), and Case 5 (0.5 µg·kg<sup>-1</sup>·h<sup>-1</sup>). All patients maintained spontaneous ventilation and responded appropriately to verbal commands during surgery, with no episodes of oversedation (RSS > 4) or respiratory depression. Anesthesia quality was rated as shown in Table 1.

Surgery duration was 57–115 minutes with blood loss of 100–300 mL (Table 1) and their vital signs were stable during the operation. In the PACU, all patients were comfortable with VAS scores of 0–1.

Postoperative complications included one case (20%) of surgical site dehiscence requiring reoperation on postoperative day 15 (Case 4) and one case (20%) of transient dizziness (Case 5). Mild postoperative pain was effectively managed with the prescribed analgesic regimen (Table 1). All patients showed satisfactory recovery without requiring additional interventions. Their length of hospital stay is summarized in Table 1.

## Discussion

Hip joint sensory innervation is complex and arises from multiple sources. The nerves innervating the hip joints derive from the ventral rami of the spinal nerve roots of the lower part of the lumbar plexus (L2–4) and the upper part of the sacral plexus (L4–S1).<sup>13</sup> Ultrasound-guided lumbar and sacral plexus blocks have been widely used in hip fracture surgeries recently, especially for those high-risk patients with cardiopulmonary dysfunction.<sup>14,15</sup> However, they require patients to be in lateral decubitus position, which may cause severe pain, discomfort, or complications in HF patients.

The PENG block targets articular branches of the femoral, obturator, and accessory obturator nerves, which play a major role in hip capsule innervation.<sup>8,10</sup> Compared with traditional posterior lumbar plexus block, ultrasound-guided PENG block offers advantages such as easy of performance, rapid onset, distance from key anatomical sites and retaining motor function. Moreover, it can be performed in the patient’s supine position, which facilitates the pain relief during the subsequent sacral plexus block in lateral decubitus position. So, it could be a reasonable alternative to posterior lumbar plexus block.

Compared with fascia iliaca compartment block, PENG block also offers benefits, such as lacking motor blockade, long-lasting analgesia, and requiring lower volumes of local anesthetic. When combined with LFCN and sacral plexus blocks, it can block nearly all sensory nerves innervating the hip, effectively meeting the anesthetic demands of hip fracture surgery. The LFCN block can be easily visualized and performed by inserting the needle into the space between

the fascia lata and iliac fascia without changing the needle position after completing the PENG block, thus enhancing procedural efficiency via a single injection.<sup>16</sup>

Our triple-block approach offers several clinical advantages: effective analgesia, minimal cardiovascular adverse effects, high patient satisfaction, and no major complications. By sparing pelvic or abdominal visceral nerves, the incidence of urinary retention is low, and postoperative fasting is not required. Furthermore, this combined technique offers adequate postoperative analgesia and preserves motor function, allowing for early exercise and rehabilitation, which contributes to accelerating recovery and reducing postoperative deep vein thrombosis (DVT) and pressure ulcers. Additionally, effective postoperative analgesia reduces opioid consumption, potentially lowering the risk of opioid-associated delirium.

The inclusion of the sacral plexus block in our combined approach provides significant benefits by addressing pain from the posterior hip joint, which has not been extensively studied in previous reports combining PENG and LFCN blocks alone. Our results suggest this combination provides more comprehensive pain management strategy, improving overall outcomes for high-risk patients. This novel approach could serve as an effective alternative to traditional anesthesia techniques and warrants further validation through larger studies and randomized controlled trials (RCTs).

There are some limitations to this protocol. Firstly, there is no prospective randomized controlled study to provide sufficient evidence. Secondly, since it cannot provide adequate muscle relaxation, its use in robust young patients needs further study. Thirdly, whether these anticoagulant patients can undergo PENG block or sacral plexus block may be controversial. Finally, due to the complexity and time involved in performing the blocks, we do not recommend it for routine use in hip surgery when neuraxial anesthesia is not contraindicated. In view of this, observational and experimental studies are needed to assess the efficacy and safety of this protocol. Future studies, particularly RCTs, are needed to better assess the efficacy, safety, and outcomes of this novel anesthesia technique in a broader patient population. The inclusion of a control group would help determine whether this combined approach offers superior pain relief, lower complication rates, and better overall outcomes compared to standard anesthesia methods.

## Conclusions

In this case series, combined PENG, LFCN, and sacral plexus blocks effectively targeted sensory innervation of the hip joint. When supplemented with dexmedetomidine sedation, this technique provided high-quality anesthesia, sustained analgesia, and excellent patient satisfaction without major complications. These findings suggest that it is a viable alternative for hip fracture surgeries in high-risk patients with contraindications to neuraxial anesthesia. Further RCTs are warranted to validate these results.

## Ethics Approval and Consent to Participate

Ethical approval for this report was provided by the Ethical Committee of The Second People's Hospital of Dongying (approval number ID 202404223). Prior to the surgery, written informed consent for all procedures and publication of the data were obtained from all patients.

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## Disclosure

The authors report no conflicts of interest in this work.

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