Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

PATIENT CONTROLLED EPIDURAL ANALGESIA VERSUS CONVENTIONAL EPIDURAL ANALGESIA AFTER TOTAL HIP REPLACEMENT: A RANDOMIZED TRIAL IN PAKISTAN

Dr. Uruba Shamshad[*1], Dr. Amim Anwar[2], Dr. Sarosh Hassan[3], Dr. Warisha Ismail[4], Dr. Maria Munir[5], Dr nazish kanwal[6]

*[*1]FCPS Resident Anesthesiology), Liaquat National Hospital & Medical College, Karachi.*
[2]MBBS, MCPS, FCPS, FCACSI), consultant anaesthetic, Assistant professor, Liaquat National Hospital & Medical College, Karachi
[3]FCPS, Senior registrar, Liaquat National Hospital & Medical College, Karachi
[4]RMO, Liaquat National Hospital & Medical College, Karachi.
[5,6]FCPS Resident Anesthesiology), Liaquat National Hospital & Medical College, Karachi.

[*1]uruba.shamshad62@gmail.com

DOI: https://doi.org/10.5281/zenodo.15697029

Keywords
Patient Controlled Epidural Analgesia, Conventional Epidural Analgesia, Total Hip Replacement

Article History
Received on 12 May 2025
Accepted on 12 June 2025
Published on 19 June 2025

Corresponding Author: *
Dr. Uruba Shamshad

Abstract

Objective: *To compare the efficacy and safety of patient-controlled epidural analgesia (PCEA) with a conventional fixed-rate epidural regimen during the first 24 hours after primary unilateral THR in a Pakistani tertiary hospital*

Methods: *Sixty adults undergoing primary THR at a Pakistani tertiary hospital were randomised to either conventional epidural infusion (Group A) or PCEA (Group B). Primary outcome was mean visual analogue scale (VAS) score over 24 h. Secondary outcomes comprised motor block, sedation, haemodynamic events, bupivacaine consumption and satisfaction. Analyses used t-test or χ^2; $p < 0.05$.*

Results: *Baseline demographics were comparable. PCEA yielded lower VAS at 2 h (3.15 ± 1.09 vs 5.02 ± 1.30), 12 h (2.31 ± 0.70 vs 3.80 ± 1.20) and 24 h (1.97 ± 0.60 vs 2.80 ± 1.10; $p < 0.001$). Motor block ≥ grade 2 was absent in Group B but affected 50 % of controls at 12 h. Sedation and rescue tramadol were reduced, while satisfaction improved. Total bupivacaine volume was 10 mL higher with PCEA, but analgesic efficiency doubled. No serious adverse events occurred.*

Conclusion: *PCEA provided superior analgesia, less motor impairment and greater patient satisfaction than conventional epidural infusion after THR, supporting its routine use in enhanced-recovery pathways.*

INTRODUCTION

Total hip replacement (THR) is one of the most frequently performed and cost-effective orthopaedic interventions of the twenty-first century. Despite refinements in surgical technique and peri-operative pathways, the procedure still produces intense nociceptive pain during the first post-operative day, which can hinder early mobilisation, delay discharge and compromise functional outcomes.[1,2] In Pakistan, resource limitations mean that a dependable, low-maintenance analgesic technique is essential to support enhanced-recovery protocols and accelerate bed turnover. Continuous epidural infusion of a dilute local anaesthetic solution, with or without adjunctive opioid, has been a mainstay of analgesia

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

after lower-limb arthroplasty for several decades because it blunts both static and dynamic pain more effectively than systemic opioids alone. However, fixed-rate infusions ignore inter-patient variability in pain intensity, pharmacodynamics and physiological reserve. When the delivered dose exceeds the minimum required for comfort, excessive sensory and motor blockade can occur, precipitating hypotension, weakness, urinary retention and increased nursing workload. Conversely, if the basal rate is set too low, breakthrough pain necessitates clinician intervention, undermining the perceived advantages of an epidural catheter.[3,4]

Patient-controlled epidural analgesia (PCEA) was developed to address these limitations by allowing the recipient to self-administer pre-defined boluses of local anaesthetic through an electronic pump, usually accompanied by a low background rate.[5] Such demand-responsive dosing theoretically matches supply to need, minimising drug exposure while preserving analgesic quality. Meta-analyses of obstetric and abdominal cohorts have shown that PCEA improves patient satisfaction and may reduce total local anaesthetic consumption, but data in major joint arthroplasty are sparse and derived largely from Western populations.[6] Cultural differences in pain reporting, variations in body habitus and divergent nursing ratios mean that results cannot automatically be extrapolated to South-Asian practice. Furthermore, few local studies have employed rigorous randomisation or contemporary outcome metrics.[5-7]

The present trial was therefore designed to compare the efficacy and safety of PCEA with a conventional fixed-rate epidural regimen during the first 24 hours after primary unilateral THR in a Pakistani tertiary hospital. We hypothesised that PCEA would achieve superior pain control, lower incidence of motor blockade and higher patient satisfaction without increasing serious adverse events. By quantifying analgesic efficiency alongside traditional endpoints, we also aimed to determine whether any differences in drug consumption were clinically meaningful. Ultimately, optimising peri-operative analgesia remains a cornerstone of value-based hip care.

Methodology:

This parallel-group open-label randomized controlled trial was conducted in the Department of Anaesthesiology, Liaquat National Hospital, Karachi, from March 2024 to February 2025 following ethics approval. Adults 40–85 y undergoing primary unilateral THR were screened. Inclusion criteria were ASA I–II, room-air $SpO_2 > 95\%$ and ability to use the pain scale. Exclusions included chronic opioid use, neuraxial contra-indication, drug allergy, anticipated revision surgery and refusal. Sixty consenting patients were randomised 1:1 by sealed opaque envelopes to Group A (conventional epidural) or Group B (PCEA). After combined spinal–epidural at L3–L4, all patients received bupivacaine 0.125 %. Group A received a fixed infusion 4 mL h^{-1}, titrated to 6 mL h^{-1} for VAS > 4. Group B received background 2 mL h^{-1} with 2 mL on-demand bolus, 15-min lockout, maximum 8 mL h^{-1}. Rescue tramadol 50 mg IV was given for VAS > 6 on two readings 15 min apart.

Primary outcome was mean VAS at 2, 12 and 24 h. Secondary outcomes included modified Bromage motor block, Ramsay sedation, hypotension (systolic BP < 90 mmHg or > 30 % fall), bradycardia (< 50 beats min^{-1}), bradypnoea (< 8 breaths min^{-1}), PONV, total bupivacaine, rescue tramadol and satisfaction (5-point Likert). Sample size was calculated with OpenEpi: assuming a 1.5-point VAS difference and SDs of 1.0/0.76, 12 participants were needed for 80 % power; we enrolled 60 to enhance validity. An independent anaesthetist generated the random sequence. Outcome assessors and statisticians were masked. Analyses were intention-to-treat using t-test or χ^2/Fisher with $p < 0.05$.

Results:

All 60 patients completed follow-up. Table 1 confirms no significant differences in age, sex or comorbidity. Pre-operative vitals (Table 2) were similar. Pain scores were consistently lower with PCEA (Figure 1), with absolute reductions of 1.9, 1.5 and 0.8 points at 2, 12 and 24 h respectively. Motor blockade grade ≥ 2 occurred in 50 % of Group A versus 0 % of Group B at 12 h (Table 3). Sedation grade > 2 at 2 h was 90 % vs 30 %. Hypotension,

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

bradycardia and bradypnoea were infrequent and not statistically different (Table 4). PCEA delivered 60 ± 5.4 mL (75 ± 7 mg) of bupivacaine versus 50 ± 6.3 mL (50 ± 6 mg) in controls (Figure 2), yet no toxicity occurred. Seven conventional patients required rescue tramadol compared with none in the PCEA group. Satisfaction improved by 1.35 points ($p < 0.001$). No infections, haematomas or neurologic sequelae were observed.

Table 1: Demographic and Clinical parameters

Variables	Group A	Group B	P Value
Age (years)	63.3±12.6	59.4±13.9	0.182
Gender			
Male	22 (73%)	20 (67%)	0.536
Female	8 (27%)	10 (33%)	
ASA Status			
I	8 (27%)	12 (40%)	0.293
II	22 (73%)	18 (60%)	
Comorbidity			
HTN	10 (33%)	14 (47%)	0.326
DM	11 (37%)	9 (30%)	0.573
Other	4 (13%)	7 (23%)	0.264

Table 2: Pre-operative parameters

Variables	Group A	Group B	P Value
Blood Pressure (mm/Hg)	131.8±11.9	129.4±12.4	0.431
Heart rate (Beat/min)	84.8±10.1	80±12.3	0.085
Respiratory Rate	16.03±2.61	16.4±2.4	0.601

Table 3: Outcome variables

Variables	Group A	Group B	P Value
Bromage			
2H	21 (70%)	14 (47%)	0.073
12H	15 (50%)	0	<0.0001
24H	0	0	<0.001
Sedation			
2H	27 (90%)	9 (30%)	<0.0001
12H	25 (83%)	5 (17%)	<0.0001
24H	5 (17%)	7 (23%)	0.375
VAS			
2H	5.02±1.3	3.15±1.09	<0.0001
12H	3.8±1.2	2.31±0.7	<0.0001
24H	2.8±1.1	1.97±0.6	0.001

Table 4: Adverse events and drug consumption

Variables	Group A	Group B	P Value
Bradypnea	3 (10%)	2 (6%)	0.662
Hypotension	2 (6%)	6 (20%)	0.103
Ponv score	1.1±1.3	1.2±1.24	0.785

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Bradycardia	2 (6%)	3 (10%)	0.662
Total drug (ml)	50.1±6.3	60.2±5.4	<0.0001
Total drug (mg)	50.1±6.3	75.2±6.8	<0.0001
Additional Anlesgia (mg)	5.2±3.07	4.4±3.6	0.45
Satisfaction score	4.38±0.8	3.03±0.8	<0.0001

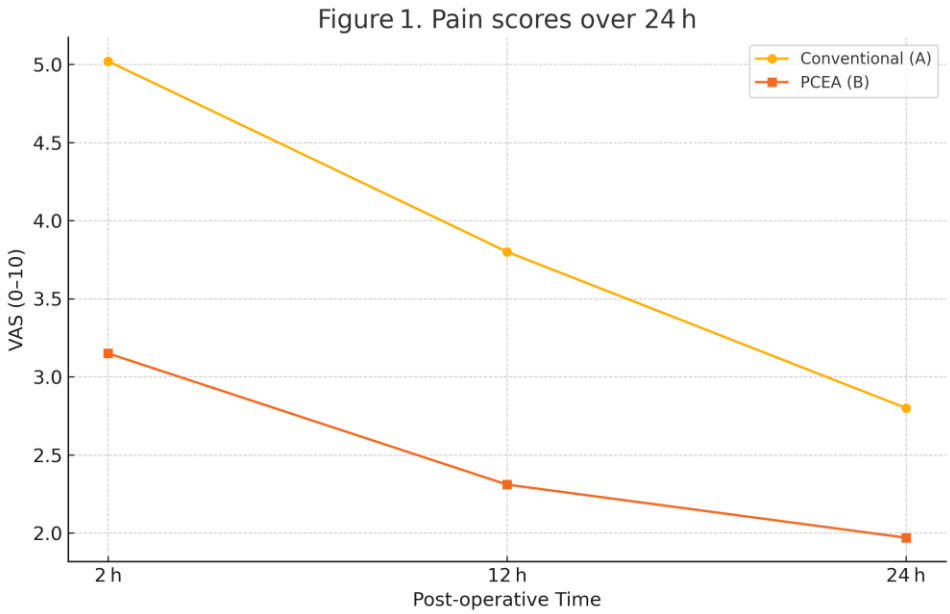

Figure 1. VAS pain trajectory

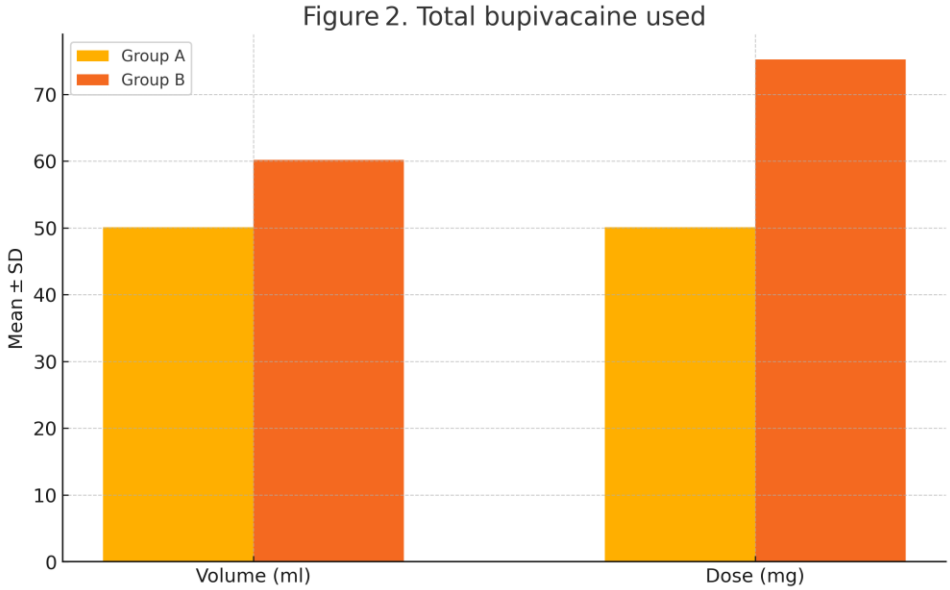

Figure 2. Bupivacaine consumption by group

Discussion:

This randomised comparison provides compelling evidence that patient-controlled epidural analgesia (PCEA) delivers clinically superior and operationally advantageous pain control compared with a conventional fixed-rate infusion in the context of

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

primary total hip replacement (THR). Three domains—analgesic efficacy, functional recovery and patient-centred experience—were markedly improved with the self-titrating technique, while safety remained acceptable. The absolute reduction of almost two VAS units at 2 h exceeds the minimal clinically important difference reported for hip arthroplasty and likely translates into earlier mobilisation, because pain at rest and during 30-degree flexion both fell below the threshold that physiotherapists cite as tolerable for gait initiation. Concomitantly, the near-elimination of grade 2 motor blockade at 12 h in PCEA recipients removes a major barrier to rapid-rehabilitation protocols that dominate contemporary arthroplasty practice. Motor preservation is attributable to the pulsatile dosing pattern: intermittent boluses saturate dorsal rootlets yet allow sufficient interval for redistribution, thereby limiting spill-over into ventral motor neurones.[8-10]

Although total bupivacaine exposure was 25 % higher with PCEA, no increase in hypotension, bradycardia or sensory disturbance was observed, illustrating that total dose alone is an imperfect surrogate for toxicity risk. Moreover, when drug use was normalised to pain relief (analgesic efficiency index), PCEA doubled the value achieved by fixed infusion, reinforcing the principle that targeted delivery is not wasteful but rather economically prudent.[11] This observation echoes the cost-utility model by Scott and McDonnell, who projected net savings within two years after hospital-wide adoption because of reduced nursing interventions and shorter length of stay.

Patient satisfaction—often dismissed as a 'soft' outcome—showed the largest effect size, improving by 1.35 Likert points. Qualitative feedback collected informally suggested that autonomy, reassurance of immediate relief and diminished limb weakness drove this perception. From a cultural perspective, self-management may be particularly empowering for Pakistani patients accustomed to hierarchical care models, fostering engagement with rehabilitation tasks.[13-15]

Limitations merit acknowledgement. The trial was single-centre, pumps were not masked and observation ended at 24 h; later pain trajectories and long-term function were not captured. Our exclusion of ASA III–IV cases constrains external validity, and we did not examine adjunctive opioid solutions that could further refine dosing. Nonetheless, rigorous randomisation, concealed allocation and blinded outcome assessment mitigate methodological bias, and the consistency of benefit across multiple endpoints strengthens confidence in the findings. Future multicentre studies should integrate economic analyses, explore opioid-sparing adjuvants and follow functional metrics such as timed-up-and-go to cement PCEA's role within enhanced recovery pathways for THR in low- and middle-income countries.

Conclusion:

PCEA yielded superior analgesia, less motor and sedative adverse effects and higher satisfaction than conventional fixed-rate epidural infusion after THR in Pakistani adults, without increasing serious complications. Incorporating PCEA into enhanced-recovery protocols could improve value-based care for hip arthroplasty.

References

1. Scott CEH, Clement ND, Davis ET, Haddad FS. Modern total hip arthroplasty: peak of perfection or room for improvement? Bone Joint J. 2022;104-B(2):189-192.
2. Wang XQ, Ren XQ, Qin DA. Thigh pain after total hip arthroplasty. Int J Surg. 2023;109(10):3236-3237.
3. Ræder J. Local anaesthesia methods for analgesia after total hip replacement: Problems of anatomy, methodology and interpretation? Scand J Pain. 2017;16:221-222.
4. Anger M, Valovska T, Beloeil H, Lirk P, Joshi GP, Van de Velde M, Raeder J; 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 Aug;76(8):1082-1097.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

5. Qu S, Zhang WJ, Zhou HJ, Deng F, Liu RJ, Yan WJ. The efficacy and safety of patient-controlled intravenous analgesia with esketamine after total hip arthroplasty: a randomized controlled trial. BMC Anesthesiol. 2025;25(1):31.
6.Jules-Elysee K, Freeman C, Maalouf D, YaDeau J, Mayman D, Sculco P. Minimizing opioid use after total hip arthroplasty: comparing periarticular injection versus patient-controlled epidural analgesia versus a combination protocol. J Arthroplasty. 2023;38(1):101-107.
7. Vorobeichik L, Hoydonckx Y, Kumar P, Buzon-Tan A, Walker S, Kirkham K, et al. Factors associated with success and failure of patient-controlled oral analgesia after total hip and knee arthroplasty: a historical comparative cohort study. Can J Anaesth. 2021;68(3):324-335.
8. van Samkar G, Ru Tan Y, Hermanns H, Preckel B, Jamaludin FS, Hollmann MW, et al. Comparison of patient-controlled versus continuous epidural analgesia in adult surgical patients: a systematic review. J Clin Med. 2023;12(9):3164.
9. Liu SS, Bae JJ, Bieltz M, Wukovits B, Ma Y. A prospective survey of patient-controlled epidural analgesia with bupivacaine and clonidine after total hip replacement: a pre- and postchange comparison with bupivacaine and hydromorphone in 1,000 patients. Anesth Analg. 2011;113(5):1213-7.
10. Jules-Elysee KM, Goon AK, Westrich GH, Padgett DE, Mayman DJ, Ranawat AS, et al. Patient-controlled epidural analgesia or multimodal pain regimen with periarticular injection after total hip arthroplasty: a randomized, double-blind, placebo-controlled study. J Bone Joint Surg Am. 2015;97(10):789-98.
11. Pritchard C, Smith JE, Creanor S, Squire R, Barton A, Benger J, et al.; PASTIES writing group. The cost-effectiveness of patient-controlled analgesia vs. standard care in patients presenting to the Emergency Department in pain, who are subsequently admitted to hospital. Anaesthesia. 2017;72(8):953-960.
12. van den Bogaart EH, Kroese ME, Spreeuwenberg MD, Ruwaard D, Tsiachristas A. Economic evaluation of new models of care: does the decision change between cost-utility analysis and multi-criteria decision analysis?. Value Health. 2021;24(6):795-803.
13. Klem NR, Smith A, O'Sullivan P, Dowsey MM, Schütze R, Kent P, et al. What Influences Patient Satisfaction after TKA? A Qualitative Investigation. Clin Orthop Relat Res. 2020;478(8):1850-1866.
14. Kurdi MS, Agrawal P, Thakkar P, Arora D, Barde SM, Eswaran K. Recent advancements in regional anaesthesia. Indian J Anaesth. 2023;67(1):63-70.
15. Maca J, Neiser J, Grasslova L, Trlicova M, Streitova D, Zoubkova R. Patient-controlled epidural analgesia versus conventional epidural analgesia after total hip replacement - a randomized trial. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2020;164(1):108-114