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ORIGINAL ARTICLE

A Comparative Evaluation of Combined Nerve Block Versus Periarticular Infiltration on Postoperative Pain Relief in Total Hip Arthroplasty

Akhil Wadhawan[1] · **Sumit Arora**[1] · **Anant Krishna**[2] · **Mainak Mandal**[1] · **Anju Bhalotra**[3] · **Manoj Kumar**[1]

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Abstract

Introduction To minimize the side effects of the central neuraxial blockade to obtain postoperative pain relief, there has been an increasing preference for targeting the peripheral structures in patients undergoing total hip arthroplasty (THA).

Patients and Methods This prospective study was performed between September 2019 and September 2021 and involved 30 patients that were randomized to two groups. One group ($n = 15$) received combined nerve block (CNB) [obturator nerve, nerve to quadratus femoris, superior gluteal nerve, and femoral nerve], while another group ($n = 15$) received periarticular infiltrative analgesia (PIA). All the patients were given the same volume and composition of the drug cocktail (20 ml 0.5% ropivacaine, 1 ml (100 mcg) dexmedetomidine, and 29 ml normal saline).

Results The patients in group CNB had a significantly lower visual analog score (VAS) at 6, 12, 18, 24, 30, 36, 42 and 48 h after surgery ($p < 0.05$). Patients in group CNB required fewer ($p < 0.001$) doses of the rescue analgesic (1.67 ± 0.90 doses) as compared to group PIA (3.53 ± 0.64 doses). Time to the first rescue analgesia was significantly longer ($p = 0.01$) in group CNB (6.71 ± 2.36 h) as compared to group PIA (4.80 ± 1.26 h). However, patients in group PIA had significantly faster sensory ($p < 0.001$) and motor recovery ($p < 0.001$) as compared to group CNB. It took significantly longer ($p < 0.001$) to administer the nerve block (16.87 ± 1.80 min) as compared to periarticular infiltration (6.53 ± 1.18 min). There were no complications in either group.

Conclusion CNB registered significant superiority over PIA with respect to postoperative pain relief and time to rescue analgesia. However, the time taken to administer CNB was significantly higher and the patients in the PIA group had early recovery in sensory and motor modalities.

Level of Evidence III (therapeutic).

Keywords Total hip arthroplasty · Nerve block · Periarticular infiltrative analgesia · Pain relief

Investigations performed at: Department of Orthopaedic Surgery, Maulana Azad Medical College & associated Lok Nayak Hospital, New Delhi-110002 (India).

✉ Sumit Arora
mamc_309@yahoo.co.in

Akhil Wadhawan
akhilwadhawan1505@gmail.com

Anant Krishna
anantkrishna1209@gmail.com

Mainak Mandal
mainak.m93@gmail.com

Anju Bhalotra
drakgk@yahoo.co.in

Manoj Kumar
manojkumar.acad@gmail.com

[1] Department of Orthopaedic Surgery, Maulana Azad Medical College, Associated Lok Nayak Hospital, New Delhi, Delhi 110002, India

[2] Department of Orthopaedics, SGT Medical College Hospital, Research Institute, Gurugram, Haryana 122505, India

[3] Department of Anaesthesiology and Intensive Care, Maulana Azad Medical College, Associated Lok Nayak Hospital, New Delhi 110002, India

Introduction

Considering the complexity of the perception and pathogenesis of pain, a multimodal approach appears logical [1]. Uncontrolled postoperative pain after total hip arthroplasty (THA) may lead to delayed rehabilitation, delayed discharge from the hospital, and poor patient satisfaction. The majority of the centers use epidural anesthesia with a top-up in the postoperative period, injectable opioids and/ or NSAIDS, or patient-controlled analgesia (PCA). Although both PCA and continuous epidural analgesia are technically less demanding and provide adequate joint analgesia, they are associated with multiple side effects such as hypotension, urinary retention, nausea, and vomiting related to the frequent use of opioids [2]. Recently, other modalities such as nerve blocks and periarticular infiltration are gaining popularity. Lumbar plexus block provides good analgesia, but it is a technically demanding procedure and may cause serious complications like retroperitoneal hemorrhage [2–5].

With recent advances, it has been the tendency to aim more peripherally located structures for pain relief. Though continuous femoral nerve block has fewer side effects, it is difficult to achieve adequate analgesia with an isolated nerve block. Thus, a combined block of all the nerves supplying the hip joint seems a comprehensive and logical modality of providing pain relief in patients undergoing THA [2–5]. Another alternative to the conventional techniques of providing analgesia in the postop period is periarticular infiltrative analgesia with a cocktail of drugs. Ropivacaine is gaining popularity for providing postoperative analgesia due to its differential sensory and motor blockade, wherein it provides good analgesia with minimal motor blockade [6]. There is a paucity of studies in the literature comparing two postoperative pain control modalities in patients undergoing THA [2, 7–12].

In the present study, we prospectively evaluated combined nerve block (CNB) and periarticular infiltrative analgesia (PIA) for obtaining pain relief in patients undergoing THA.

Patients and Methods

This prospective, interventional, comparative study was performed in a tertiary-level, referral, teaching institute attached to a reputed medical college between September 2019 and September 2021. Approval from the institutional ethics committee was granted and it was registered under the Clinical Trial Registry of India (CTRI). Written informed consent was obtained from all the patients for treatment, radiological investigations, and photographic documentation. All ASA I–II patients in the age group 18–60 years that underwent uncemented primary THA via the posterior approach in the stipulated time period were included in our study. Patients having ASA grade III–IV physical status, neurological disorders, coagulopathy, allergy to local anesthetics, or not willing to participate in the study were excluded from the study. All the patients that underwent bilateral THA in the same sitting were also excluded from the study.

At 95% confidence level and 80% power, taking mean analgesia consumption within the first 24 h as 16.4 ± 10.7 in the periarticular infiltration group and 30.0 ± 16.6 in the femoral nerve block group (as reported by Kuchálik et al[8]), the sample size for our study was calculated as 32 per group. However, due to time constraints in our study, we enrolled a total of 30 patients that were randomized in either of the following two groups using an odd and even number system: (1) group CNB ($n = 15$): the patients received blocks for obturator nerve, nerve to quadratus femoris, superior gluteal nerve, and femoral nerve; (2) group PIA ($n = 15$): the patients received periarticular infiltrative analgesia in this group. The patient, as well as the clinician who was evaluating postoperative pain scores, was not made aware of the respective group allocation.

Technique

All the patients were operated on through the posterior approach by the same team of surgeons (authors at serial numbers 2 and 6) using uncemented hip prostheses. All were administered spinal anesthesia alone and none of them received any pre-emptive analgesia. We used the same volume and composition of drug cocktail in both the groups that were made using 20 ml 0.5% ropivacaine, 1 ml (100 mcg) dexmedetomidine, and 29 ml normal saline (to make a total of 50 ml).

1. *Group CNB:* Obturator nerve, nerve to quadratus femoris, superior gluteal nerve, and femoral nerve were blocked in this group. We exercised due precautions while giving nerve blocks: documentation of pre-existing sensory/motor deficit in the distribution of the proposed block; sensitivity testing with the drugs; negative aspiration of blood before injecting the drug cocktail; and incremental administration of drug cocktail under vital monitoring.

The obturator nerve, nerve to quadratus femoris, and superior gluteal nerve were blocked intraoperatively by the surgeon. The femoral nerve, however, was blocked by the anesthetist after the patient was made supine on wound closure. These nerve blocks were guided by a nerve stimulator (Stimuplex Dig RC, B Braun Melsungen AG, Germany). Nerve stimulation was begun using a current intensity of 2–3 mA (2 Hz). The desired placement of the needle tip was marked by the presence of contraction of the muscles supplied by the respective nerve even at a current intensity of 0.3–0.5 mA. These nerves were blocked sequentially as mentioned below:

A. Obturator nerve: It was blocked after the acetabular component was placed. Taking the anterior cotyledon as the landmark (Fig. 1A–D), the needle attached to the nerve stimulator was inserted from the anteroinferior aspect of the transverse acetabular ligament and directed 40° anteriorly, 20° inferiorly, and medially (Fig. 2). The drug cocktail (15 ml) was then infiltrated after confirming the correct position of the needle by looking for the contraction of the adductors.

B. Nerve to quadratus femoris: It was blocked before the removal of Charnley's retractor. It was identified as a thin branch running parallel to the sciatic nerve at the superior border of the quadratus femoris just below the obturator externus, approximately 4 cm medial to the intertrochanteric crest. The drug cocktail (8 ml) was administered after confirming the correct position of the needle by looking for the contraction of the quadratus femoris muscle.

C. Superior gluteal nerve: It was also blocked before the removal of Charnley's retractor. The drug cocktail (7 ml) was administered at the superior border of the piriformis after checking for the contraction of the gluteus medius.

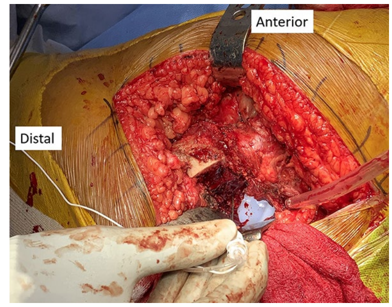

Fig. 2 Clinical intraoperative photograph showing a surgeon administering the obturator nerve block. A note may be made of the needle directed 40° anteriorly, 20° inferiorly, and medially

D. Femoral nerve: It was blocked by an anesthetist (author at serial number 3) on the operating table in the supine position after the completion of the surgery. The block was given with the ipsilateral extremity abducted 15–20° and slightly externally rotated. The site of needle insertion was located immediately lateral (1–1.5 cm) to the pulse of the femoral artery and 1–2 cm below the inguinal crease. The needle was introduced at a 30–45° angle to the skin in a cephalad direction after connecting it to a nerve stimulator. Loss of resistance was felt as the needle pierced the fasciae. The drug cocktail (20 ml) was administered after checking for the contraction of quadriceps muscle (patellar twitch) (Fig. 3).

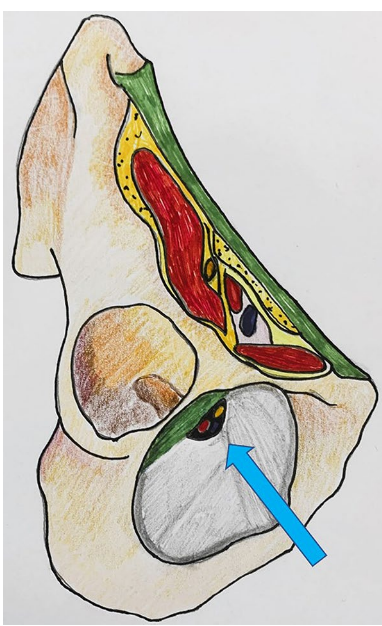

Fig. 1 A Schematic diagram illustrating the anatomy of the obturator nerve in relation to the anterior cotyledon and transverse acetabular ligament (the blue arrow shows the location of the obturator nerve and vessels)

Fig. 3 A schematic diagram illustrating the technique of blocking the femoral nerve, which can be found immediately lateral (1–1.5 cm) to the pulse of the femoral artery and 1–2 cm below the inguinal crease

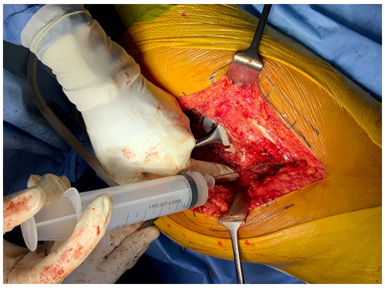

Fig. 4 Clinical intraoperative photograph showing a surgeon infiltrating the iliopsoas and its insertion at the lesser trochanter

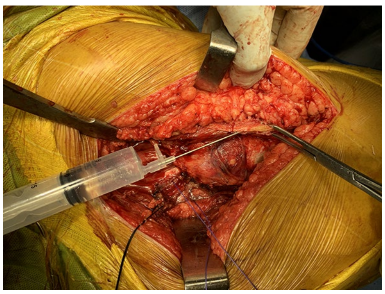

Fig. 5 Clinical intraoperative photograph showing a surgeon infiltrating the fascia lata

2. *Group PIA:* The structures around the hip, thought to be responsible for postoperative pain in patients undergoing THA, were infiltrated intraoperatively by the surgeon with the drug cocktail. We infiltrated the iliopsoas insertion (7 ml) (Fig. 4) and anterior capsule (5 ml) before the final reduction of hip prosthesis. The posterior capsule (5 ml), short external rotators (5 ml), gluteus maximus with its insertion (8 ml), abductors (5 ml), and fascia lata (15 ml) (Fig. 5) were infiltrated after the final reduction of the hip prosthesis.

Aftercare

The patients received standard postoperative care. They were given an injection of diclofenac 75 mg intramuscularly for rescue analgesia (VAS $\geq$ 4) unless contra-indicated. In those cases where injection of diclofenac was contraindicated, we used injection of paracetamol (1 gm intravenous). They were observed for any complications like respiratory depression, bradycardia, renal insufficiency, and urinary retention.

As a part of deep vein thrombosis (DVT) protocol, the following measures were taken: (1) injection of enoxaparin 0.4 ml s/c 24 hourly (prophylactic dose) was started on POD1, which was continued for a week; (2) compression stockings were used; and (3) all the patients underwent venous duplex ultrasonography on postoperative day 3 to rule out/ help early diagnose DVT.

Outcome Variables

(1) visual analog score (VAS): it was measured in the recovery room and then 6 hourly over the next 48 h by the author at serial number 1; (2) time to rescue analgesia: it was the time from the completion of CNB/ PIA till the time VAS was 4 or more; (3) number of doses of rescue analgesia needed in next 48 h; (4) time taken to administer CNB or PIA; (5) time taken for complete sensory and motor recovery; (6) complications observed in any of the patients such as intravascular injections, hypotension, hypersensitivity, prolonged motor blockade, bradycardia (heart rate < 60 bpm), respiratory depression ($SpO_2 < 88\%$), renal insufficiency (serum creatinine increases more than 0.5 above the baseline value in 24 h), and DVT.

Data Analysis

Data were analyzed and statistically evaluated using the SPSS-PC-25 version. Quantitative data were expressed as mean ± standard deviation or median with interquartile range which depends on normality distribution. The difference between the two comparable groups was tested by Student's t test (unpaired) or Mann–Whitney '*U*' test. Qualitative data were expressed in percentages and statistical differences between the proportions were tested by Chi-square test or Fisher's exact test.

Results

Age and Gender

The study cohort had an identical gender distribution with 12 men and 3 women in each group. The mean age of patients in the two groups [34.80 ± 10.80 years in group CNB and 39.33 ± 12.24 years in group PIA] were comparable ($p = 0.29$).

VAS

The values, in the recovery room and then at 6, 12, 18, 24, 30, 36, 42, and 48 h after surgery, were 1.53 ± 0.64, 2.80 ± 0.77, 3.87 ± 0.99, 3.0 ± 1.0, 2.93 ± 1.16, 2.13 ± 0.64, 1.20 ± 0.41, 1.20 ± 0.41, and 1.0 ± 0.0 in group CNB versus 1.60 ± 0.51, 4.93 ± 1.38, 4.73 ± 0.79, 4.40 ± 1.35, 3.67 ± 0.90, 3.0 ± 1.31, 2.33 ± 1.11, 1.73 ± 0.70, and 1.33 ± 0.48 in group PIA, respectively. It was significantly less at 6 h ($p < 0.001$), 12 h ($p = 0.02$), 18 h ($p < 0.01$), 24 h ($p < 0.05$), 30 h ($p = 0.04$), 36 h ($p < 0.01$), 42 h ($p = 0.02$), and 48 h ($p = 0.01$) in group CNB as compared to that measured in group PIA (Table 1). However, VAS in the recovery room was comparable in both the groups ($p = 0.62$).

Table 1 VAS of patients at different time durations in both the groups

VAS score	Group		*P* value
	CNB group ($n=15$)	PIA group ($n=15$)	
At recover room	1.53 ± 0.64	1.60 ± 0.51	0.62
At 6 h	2.80 ± 0.77	4.93 ± 1.38	< 0.001*
At 12 h	3.87 ± 0.99	4.73 ± 0.79	0.02*
At 18 h	3.0 ± 1.0	4.40 ± 1.35	< 0.01*
At 24 h	2.93 ± 1.16	3.67 ± 0.90	< 0.05*
At 30 h	2.13 ± 0.64	3.0 ± 1.31	0.04*
At 36 h	1.20 ± 0.41	2.33 ± 1.11	< 0.01*
At 42 h	1.20 ± 0.41	1.73 ± 0.70	0.02*
At 48 h	1.0 ± 0.0	1.33 ± 0.48	0.01*

*Denotes a statistically significant *p* value

Table 2 Time to complete sensory and motor recovery in the patients of both the groups

	Group		*P* value
	CNB group ($n=15$)	PIA group ($n=15$)	
Time to complete sensory recovery (h)			
Mean ± SD	7.63 ± 1.52	2.90 ± 0.43	< 0.001*
Median (IQR)	8 (6.5–9)	3 (2.5–3.0)	
Time to complete motor recovery (h)			
Mean ± SD	3.86 ± 0.67	1.77 ± 0.45	< 0.001*
Median (IQR)	4 (3.5–4.5)	2 (1.5–2.0)	

*Denotes a statistically significant *p* value

Rescue Analgesia

Time to the first rescue analgesia was significantly longer ($p = 0.01$) in group CNB (6.71 ± 2.36 h) as compared to group PIA (4.80 ± 1.26 h). A mean of 1.67 ± 0.90 doses of intramuscular diclofenac was used in patients who were given CNB, which was significantly less ($p < 0.001$) than the number of doses required in patients who were given PIA (3.53 ± 0.64 doses).

Sensory and Motor Recovery

Time to complete sensory and motor recovery in patients of group PIA was 2.90 ± 0.43 h and 1.77 ± 0.45 h, respectively, which was significantly less ($p < 0.001$) as compared to patients in group CNB (7.63 ± 1.52 and 3.86 ± 0.67, respectively) (Table 2).

Time Taken to Administer Analgesia

It took significantly longer ($p < 0.001$) to administer CNB (16.87 ± 1.80 min) as compared to PIA (6.53 ± 1.18 min).

Complications

There were no complications in any of the patients.

Discussion

The International Association for the Study of Pain (IASP) suggested the definition of pain as ‘an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage’. Various modalities such as parenteral injections of NSAIDS/opioids, PCA, epidural top-up, lumbar plexus block, and newer alternatives like PIA and CNB can be used to provide pain relief in patients undergoing THA [2–5]. Multimodal analgesia is the cornerstone of enhanced recovery after surgery protocol (ERAS) [2–5]. It aims at using the synergistic and potentiating actions of various pharmacological agents to provide maximum analgesia with minimum side effects. The additive action of various drugs makes it possible to use a multitude of drugs in smaller doses for optimum action without an associated increase in adverse effects. It aims at replacing opioids as the chief analgesic agent in postoperative pain control protocols owing to its well-documented side effects. The multimodal protocol targets pain receptors at all levels, thereby decreasing the central and peripheral perception of pain that enables the patient to initiate the postoperative rehabilitation as early as possible for better functional outcomes. A review of the studies on the comparison of two postoperative pain control modalities in patients undergoing THA is summarized in Table 3 [2, 7–12].

Limitations of the Study

Despite it being a randomized blinded comparative study, we could identify the following limitations: (1) we did not record the preoperative VAS which could have a confounding effect, as patients with a higher preoperative VAS usually have higher scores postoperatively; (2) since this was a time-bound study, we could enroll 15 patients in each group. We recognize that a higher sample size would have further validated our results (Table 4).

Addressing the Anatomical Basis of Pain Relief

A comprehensive understanding of anatomical structures responsible for causing postoperative pain in patients undergoing THA is a prerequisite for providing optimum pain relief. In the present study, we compared CNB and PIA of structures thought to be responsible for the genesis of pain after surgery by administering the same drug cocktail in both groups. In the first group, nerve supply of the hip (obturator nerve, superior gluteal nerve, nerve to quadratus femoris,

Table 3 A comprehensive literature review comparing the efficacy of various nerve blocks versus infiltrative analgesia for postoperative analgesia in patients undergoing primary THA

S. No	Author (Year)	Type of study	Number of patients	Comparative groups	Procedure	Results	Limitations
1	Jimenez Almonte et al. [7] (2015)	Network meta-analysis	2296	Comparison between LIA and PNB	6 databases, 35 RCT	Similar analgesic efficacy between local infiltration analgesia and peripheral nerve blocks, in terms of patient-reported pain scores and total opioid consumption at 24 h after primary THA LIA more cost-effective	
2	Tetsunaga et al. [2] (2016)	Retrospective study	93	Combination therapy with continuous three-in-one femoral nerve block and periarticular multimodal drug infiltration after total hip arthroplasty	Group CFNB—3 in 1 block (obturator, femoral and lateral femoral cutaneous nerve) 0.2% ropivacaine (2 mg/ml) at a rate of 4 ml/h beginning immediately postoperatively Group LIA—225 mg of 0.75% ropivacaine, 10 mg of morphine hydrochloride and 0.5 mg of epinephrine (1: 1000) were mixed with 18.5 ml of sterile normal saline solution to make a combined volume of 50 ml, which was injected into the periarticular soft tissue Group CFNB and LIA—both interventions	Combination therapy with CFNB and LIA provided better pain relief after THA than CFNB or LIA alone, with few side effects	Retrospective study, Under GA Japanese universal health insurance system complicates the analysis of length of hospital stay Results of this study apply only to patients who undergo THA via the direct lateral approach or modified Watson Jones approach

Table 3 (continued)

S. No	Author (Year)	Type of study	Number of patients	Comparative groups	Procedure	Results	Limitations
3	Kuchálik et al. [8] (2017)	A randomized, double-blind study	56 patients	Local infiltration analgesia versus femoral nerve block for postoperative pain management in patients undergoing total hip arthroplasty	Group FNB—30 ml of ropivacaine 7.5 mg/ml (225 mg) Group LIA—300 mg (150 ml) ropivacaine, ketorolac 30 mg (1 ml) and adrenaline 0.5 mg (0.5 ml) (total volume 151.5 ml) periarticularly and subcutaneously followed by infusion postoperatively	Local infiltration analgesia significantly reduced pain intensity on standing and mobilization, and rescue analgesic consumption compared to femoral nerve block without causing significant side effects	Did not evaluate the effect of the FNB before application of the spinal anesthetic Second injection in the LIA group at 23 h
4	Johnson et al. [9] (2017)	A three-arm randomized clinical trial	159 patients (51, 54, and 54 patients in the PNB, PAI-R, and PAI-L groups, respectively	Continuous posterior lumbar plexus nerve block versus periarticular injection with ropivacaine or liposomal bupivacaine for postoperative pain relief	PNB—bupivacaine 0.5% with 1:200,000 epinephrine 30 ml bolus (preop), followed by an infusion of bupivacaine 0.2% PAI-R group—ropivacaine, epinephrine, ketorolac, saline (120 ml) PAI-L group—liposomal bupivacaine, bupivacaine, epinephrine, ketorolac, saline (120 ml) PAI-L, PAI-R-60 ml into femoral neck, trochanteric bursa and capsule, 60 ml into iliotibial band, subcutaneous tissue and other periarticular structures	Modest improvement with respect to analgesia and opioid consumption following total hip arthroplasty in patients receiving PNB compared with those who received PAI-R, but not compared with those who had PAI- L. Secondary analyses suggested that PNB or PAI-L provided postoperative analgesia that was superior to PAI-R	Technique-dependent standardization was difficult Blinding between PNB and PAI was difficult

Table 3 (continued)

S. No	Author (Year)	Type of study	Number of patients	Comparative groups	Procedure	Results	Limitations
5	Fahs et al. [10] (2018)	Prospective randomized clinical trial	49-psoas compartment block (PCB0 50-PAI	Psoas compartment block (femoral, obturator, lateral femoral cutaneous nerve) versus periarticular local anesthetic infiltration	Surgeon administers PCB after head extraction 40 mL of 0.2% ropivacaine and 10 mL of 0.9% NaCl 30 mL 0.5% ropivacaine, 0.15 mg epinephrine, 4 mg morphine, and 30 mg ketorolac diluted with 0.9% NaCl to a volume of just over 50 ml was injected after component implantation and prior to closure into joint capsule, rectus femoris direct and reflected heads, tensor fascia lata, and subcutaneous tissues circumferentially every 25 mm	Periarticular infiltration esthetic is preferred over the PCB due to improved immediate postoperative pain scores, and avoidance of potential symptoms associated with nerve blockade	
6	Gasanova et al. [11] (2018)	A randomized controlled trial	60	Ultrasound-guided suprainguinal fascia iliaca compartment block versus periarticular infiltration for pain management after total hip arthroplasty	Solution—60 mL ropivacaine 300 mg and epinephrine 150 µg SFICB—USG guided PAI—20 mL into the posterior capsule and posterior soft tissue, 20 mL in the mid-layer and 20 mL into the subdermal tissues and around the drain	SFICB provided similar pain relief compared with PAI, but was associated with muscle weakness at 6 h post-operatively	Did not use a double-blind design or a placebo The volume used for SFICB was higher than that used in clinical practice
7	Frassanito et al. [12] (2019)	Observational study	207 (78-THA, 129-TKR)	ERAS after THA and TKR—using nerve block and LIA	LIA—ropivacaine 0.2% 120 ml, ketorolac 30 mg and epinephrine 0.5 mg Iliac fascia compartment block (FICB) with ropivacaine 0.2% 40 ml	ERAS—better patient satisfaction, rehab and early discharge	Descriptive study—Level 4 evidence Short follow-up

Table 4 A comprehensive list of the studies evaluating surgeon-administered nerve blocks for postoperative analgesia

S. No	Author (year)	Type of study	Number of patients	Surgery performed	Nerve block	Results	Limitations
1	Lako et al. [16] (2009)	Prospective, double-blind, randomized study	30	Pelvic osteotomy in children	Morphine IV and placebo (saline) via an FIC catheter (Group M) Placebo (saline) IV and ropivacaine via an FIC catheter (Group R) FIC catheter was placed by the surgeon	Continuous incisional FIC block provided excellent postoperative pain relief, less sedation, and better return of appetite than morphine IV after pelvic osteotomy in children	
2	Owen et al. [17] (2010)	Case series	16	Lower segment cesarean section	Surgical TAP block	Lower pain scores, less need for rescue analgesia and longer duration before the requirement of the first rescue analgesic Surgical TAP block could prove a useful adjunct to obstetric anesthesia This technique could be used during any anterior major abdominal surgery like hysterectomy	Small sample size
3	Johns et al. [18] (2012)	Prospective cohort study	36	Right hemicolectomy	TAP block and post-operative patient-controlled anesthesia (PCA) ($n=20$) Control group who received subcutaneous local anesthetic infiltration and PCA ($n=16$)	Open TAP blocks are safe and reduce postoperative opioid requirements and sedation after right hemicolectomies	
4	Wheble et al. [19] (2013)	Retrospective analysis of a surgeon's experience	31 (4 were later excluded)-27	Autologous breast reconstruction	Surgeon-delivered TAP block (12) Not receiving TAP block (15)	Patients receiving TAP block had a significantly shorter length of stay, lower usage of morphine, and fewer episodes of perioperative nausea and vomiting	Small sample size Did not record patient-related outcomes

Table 4 (continued)

S. No	Author (year)	Type of study	Number of patients	Surgery performed	Nerve block	Results	Limitations
5	Lapmahapaisan et al. [20] (2015)	Stratified, randomized controlled trial	54	Non-laparoscopic major abdominal surgery	LA group received 0.25% bupivacaine for local wound infiltration sTAP group received 0.25% bupivacaine for TAP block performed by a surgeon Control group received no block	There was no significant advantage of the sTAP block over local infiltration or no intervention for postoperative pain control in pediatric patients undergoing non-laparoscopic major abdominal surgeries	Observer bias Patients in a broad age group Pain score in older children more reliable than younger Wide variety of surgeries
6	Desroches et al. [21] (2016)	A randomized controlled noninferiority trial	59 patients met the inclusion criterion (6 were excluded later)	Arthroscopic rotator cuff repair	ISB was performed under ultrasound guidance by an anesthesiologist SSB was performed based on specific anatomic landmarks by a surgeon	SSB was as effective as ISB for mean pain control within the first 24 h, but ISB was more effective in relieving pain in the recovery room after arthroscopic supraspinatus and/or infraspinatus tendon repair	Age ASA Cost Discharge from recovery room fixed; thus, difference cannot be calculated
7	Tamura et al. [22] (2017)	Randomized controlled trial	80–8 withdrew (36 in each group)	Lung cancer patients undergoing thoracotomy	Group E—epidural catheter place by the anesthetist Group—paravertebral catheter placed by the surgeon	The Epi was superior to PVB-sf for the management of post-thoracotomy pain in this patient cohort	The addition of opioids to a local anesthetic solution has been reported to improve the quality of sensory block and pain control
8	Lanier et al. [23] (2018)	A prospective, randomized, double-blinded, placebo-controlled, clinical trial	47	Tissue expander breast reconstruction	Intraoperative intercostal and pectoral nerve blocks with 0.25% bupivacaine with 1:200,000 epinephrine and 4 mg dexamethasone were compared to sham blocks	No significant difference between the two groups. However, the technique is safer and cost-effective	
9	Obata et al. [24] (2018)	Interventional study	101	Surgery for distal end radius fracture	Ultrasound-guided brachial plexus block administered by orthopedists. Brachial plexus block was administered through the supraclavicular approach	The operation could be completed with brachial plexus block alone and additional local infiltration anesthesia or intravenous anesthesia in 94.1% (95 cases)	

Table 4 (continued)

S. No	Author (year)	Type of study	Number of patients	Surgery performed	Nerve block	Results	Limitations
10	Narasimhulu et al. [25] (2018)	Randomized comparative study	41	Cesarean section	Surgeon-administered TAP block (20) Conventional TAP block (21)	Surgical TAP blocks are feasible and less time consuming than conventional TAP blocks, while providing comparable analgesia after cesarean delivery	Not blinded Secondary outcomes needed a larger sample size
11	Caldwell Jr et al. [26] (2019)	Prospective observational study	60	Anterior cruciate ligament reconstruction (ACLR)	Circumferential anterior genicular nerve block was given by the surgeon with patient still under GA (10 SITES) -0.25% bupivacaine 60 cc	Opioid usage was unexpectedly low among patients undergoing ACLR after a surgeon administered genicular nerve block and fat pad infiltration	Opioid usage not always reported Ibuprofen use not recorded
12	Laumonerie et al. [27] (2019)	Comparative cadaveric study	30 (15 in each group)	distal suprascapular nerve (dSSN) blockade performed using 2 techniques	Group 1—ultrasound-guided regional anesthesia (USRA) Group2—landmark-based approach (LBA) 10 mL of methylene blue-infused ropivacaine 0.75% along with 2.5 mL of red latex solution was injected to identify the position of the needle tip. The division and distribution of the sensory branches originating from the SSN were described	LBA is as reliable and accurate as US guidance for esthetic blockade of the dSSN The study demonstrates landmark-based approach to esthetic blockade of the distal suprascapular nerve is accurate and can be performed by orthopedic surgeons lacking experience in ultrasound-guided esthetic techniques	Cadaveric study Dissection would have distorted the anatomy Single experienced anesthetist performed USG blocks USG technique highly operator dependent
13	Wong et al. [28] (2020)	A blinded, randomized non-inferiority trial	60	Laparoscopic colorectal surgery	Laparoscopic TAP block—surgeon administered USG guided TAP block—anesthetist administered	Surgeon-delivered LTAPs are safe, effective, and non-inferior to anesthesia-administered UTAPs in the immediate postoperative period	No placebo Single subcostal technique Intravenous opioids used routinely

Table 4 (continued)

S. No	Author (year)	Type of study	Number of patients	Surgery performed	Nerve block	Results	Limitations
14	Peterson et al. [29] (2020)	Retrospective cohort study	100	Primary TKA	Group 1—surgeon-performed high-dose periarticular injection and intra-articular saphenous nerve block (60 mL 0.5% bupivacaine, 30 ml saline, 30 mg ketorolac) Group 2—anesthesiologist-performed adductor canal catheter (0.25% bupivacaine 6 mL/ h infusion pump placed postoperatively with ultrasound guidance	Group 1 registered lower pain scores and less IV narcotic use (breakthrough pain) on the day of surgery	Retrospective study Nurses not blinded Adductor canal block group—posterior capsule was spared
15	Greenky et al. [30] (2020)	A prospective randomized trial	63 (34 in group 1, 29 in group2)	Primary TKA	Group 1—anesthesiologist-administered adductor canal block (ACB) Group 2—surgeon-administered ACB	Surgeon-administered ACB is not inferior to anesthesiologist-administered ACB with respect to pain, opioid consumption, range of motion, patient satisfaction, or short-term functional outcomes	Beta error No control for the time of administration of ACB relative to VAS pain assessments Did not perform pericapsular injection of local anesthesia
16	Caldwell Jr et al. [31] (2020)	Prospective observational study	87 out of total 91 were followed up	Arthroscopic rotator cuff repair	Sensory branches of the suprascapular nerve and axillary nerve, as well as local infiltration about the shoulder. We termed this a “local–regional block” of the shoulder—60 cc of 0.25% bupivacaine	Opioid use after ARCR was unexpectedly low, and a large proportion of patients recovered without any post-surgical opioids	Opioid usage not always reported Ibuprofen use not recorded

Table 4 (continued)

S. No	Author (year)	Type of study	Number of patients	Surgery performed	Nerve block	Results	Limitations
17	James et al.[32] (2021)	Safety and efficacy of axillary block for emergency upper limb orthopedic interventions, where there is no anesthesiologist	68	Emergency upper limb orthopedic interventions	A cocktail of 0.25% bupivacaine or 0.75% ropivacaine (10 ml) and 2% lidocaine (10 ml) with 1:200 000 epinephrine was used for AB. Axillary block was given by the surgeon by palpatory method	Axillary regional block is an efficacious, low-risk anesthesia for emergency orthopedic procedures of the hand, forearm and elbow, in resource-limited settings where an anesthesiologist is not available	Study unable to objectively compare the results

and the femoral nerve) was blocked after a detailed review of the article by Birnbaum et al. [13] on the sensory innervation of the hip joint and cadaveric dissection of the anatomical landmarks for the above nerves. The idea of targeting specific nerves and not administering a sciatic nerve block for blanket coverage of the sensory innervation of the hip was conceived with the thought that blocking the femoral nerve and the sciatic nerve would lead to complete paralysis of the limb in the postoperative period, thus increasing the risk of DVT and dislocation. Uppal [14] reported a case of permanent sciatic nerve injury caused by a preoperative intraneural injection of the local anesthetic agent. In the second group, various periarticular structures thought to be considered the source of postoperative pain, as outlined by Maheshwari et al. [15], were infiltrated with the drug cocktail.

The Rationale for the Different Constituents of the Cocktail of Drugs

Over the years, there has been immense debate on the constituents of the drug cocktail to be used. It essentially has three components: NSAID/ local anesthetic, adjuvant/s, and diluent. It offers good pain control, reduced narcotic consumption, and early rehabilitation [2–5]. Keeping in mind the three basic components, we devised our own cocktail of drugs based on available evidence. The use of ropivacaine was backed by the better safety profile and the differential sensory motor blockade in comparison to bupivacaine [6]. The idea of using dexmedetomidine as an adjuvant was backed by its ability to prolong the duration of action of the local anesthetic with an additive effect and a better safety profile when compared to other adjuvants like epinephrine. We did not use a steroid in our drug cocktail considering its propensity of causing infection owing to its immune-suppressive effects. We did not use morphine in our drug cocktail owing to its propensity to cause adverse reactions such as nausea, vomiting, and urinary retention. Additionally, the use of morphine is associated with a high incidence of respiratory depression, necessitating intensive care postoperatively, which may be of concern in a resource-limited setting like ours. All the patients were given intravenous injection of ceftriaxone 1 g half an hour prior to surgery obviating the need for adding an antibiotic to our drug cocktail.

Surgeon-Administered Blocks

The conventional method of providing analgesia such as PCA, epidural top-up, or opioid injections often necessitates intensive monitoring. Anesthetist-administered nerve blocks are commonly employed for postoperative pain relief, but only those nerves that are accessible through a percutaneous approach can be blocked effectively. The concept of surgeon-administered blocks can be utilized especially for the nerves: (1) that are there in the vicinity of the surgical field; (2) that are relatively small or found in deeper planes, and not accessible via a percutaneous route, but still play an important role in the sensory supply, can be blocked effectively under vision providing optimum postoperative pain relief. A summary of all the surgeon-administered blocks, as described in the literature, is provided in Table [16–32]. This encouraged us to block the obturator nerve, superior gluteal nerve, and the nerve to quadratus femoris intraoperatively by the surgeon and the femoral nerve by the anesthetist after the procedure.

A Novel Method of Giving Surgeon-Administered Nerve Blocks

To the best of our knowledge, there is no other published study that compares CNB (involving the femoral nerve, obturator nerve, superior gluteal nerve, and the nerve to quadratus femoris) and PIA. Additionally, we describe a novel intraoperative technique of blocking the obturator nerve, superior gluteal nerve, and the nerve to quadratus femoris in patients undergoing THA.

We used the anterior cotyledon of the acetabulum as the landmark to block the obturator nerve after placement of the acetabular cup (Fig. 6). The needle attached to the nerve stimulator was inserted from the anteroinferior aspect of the transverse acetabular ligament and directed 40° anteriorly, 20° inferiorly, and medially to block the obturator nerve. The surgeon should be aware of the branching pattern of the common obturator nerve at different levels. It has been suggested that its bifurcation (anterior and posterior) may be intrapelvic (23.22%), within the obturator canal (51.78%), or in the medial thigh (25%) [33]. In our study, we blocked the obturator nerve at its exit from the obturator canal, which in the majority of the patients is after its bifurcation. The correct positioning of the needle was determined by the contractions of thigh adductors.

After that, the nerve to quadratus femoris (branch of the anterior division of sacral plexus) was given by the surgeon. It courses almost parallel and posterior to the sciatic nerve above the piriformis. After emerging through the infra piriformis fossa, the nerve lies medial to the sciatic nerve just before it innervates the quadratus femoris and posterior aspect of the hip joint capsule. In our study, we blocked the nerve to the quadratus femoris in the interval between the obturator externus and quadratus femoris approximately 4 cm medial to the intertrochanteric crest, and correct positioning of the needle was determined by the contractions of the quadratus femoris [34].

Subsequently, the superior gluteal nerve (branch of the dorsal division of sacral plexus) was blocked by the surgeon before the removal of Charnley's retractor. It crosses the supra-piriform foramen and runs in the plane between the the gluteus medius and minimus. It is accompanied by superior gluteal vessels and innervates the gluteus medius, minimus, and tensor fascia lata [35, 36]. The drug cocktail (7 ml) was administered at the superior border of the piriformis after checking for the contraction of the gluteus medius.

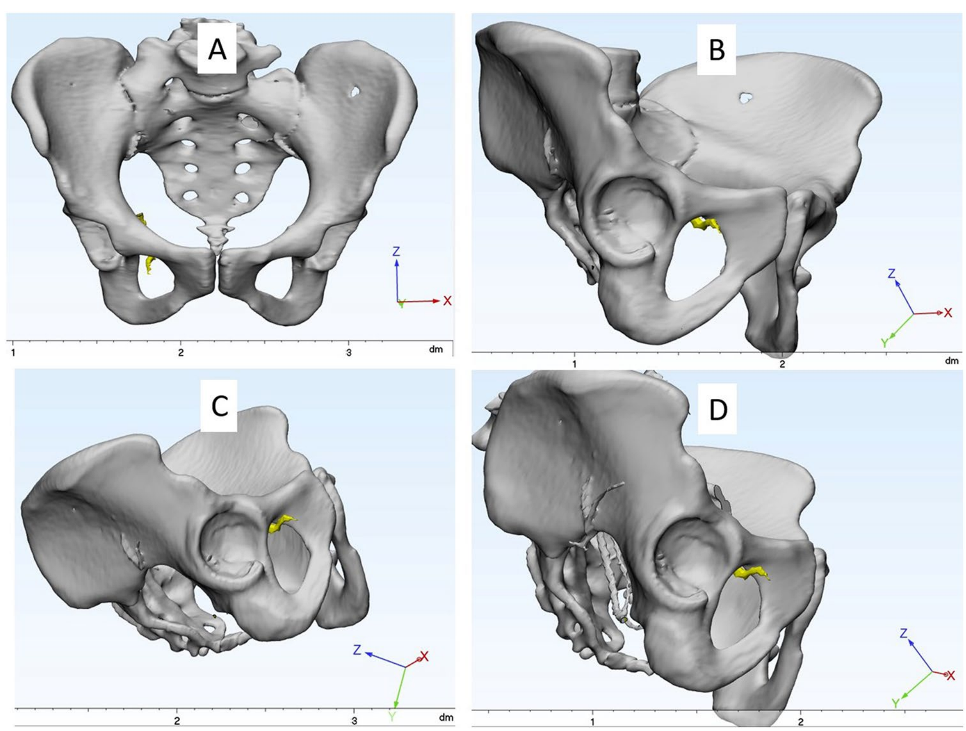

Fig. 6 **A**–**D** Three-dimensional images of the pelvis showing the relationship of obturator nerve (yellow structure) exiting the pelvis through the obturator foramen just anteroinferior to the anterior cotyledon

Conclusions

Combined nerve block and periarticular infiltrative analgesia are safe procedures. The combined nerve block technique provides superior postoperative analgesia; however, it is more time-consuming and takes more time until motor and sensory recovery when compared with periarticular infiltration. Future studies may be directed toward comparing the efficacy of different drug cocktails (including liposomal preparations).

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Data availability Not applicable.

Declarations

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical Approval Granted.

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