Comparative efficacy of pericapsular nerve group block *versus* fascia iliaca block in postoperative analgesia for total hip arthroplasty: a retrospective observational study

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Abstract

Effective postoperative pain management is essential to optimize outcomes in total hip arthroplasty (THA). While the fascia iliaca (FI) block has been commonly used, the pericapsular nerve group (PENG) block has emerged as a potentially more targeted alternative. This study aimed to compare the analgesic efficacy and safety of the PENG block *versus* the FI block in patients undergoing elective THA.

In this retrospective observational study, 30 patients scheduled for primary elective THA were divided into two groups: one receiving an FI block (40 mL of 0.25% ropivacaine + 4 mg dexamethasone) and the other a PENG block (20 mL of 0.25% ropivacaine + 4 mg dexamethasone), both performed under ultrasound guidance. Pain scores were assessed using the Numeric Rating Scale (NRS) at 0, 6, 12, 18, and 24 hours postoperatively. Additional outcomes included opioid consumption, time to ambulation, and adverse events.

The PENG group reported significantly lower NRS scores at all time points ($p<0.05$), with the most pronounced difference observed immediately postoperatively and at 24 hours. Time to ambulation was significantly shorter in the PENG group (9.2±2.1 hours *vs.* 11.6±2.8 hours; $p=0.01$). Opioid consumption and incidence of adverse events were similar between groups.

The PENG block provided superior early postoperative analgesia and facilitated earlier mobilization compared to the FI block in patients undergoing elective THA, without increasing opioid use or complications. These findings support its integration into multimodal analgesic protocols for hip surgery.

Introduction

Total hip arthroplasty (THA) represents one of the most effective surgical interventions for relieving chronic hip pain and improving mobility in patients with end-stage osteoarthritis and other degenerative conditions.[1] As global life expectancy increases and population aging accelerates, the volume of THA procedures is expected to rise accordingly. Optimal postoperative pain management is pivotal in facilitating early mobilization, reducing complications, and shortening hospital stays.[2] Effective pain con-

trol after THA is essential to enable early mobilization and improve patient satisfaction. However, due to the complex innervation of the hip joint, the ideal regional anesthesia technique for THA is still debated.[3,4]

The supra-inguinal fascia iliaca (SIFI) block is a modified version of the classic fascia iliaca (FI) block that allows for a more cranial spread of local anesthetic beneath the fascia iliaca, potentially improving its distribution.[5] This technique has been a mainstay in perioperative analgesia for lower limb surgeries; however, limitations in its ability to reliably anesthetize all the nerves supplying the hip joint have prompted the exploration of newer approaches.[6] Based on these findings, Girón-Arango *et al.* described the pericapsular nerve group (PENG) block, which aims to selectively anesthetize the articular branches of the femoral, accessory obturator, and obturator nerves.[7] The difference in required volumes between the supra-inguinal FI block and PENG block is primarily due to the anatomical spread needed to reach their respective target nerves. The supra-inguinal FI block aims to anesthetize multiple nerves of the lumbar plexus, including the femoral nerve, lateral femoral cutaneous nerve, and obturator nerve. These nerves are located within the fascia iliaca compartment, a potential space that extends cranially towards the lumbar plexus. To ensure adequate spread of the local anesthetic to reach all these nerves, a larger volume – typically around 30-40 mL – is necessary.[5,6] In contrast, the PENG block targets specific articular branches near the hip joint in a more confined anatomical space. Therefore, a smaller volume of local anesthetic – usually about 20 mL – is sufficient for effective analgesia.[7] This study was designed to compare the efficacy and safety of these two techniques in patients undergoing elective THA.

Materials and Methods

Study design and ethical considerations

This retrospective comparative observational study was conducted at the Department of Neuroscience, Reproductive and Odontostomatological Sciences of the "Federico II" University of Naples. The study period extended from May 2023 to February 2024. Federico II University's ethics committee did not consider approval necessary for this type of study, and all procedures adhered to the ethical principles outlined in the Declaration of Helsinki. Despite the retrospective nature of the study, written informed consent for the use of anonymized clinical data was obtained from all patients at the time of hospitalization. Subsequently, data on patients undergoing THA, recorded as part of daily clinical practice, were obtained from the department's archive, anonymized, and stored in a password-protected computerized database using Microsoft Office Excel 2007 (Microsoft, Redmond, WA, USA). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement was followed.

Inclusion and exclusion criteria

The inclusion criteria comprise individuals aged 60 years or older, diagnosed with end-stage osteoarthritis or degenerative hip disease, classified as ASA (American Society of Anesthesiologists) physical status II or III, scheduled for elective primary total hip arthroplasty under spinal anesthesia, and the availability of complete medical records along with follow-up pain assessments for the initial 24 hours postoperatively.

Exclusion criteria include allergy to local anesthetics or dexamethasone, coagulopathy or ongoing anticoagulant therapy, cognitive impairment precluding reliable pain scoring, chronic opioid use or history of substance abuse, prior surgery or anatomical abnormalities of the hip, and neuropathic disease of the affected limb.

Study population

Based on the application of the aforementioned criteria, 13 out of 43 patients were excluded due to neuraxial anesthesia contraindications, receiving different surgical hip procedures, or having incomplete clinical data in medical records. As a result, 30 patients were deemed eligible for inclusion in the study (Figure 1).

Anesthesiologic management

Patient preparation

In the block room, venous access was established using an 18-16 G catheter. Intravenous pantoprazole (40 mg) and antibiotic prophylaxis (cefazolin 1 or 2 g IV, or clindamycin 600 mg IV in case of allergy) were administered 30 minutes prior to skin incision. Patients were continuously monitored with electrocardiography (ECG), pulse oximetry (SpO_2), body temperature (TC), and non-invasive blood pressure (NIBP) measurements. The risk factors for postoperative nausea and vomiting (PONV) were analyzed using an Apfel score for each patient. Intraoperative and postoperative antiemetic treatments were administered according to the 2020 Fourth Consensus Guidelines for the Management of Postoperative Nausea and Vomiting.[8]

Preoperative: anesthesiologic technique and block procedures

All nerve blocks were performed under strict aseptic conditions by two experienced anesthesiologists (each with over 5 years of experience in ultrasound-guided regional anesthesia). The choice of block technique was based on the anesthesiologist's preference and experience, consistent with standard institutional practices.

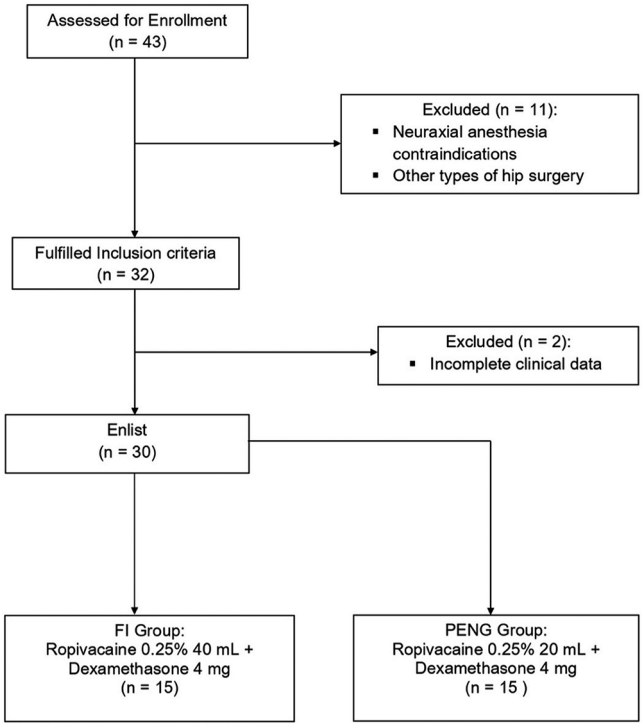

Figure 1. Flowchart of the study.

FI block (caudo-cranial supra-inguinal approach)

The patient was placed in a supine position. Using a high-frequency linear ultrasound probe, the anterior superior iliac spine (ASIS) was identified, and the probe was placed in a transverse orientation just cranial to the inguinal ligament, over the internal oblique and sartorius muscles. The transducer was then rotated to obtain a parasagittal (longitudinal) view of the iliacus muscle and the fascia iliaca. A 100 mm needle was inserted in-plane with a caudal-to-cranial approach, from just below the inguinal ligament toward the iliac fossa. Under ultrasound guidance, the needle tip was advanced deep to the fascia iliaca but superficial to the iliacus muscle. After negative aspiration, 40 mL of ropivacaine 0.25% with 4 mg dexamethasone was slowly injected, confirming spread cranially under the fascia iliaca (Figure 2).

PENG block

With the patient positioned supine, the inguinal region was exposed and prepped in a sterile manner. A curvilinear ultrasound probe is initially placed in a transverse orientation over the anterior inferior iliac spine (AIIS) and then moved medially to identify the iliopubic eminence (IPE), the psoas tendon, and the femoral artery. The probe was then rotated slightly to obtain an oblique sagittal view that clearly visualized the IPE, the overlying psoas tendon, and the iliopsoas muscle. Under continuous ultrasound guidance, a 100 mm needle was inserted in-plane from lateral to medial, toward the IPE, between the psoas tendon and the pubic ramus. After negative aspiration, a small volume (1-2 mL) of saline was injected to confirm the correct needle tip placement. This was followed by the administration of 20 mL of ropivacaine 0.25 with 4 mg of dexamethasone, observing its spread on the fascial plane, which raised the psoas tendon (Figure 3).

Block success was confirmed by loss of sensation in the affected limb, tested by pinprick and ice test, through the Hollmen scale.

In the operating room, after performing sedation with midazolam 0.025 mg/kg, all patients, positioned in sitting decubitus, received spinal anesthesia using hyperbaric bupivacaine 12.5 mg.

Intraoperative

All patients received oxygen therapy through a nasal cannula at a flow rate of 2 L/min. Additionally, intravenous crystalloid fluids were administered intraoperatively at a rate of 15-20 mL/kg/h. Throughout the procedure, vital signs were continuously monitored. Intraoperative hemodynamic complications were recorded. They were defined as hypotension, which was identified by a systolic blood pressure (SBP) of less than 90 mm Hg for more than five minutes or a reduction of more than 35% in the mean arterial pressure (MAP), and/or bradycardia, defined by a heart rate (HR) of fewer than 60 beats per minute for more than five minutes.

Postoperative

In the postoperative period, patients were monitored in the post-anesthesia care unit (PACU) for an average of 45 minutes before being transferred to the ward. After surgery, we administered 1 g of intravenous paracetamol three times a day. Rescue analgesia consisted of IV morphine 2-5 mg in case NRS was ≥4.

Data extraction

The following data were obtained from medical records: demographics (age, sex, body mass index [BMI], comorbidities); surgical data (duration of surgery); block-related variables (time to perform block, number of needle passes, and complications such as hematomas, infections, and local anesthetic systemic toxicity); postoperative functional assessment (time to first ambulation); adverse events (nausea, vomiting, urinary retention, falls, or hemodynamic instability); and total opioid consumption within 24 hours and postoperative pain. Postoperative pain was assessed using the NRS (0 = no pain, 10 = worst imaginable pain) at five predefined time points: immediately after surgery (0 hours) and 6, 12, 18, and 24 hours postoperatively. Total opioid consumption within the first 24 hours was recorded in morphine milligram equivalents (MME).

Statistical analysis

Data were analyzed using SPSS v27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as means ± standard deviation (SD) for continuous variables and as frequencies or percentages for categorical variables.

Comparisons between groups were conducted using independent t-tests for continuous variables (*e.g.*, NRS scores, opioid consumption) and chi-square or Fisher's exact test for categorical data (*e.g.*, side effects). A p-value <0.05 was considered statistically significant.

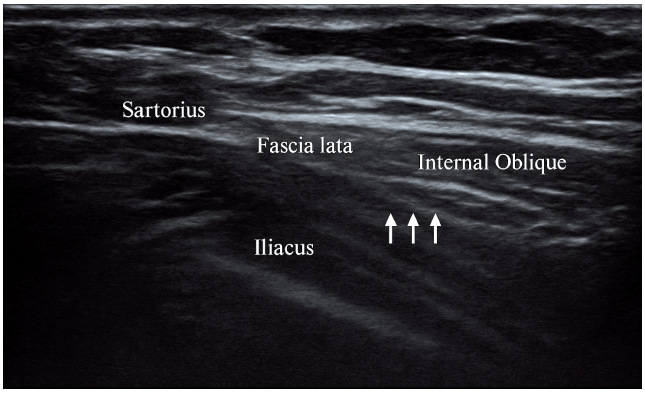

Figure 2. Supra-inguinal FI block. White arrows indicate the fascia iliaca.

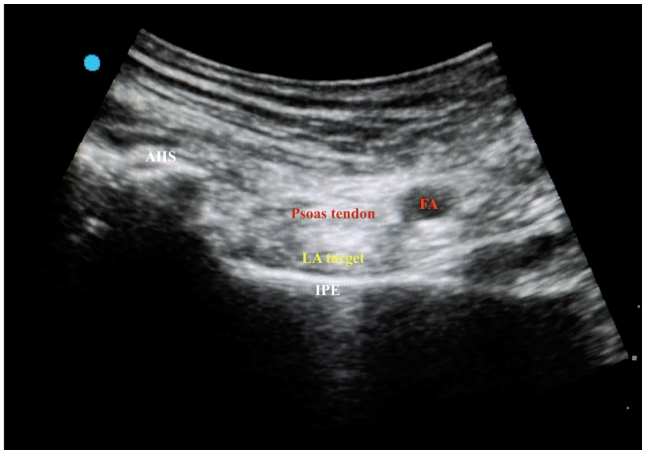

Figure 3. PENG block. AIIS, anterior inferior iliac spine; LA target, target to inject local anesthetic; IPE, iliopubic eminence; FA, femoral artery.

Sample size was limited by the retrospective nature of the study. No formal power calculation was performed, but the data provide a useful exploratory insight into real-world analgesic outcomes for these two regional techniques.

Results

Patient demographics and surgical characteristics

Baseline characteristics between groups were comparable in terms of age, sex, BMI, ASA physical status, and comorbidity profiles (Table 1). The mean age was 69.4±7.1 years in the FI group and 68.7±6.9 years in the PENG group (p=0.72). BMI was slightly higher in the FI group (28.3±3.2) compared to the PENG group (27.1±2.9), but the difference was not statistically significant (p=0.21). Surgical duration averaged 92±15 minutes in the FI group and 89±14 minutes in the PENG group (p=0.48).

Pain scores and analgesic efficacy

Postoperative pain intensity, assessed *via* NRS, was consistently lower in the PENG group at all time points (Table 2):

- Immediate postoperative period (0 hours): mean NRS score was 3.5±1.0 in the FI group *vs.* 2.1±0.9 in the PENG group (p=0.003).
- 6 hours postoperatively: 3.2±0.8 (FI) *vs.* 1.9±0.7 (PENG), p=0.002.
- 12 hours postoperatively: 2.9±0.7 (FI) *vs.* 1.5±0.6 (PENG), p=0.001.
- 18 hours postoperatively: 2.6±0.9 (FI) *vs.* 1.3±0.5 (PENG), p=0.001.
- 24 hours postoperatively: 2.8±0.8 (FI) *vs.* 1.2±0.4 (PENG), p<0.001.

The differences remained statistically significant across all time points, with the largest reduction observed during the immediate and 24-hour marks.

Adverse events

Minor adverse events were similar across both groups (Table 3). Nausea and vomiting occurred in 2 patients in the FI group and in 1 patient in the PENG group (p=0.54). Urinary retention was reported in 1 patient in each group. One case of hypotension was observed in the FI group, while no cases were reported in the PENG group (p=0.31). No falls or neurological complications were reported in either group.

Table 1. Baseline demographic and surgical characteristics.

Variable	FI group (n=15)	PENG group (n=15)	p-value
Age (years)	69.4±7.1	68.7±6.9	0.72
Sex (M/F)	8/7	7/8	0.72
BMI (kg/m²)	28.3±3.2	27.1±2.9	0.21
ASA status (II/III)	10/5	9/6	0.71
Surgery duration (min)	92±15	89±14	0.48
Comorbidities (%)			
Hypertension	60%	53%	0.72
Diabetes mellitus	27%	20%	0.63
Cardiovascular disease	33%	27%	0.71

BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 2. Postoperative pain scores (NRS 0-10).

Time point (hrs)	FI group	PENG group	p-value
0 (immediate post-op)	3.5±1.0	2.1±0.9	0.003
6	3.2±0.8	1.9±0.7	0.002
12	2.9±0.7	1.5±0.6	0.001
18	2.6±0.9	1.3±0.5	0.001
24	2.8±0.8	1.2±0.4	<0.001

NRS, Numeric Rating Scale.

Table 3. Incidence of adverse events and block-related complications.

Adverse event	FI group (n=15)	PENG group (n=15)	p-value
Nausea/vomiting	2 (13%)	1 (7%)	0.54
Urinary retention	1 (7%)	1 (7%)	1.00
Hypotension	1 (7%)	0	0.31
Falls	0	0	–
LAST	0	0	–
Infection at Block Site	0	0	–

LAST, local anesthetic systemic toxicity.

Opioid consumption and time to first ambulation

Despite differences in NRS scores, cumulative opioid consumption within the first 24 hours was similar between the two groups (Table 4). The FI group received 7.4±2.3 mg morphine equivalents, while the PENG group received 6.8±2.0 mg (p=0.39).

This suggests improved subjective pain control in the PENG group without a corresponding increase or decrease in rescue opioid use.

Patients in the PENG group ambulated earlier postoperatively compared to the FI group (Table 4). The mean time to ambulation was 9.2±2.1 hours in the PENG group and 11.6±2.8 hours in the FI group (p=0.01).

Block procedure metrics

Both techniques demonstrated similar ease of execution and safety, with no block-related complications (Table 5). The average time to perform the FI block was 6.2±1.4 minutes, compared to 7.1±1.7 minutes for the PENG block (p=0.12). The number of needle passes was comparable, with a mean of 1.3±0.6 in the FI group *vs.* 1.4±0.5 in the PENG group (p=0.65).

No instances of vascular puncture, local anesthetic systemic toxicity (LAST), or infection were recorded.

Discussion

Our results demonstrated significantly lower NRS scores in the PENG group at all postoperative time points, with statistically and clinically meaningful reductions in pain within the first 24 hours.

However, total opioid consumption did not differ significantly between groups. Both nerve block techniques were associated with low complication rates. Finally, no serious adverse events occurred, and no significant block-related complications were reported in either group, affirming the safety of both techniques when performed by experienced practitioners under ultrasound guidance.

The analgesic advantage observed with the PENG block is likely due to its anatomical precision in targeting the articular branches of the femoral, obturator, and accessory obturator nerves – key contributors to anterior hip capsule innervation. In contrast, the FI block, although widely used, does not consistently anesthetize all relevant neural structures, particularly the obturator nerve, resulting in variable efficacy across patients.[9] These observations are consistent with the findings of Iacovazzo *et al.* and Vermeylen *et al.*, who also reported better analgesic profiles and reduced NRS scores following PENG blocks in hip fracture and THA settings.[5,10]

In a randomized clinical trial comparing PENG and SIFI blocks for total hip arthroplasty, both techniques demonstrated similar analgesic efficacy, with no significant differences in postoperative pain scores or opioid consumption. However, the study noted that the PENG block might offer advantages in terms of preserving quadriceps muscle strength and facilitating early mobilization.[11] These results align with ours; in fact, the qualitative benefit in pain relief likely contributed to earlier mobilization in the PENG group – a key milestone in enhanced recovery protocols. In agreement with the Enhanced Recovery After Surgery (ERAS) protocols for THA, early ambulation is a crucial goal to minimize risks such as thromboembolic events and functional decline, particularly in older adults.[12] The use of muscle-sparing locoregional strategies has also been proposed for TKA, such as adductor canal block, which has been integrated into the procedure-specific postoperative pain management (PROSPECT) protocols for all purposes.[13-15] Contrary to our findings and those of previous studies, a randomized clinical trial by Yong Seon Choi and colleagues did not observe any significant difference in quadriceps strength between the two groups.[16] Aliste *et al.* recently reported that the PENG block was associated with a lower incidence of quadriceps motor block at 3 and 6 hours after THA compared to the supra-inguinal FI block.[11] The studies by Desmet *et al.* and Gasanova *et al.* reported a higher incidence of quadriceps motor block following supra-inguinal FI block, using 40 mL and 60 mL of 0.5% ropivacaine, respectively.[6,17] Although a direct comparison is not feasible, in our study, the supra-inguinal FI block performed with 40 mL of 0.25% ropivacaine did not result in a significantly longer time to ambulation compared to the PENG group. A possible explanation for this outcome could be the reduced concentration of local anesthetic, partly due to the use of adjuvants.[18] Moreover, motor function can also be influenced by postoperative pain and surgical factors, such as transient traction injuries or tissue disruption. Therefore, pain and surgical insult may act as confounding variables that reduce observable differences between groups.[16] Further in-depth studies that take both pain and surgical factors into account are needed to better evaluate the effect of PENG block on motor function and recovery. Recent recommendations for multimodal analgesia for THA have included regional analgesic techniques, such as single-shot FI block.[19] These techniques are particularly recommended for patients who have contraindications to standard analgesics or are expected to experience significant postoperative pain. In addition, newer fascial plane blocks have been proposed for this type of surgery, such as the ultrasound-guided erector spinae plane block.[20] This block leverages the spread of local anesthetic toward the paravertebral and partially the epidural space. It has shown promise in

Table 4. Opioid consumption and functional recovery within the first 24 hours.

Outcome	FI group	PENG group	p-value
24h opioid use (mg MME)	7.4±2.3	6.8±2.0	0.39
Time to first ambulation (hrs)	11.6±2.8	9.2±2.1	0.01

Mg MME, morphine milligram equivalents.

Table 5. Procedure-specific characteristics of FI and PENG blocks.

Parameter	FI group	PENG group	p-value
Time to perform (min)	6.2±1.4	7.1±1.7	0.12
Needle passes	1.3±0.6	1.4±0.5	0.65
Block-related complications	0	0	–

providing effective postoperative analgesia within a multimodal approach and in reducing postoperative opioid consumption.[21-23] An emerging technique, the FRONT block (femoral rami obturator nerve trunk), has recently been described as a dual-injection approach that provides comprehensive anesthetic coverage of the anterior hip joint by targeting both the sensory femoral rami and the obturator nerve trunk. Given its anatomical rationale and potential for effective analgesia, future comparative trials including the FRONT block could be of interest to further optimize perioperative pain management in hip surgery.[24] Despite the growing number of proposed techniques, further evidence is needed to identify regional anesthesia approaches that offer effective analgesia while supporting early postoperative mobilization, optimal functional recovery, and reduced postoperative morbidity within a multimodal analgesia regimen. The use of adjuvants in loco-regional anesthesia remains a widely discussed topic in current literature. Although the perineural administration of dexamethasone is considered off-label and has raised concerns about potential neurotoxicity and precipitation when combined with certain long-acting local anesthetics, no adverse effects were observed with the 4 mg dose used in the present study.[25-27] In a randomized controlled trial, Desmet *et al.* investigated interscalene nerve blocks for patients undergoing arthroscopic shoulder surgery, comparing three groups: ropivacaine 0.5% (30 mL) alone, ropivacaine 0.5% (30 mL) with 10 mg perineural dexamethasone, and ropivacaine 0.5% (30 mL) with 10 mg intravenous dexamethasone. The results showed that the addition of perineural dexamethasone approximately doubled the duration of analgesia compared to local anesthetic alone (12 hours *vs.* 24 hours). Moreover, the prolongation of analgesia was found to be comparable between the perineural and intravenous administration routes (24 hours *vs.* 21 hours, respectively).[28]

This study has several limitations. First, potential biases inherent to its retrospective design must be acknowledged. Second, the small sample size may have introduced a type II error, limiting the ability to detect significant differences between the two groups. This highlights the need for further studies involving larger patient cohorts to validate our findings. Third, patients were managed by different clinical teams during the intraoperative and postoperative periods, which may have introduced variability in care. Lastly, we recognize that certain variables, such as anxiety, were not assessed in this study, yet may have influenced patients' pain perception or contributed to postoperative symptoms such as nausea, vomiting, or shivering.

Conclusions

The PENG block provided superior early postoperative pain control and earlier ambulation compared to the FI block in patients undergoing elective THA. Both techniques were safe and well-tolerated, with no significant differences in opioid consumption or adverse events. These findings support the inclusion of the PENG block in multimodal analgesic protocols for hip surgery, particularly in enhanced recovery. Further studies are needed to clarify the postoperative clinical advantages associated with these two nerve blocks in patients undergoing THA.

References

1. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89:780-5.
2. Röstlund T, Kehlet H. High-dose local infiltration analgesia after hip and knee replacement: systematic review and meta-analysis. Br J Anaesth 2014;113:843-52.
3. Pepper AM, Mercuri JJ, Behery OA, Vigdorchik JM. Total Hip and Knee Arthroplasty Perioperative Pain Management: What Should Be in the Cocktail. JBJS Rev 2018;6:e5.
4. Bugada D, Bellini V, Lorini LF, Mariano ER. Update on Selective Regional Analgesia for Hip Surgery Patients. Anesthesiol Clin 2018;36:403-15.
5. Vermeylen K, Desmet M, Leunen I, et al. A prospective randomized double-blind comparison of the analgesic efficacy of the pericapsular nerve group (PENG) block versus the fascia iliaca block in hip fracture surgery. Reg Anesth Pain Med 2021;46:874-80.
6. Desmet M, Vermeylen K, Van Herreweghe I, et al. A Longitudinal Supra-Inguinal Fascia Iliaca Compartment Block Reduces Morphine Consumption After Total Hip Arthroplasty. Reg Anesth Pain Med 2017;42:327-33.
7. Girón-Arango L, Peng PWH, Chin KJ, et al. Pericapsular Nerve Group (PENG) Block for Hip Fracture. Reg Anesth Pain Med 2018;43:859-63.
8. Gan TJ, Belani KG, Bergese S, et al. Fourth Consensus Guidelines for the Management of Postoperative Nausea and Vomiting. Anesth Analg 2020;131:411-48. Erratum in: Anesth Analg 2020;131:e241.
9. Desai DJ, Shah N, Bumiya P. Combining Pericapsular Nerve Group (PENG) Block With the Supra-Inguinal Fascia Iliaca Block (SIFICB) for Perioperative Analgesia and Functional Recovery in Patients Undergoing Hip Surgeries: A Retrospective Case Series. Cureus 2023;15:e36374.
10. Iacovazzo C, Sara R, Buonanno P, et al. The Effects of the Pericapsular Nerve Group Block on Postoperative Pain in Patients with Hip Fracture: A Multicenter Study. Diagnostics (Basel) 202417;14:827.
11. 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;46:874-8.
12. Wainwright TW, Gill M, McDonald DA, et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Acta Orthop 2020;91:3-19.
13. Lavand'homme PM, Kehlet H, Rawal N, Joshi GP; PROSPECT Working Group of the European Society of Regional Anaesthesia and Pain Therapy (ESRA). Pain management after total knee arthroplasty: PROcedure SPEcific Postoperative Pain ManagemenT recommendations. Eur J Anaesthesiol 2022;39:743-57.
14. Coviello A, Bernasconi A, Balato G, et al. Positioning the Catheter Tip Anterior or Posterior to the Saphenous Nerve in Continuous Adductor Canal Block: A Mono-Centric Retrospective Comparative Study. Local Reg Anesth 2022;15:97-105.
15. Coviello A, Spasari E, Ianniello M, et al. Intra-procedural catheter displacement for continuous adductor canal block: Catheter-through-needle method vs catheter-through-split-cannula method. Perioper Care Oper Room Manag 2022;27:100255.
16. Choi YS, Park KK, Lee B, et al. Pericapsular Nerve Group (PENG) Block versus Supra-Inguinal Fascia Iliaca Compartment Block for Total Hip Arthroplasty: A Randomized Clinical Trial. J Pers Med 2022;12:408.
17. Gasanova I, Alexander JC, Estrera K, et al. Ultrasound-guided suprainguinal fascia iliaca compartment block versus periartic-

ular infiltration for pain management after total hip arthroplasty: a randomized controlled trial. Reg Anesth Pain Med 2019;44:206-11.
18. Coviello A, Iacovazzo C, Cirillo D, et al. Dexamethasone versus Dexmedetomidine as Adjuvants in Ultrasound Popliteal Sciatic Nerve Block for Hallux Valgus Surgery: A Mono-Centric Retrospective Comparative Study. Drug Des Devel Ther 2024;18:1231-45.
19. Anger M, Valovska T, Beloeil H, et al; PROSPECT Working Group* and the European Society of Regional Anaesthesia and Pain Therapy. PROSPECT guideline for total hip arthroplasty: a systematic review and procedure-specific postoperative pain management recommendations. Anaesthesia 2021;76:1082-97.
20. Townsend D, Siddique N, Kimura A, et al. Lumbar Erector Spinae Plane Block for Total Hip Arthroplasty Comparing 24-Hour Opioid Requirements: A Randomized Controlled Study. Anesthesiol Res Pract 2022;2022:9826638.
21. Santonastaso DP, de Chiara A, Righetti R, et al. Efficacy of bi-level erector spinae plane block versus bi-level thoracic paravertebral block for postoperative analgesia in modified radical mastectomy: a prospective randomized comparative study. BMC Anesthesiol 2023;23:209.
22. Santonastaso DP, de Chiara A, Addis A, et al. Ultrasound guided erector spinae plane block for post-operative pain control after caesarean section. J Clin Anesth 2019;58:45-6.
23. Coviello A, Esposito D, Galletta R, et al. Opioid-free anesthesia—dexmedetomidine as adjuvant in erector spinae plane block: a case series, J Med Case Rep 2021;15:276.
24. Petrucci E, Giron F, Sanchez-Ledesma MJ, Manassero A. The FRONT block: Femoral Rami and Obturator Nerve Trunk – a novel approach for anterior hip analgesia. Reg Anesth Pain Med 2024;49:109-11.
25. Hoerner E, Stundner O, Putz G, et al. Crystallization of ropivacaine and bupivacaine when mixed with different adjuvants: A semiquantitative light microscopy analysis. Reg Anesth Pain Med 2022;47:625-9.
26. Jaeger P, Grevstad U, Koscielniak-Nielsen ZJ, et al. Does dexamethasone have a perineural mechanism of action? A paired, blinded, randomized, controlled study in healthy volunteers. Br J Anaesth 2016;117:635-41.
27. Williams BA, Hough KA, Tsui BY, et al. Neurotoxicity of adjuvants used in perineural anesthesia and analgesia in comparison with ropivacaine. Reg Anesth Pain Med 2011;36:225-30.
28. Desmet M, Braems H, Reynvoet M, et al. and perineural dexamethasone are equivalent in increasing the analgesic duration of a single-shot interscalene block with ropivacaine for shoulder surgery: a prospective, randomized, placebo-controlled study. Br J Anaesth 2013;111:445-52.