Systemic Opioid-Sparing Efficacy of Emergency Department-Initiated Regional Nerve Blocks in Acute Multiple-Extremity Trauma: A Rapid Systematic Review and Meta-analysis of Resuscitation-Bay Outcomes

Ria Singh Rawat[1*], Sunita Parmar[2], Tanishka Muraleedharan[3], Suhani Doharey[3], Seersha Gurajapu[4], Josh Reji Joseph[5], Sowmya Kamakshi[6]

[1*]Department of Emergency Medicine, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India | CMO | Email: riasinghrawat18@gmail.com

[2]Department of Emergency Medicine, BGS Global Institute of Medical Sciences, Bengaluru, Karnataka, India | Assistant Professor

[3]Department of Emergency Medicine, ACS Medical College and Hospital, Chennai, Tamil Nadu, India | Medical Student

[4]Department of Emergency Medicine, Mahatma Gandhi Memorial Hospital, Warangal, Telangana, India | MBBS

[5]Department of Emergency Medicine, Kannur District Hospital, Kannur, Kerala, India | MBBS

[6]Department of Emergency Medicine, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India | Junior Resident

***Corresponding Author:** Ria Singh Rawat, CMO, Department of Emergency Medicine, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India | Email: riasinghrawat18@gmail.com

Abstract

Background: Severe pain from acute extremity trauma is commonly treated with intravenous opioids during emergency resuscitation, yet repeated dosing can complicate neurological assessment, ventilation, hemodynamic monitoring, and delirium prevention. Regional nerve blocks may interrupt nociception without the same systemic exposure, but evidence directly involving multiple-extremity trauma is sparse. Objective: To estimate the opioid-sparing association of emergency department (ED)-initiated regional nerve blocks and to determine how confidently isolated-extremity evidence can be transferred to resuscitation-bay polytrauma. Methods: A structured rapid review of PubMed-indexed studies, open full texts, guideline repositories, and backward citations was updated through 21 July 2026. Controlled ED or prehospital studies of acute traumatic extremity pain were synthesized narratively. A random-effects DerSimonian-Laird meta-analysis pooled trials reporting whether a patient received any rescue/systemic opioid after block allocation. Results: Twelve controlled or comparative studies informed the qualitative synthesis; four studies (n=459) provided compatible binary rescue-opioid data. Regional blockade reduced the probability of receiving systemic/rescue opioid compared with systemic analgesia or sham (risk ratio 0.50, 95% confidence interval 0.33-0.75), with substantial heterogeneity (I^2=80.9%; tau^2=0.123). Leave-one-out estimates remained below unity (RR range 0.44-0.55). Individual studies also reported faster pain relief, lower morphine-equivalent exposure, fewer opioid-related adverse effects, or less procedural sedation, although neutral trials occurred when background opioid treatment was already established or when sham-controlled opioid demand was low. No included randomized trial specifically enrolled hemodynamically unstable patients with simultaneous injuries to multiple extremities. Conclusions: ED-initiated regional nerve blocks produce a credible opioid-sparing signal in acute extremity trauma, especially hip and femur fractures. The pooled effect should not be presented as definitive proof for complex polytrauma; rather, it supports protocolized use after resuscitation priorities, neurological documentation, cumulative local-anesthetic dosing, and compartment-syndrome surveillance are secured.

Keywords: Emergency medicine; regional anesthesia; peripheral nerve block; trauma; opioid-sparing analgesia; femoral nerve block; fascia iliaca block; PENG block; meta-analysis.

How to cite this article: Rawat RS, Parmar S, Muraleedharan T, Doharey S, Gurajapu S, Joseph JR, Kamakshi S. Systemic opioid-sparing efficacy of emergency department-initiated regional nerve blocks in acute multiple-extremity trauma: a rapid systematic review and meta-analysis of resuscitation-bay outcomes. Int J Drug Deliv Technol. 2026;16(7): 480-492. DOI: 10.25258/ijddt.16.7.51

Pooled rescue-opioid outcome: RR 0.50 (95% CI 0.33-0.75); I^2=80.9% across four controlled studies (n=459).

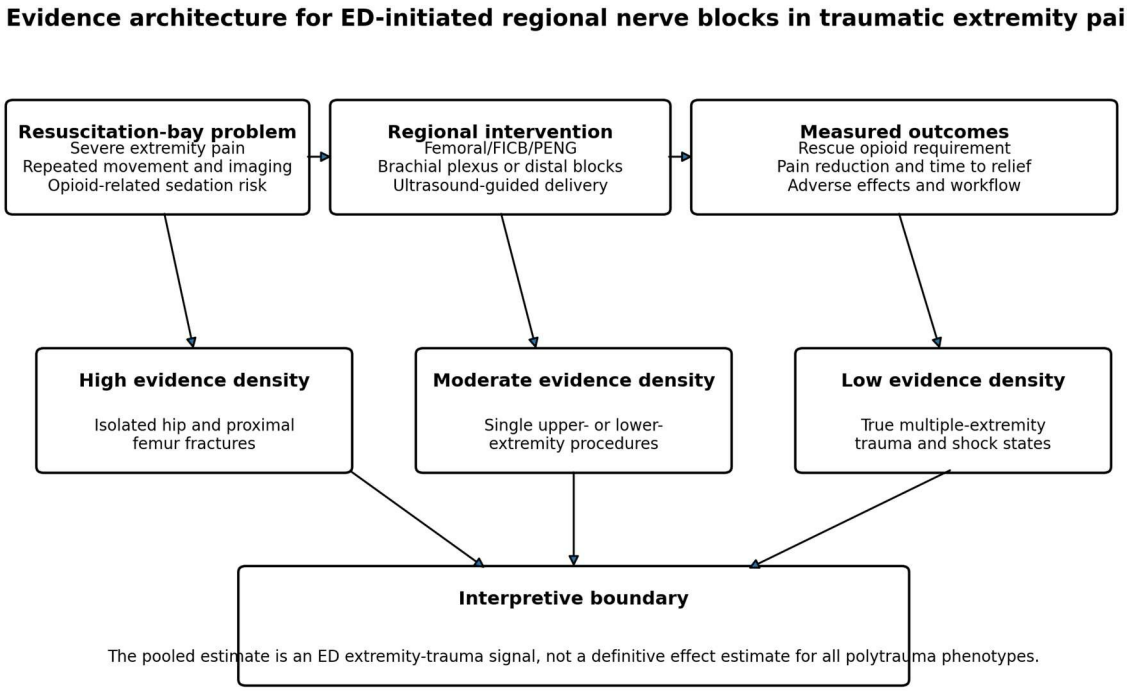

Figure 1. Evidence architecture and interpretive boundary for ED-initiated regional analgesia.

Table 1. Review question and eligibility framework.

Domain	Specification
Population	Children or adults with acute traumatic extremity pain managed in the ED or prehospital phase; primary interest in resuscitation-bay and multiple-injury applicability.
Intervention	Single-shot or continuous peripheral regional nerve block initiated before operative anesthesia; ultrasound, landmark, or nerve-stimulator guidance.
Comparator	Systemic opioid/non-opioid analgesia, sham block, procedural sedation, or another block for qualitative comparisons.
Primary pooled outcome	Proportion receiving any systemic or rescue opioid after treatment allocation.
Secondary outcomes	Cumulative opioid dose, pain intensity, time to relief, opioid-related adverse effects, procedural success, ED flow, block complications.
Quantitative inclusion	Controlled study with extractable or reconstructable binary event counts for rescue/systemic opioid use.
Exclusions	Elective procedures, blocks performed only after surgery, chronic pain, non-traumatic conditions, and reports lacking relevant analgesic outcomes.

Domain	Specification
Search update	Structured search and backward citation review completed through 21 July 2026.

1. Introduction

Acute multiple-extremity trauma creates an analgesic problem that is clinically different from a single uncomplicated fracture. Several painful structures may require repeated examination, reduction, splinting, transport, imaging, or operative preparation while the resuscitation team continues to assess cognition, perfusion, ventilation, and evolving neurovascular compromise. A systemic opioid can be rapidly titrated and remains indispensable, but escalating doses may produce respiratory depression, nausea, hypotension, sedation, pruritus, urinary retention, or delirium. These effects are especially consequential in older adults, patients with head injury, and patients whose shock physiology changes drug distribution. Contemporary trauma and emergency-pain guidance therefore treats regional anesthesia as one component of multimodal analgesia rather than as a replacement for stabilization or definitive care [1-3].

The opioid-sparing rationale has both immediate and downstream dimensions. During the first hours, reducing parenteral opioid exposure may preserve mental-status assessment and limit the need for antiemetics, airway support, or prolonged observation. At a population level, prescribing behavior in the ED can influence subsequent opioid exposure, although a single block cannot by itself resolve the broader causes of persistent use [4]. In older hip-fracture populations, inadequately controlled pain and opioid administration have each been associated with delirium risk, making balanced analgesia more important than simply minimizing one drug class [5]. Guidelines for hip-fracture care consequently recommend multimodal analgesia incorporating a preoperative nerve block when expertise is available [6].

Peripheral nerve blocks offer targeted interruption of afferent input using local anesthetic deposited near a nerve or within a fascial plane. Femoral nerve block (FNB), fascia iliaca compartment block (FICB), and pericapsular nerve group (PENG) block dominate the proximal-femur literature; interscalene, supraclavicular, axillary, forearm, popliteal-sciatic, and ankle techniques cover other injury patterns. Systematic reviews consistently show improved early pain scores and reduced systemic analgesic exposure after preoperative blocks for hip fracture, but they also identify heterogeneity in block technique, comparator treatment, opioid conversion, timing, and outcome definitions [7-12].

The biological advantage of regional analgesia is most relevant when nociceptive input is intense and anatomically localizable. Blocking sodium-channel propagation near the injured limb can decrease peripheral signaling before it amplifies spinal sensitization, while leaving the patient's central respiratory drive and global level of consciousness comparatively intact. That distinction matters during serial trauma assessment: a comfortable patient who remains interactive can cooperate with imaging, splinting, reduction, wound care, and consent. However, regional anesthesia is not physiologically neutral. Sympathetic effects are usually limited with distal peripheral blocks, but motor blockade, inadvertent intravascular injection, hematoma, and local-anesthetic toxicity remain possible. In addition, somatic blocks do not treat visceral, thoracic, or diffuse pain. The clinically useful comparison is therefore not block versus opioid as mutually exclusive choices; it is a block-centered multimodal strategy versus a strategy that relies predominantly on systemic medication. This framing avoids the unrealistic endpoint of zero opioid exposure and recognizes that the goal is better analgesic efficiency: adequate relief, fewer systemic adverse effects, preserved examination, and smoother completion of time-sensitive care.

The title question is narrower and more demanding than the available literature. The ideal evidence would randomize resuscitation-bay patients with simultaneous injuries to two or more extremities, measure cumulative morphine milligram equivalents, account for shock and head injury, and report whether blocks delayed recognition of compartment syndrome or nerve injury. Such trials were not identified. This study therefore addresses two linked aims: first, to quantify the compatible binary evidence on rescue opioid administration after ED-initiated regional blockade; and second, to distinguish what can be concluded for acute extremity trauma from what remains uncertain in true multiple-extremity polytrauma.

2. Methods

2.1 Design and reporting approach. This work was conducted as a rapid systematic review with an aggregate-

data meta-analysis. It was prepared as a research-paper draft rather than a prospectively registered review. Reporting was informed by PRISMA 2020 principles, but a conventional PRISMA flow count is not presented because searches were iterative and evidence-mapping oriented rather than executed through a frozen, deduplicated bibliographic database [46]. The absence of registration and dual independent screening is treated as a methodological limitation, not concealed as a completed protocol.

2.2 Search strategy and eligibility. Searches were updated through 21 July 2026 using combinations of emergency department, resuscitation, trauma, fracture, dislocation, extremity, regional anesthesia, peripheral nerve block, femoral nerve block, fascia iliaca, PENG, brachial plexus, ultrasound, opioid, morphine, fentanyl, and rescue analgesia. PubMed-indexed records, publisher full texts, professional guidelines, systematic reviews, and reference lists were examined. Studies were eligible for qualitative synthesis when they included acute traumatic extremity pain treated in the ED or prehospital phase, delivered a regional block before operative anesthesia, and reported pain, opioid use, rescue analgesia, procedural sedation, adverse effects, or workflow outcomes. Elective surgery and purely postoperative block studies were excluded from the main evidence table but could inform technique or safety discussion.

2.3 Meta-analysis eligibility and outcome definition. The quantitative synthesis was restricted to controlled studies that allowed reconstruction of the number of participants receiving any systemic or rescue opioid after allocation. Four studies met this requirement: an ultrasound-guided three-in-one FNB trial, a representative geriatric FNB trial, a double-blind FNB-versus-fentanyl trial, and a placebo-controlled FICB trial [13-16]. Event counts in O'Connor et al. were reconstructed from reported opioid-free proportions; all other counts were directly reported or recoverable from trial tables. Continuous opioid doses were not pooled because investigators used different time windows, agents, routes, conversions, and summary statistics.

2.4 Data extraction and outcome harmonization. Sample size, treatment assignment, injury type, block technique, comparator, local anesthetic, follow-up interval, rescue-analgesia events, cumulative opioid exposure, pain outcomes, and reported complications were extracted from full text or detailed trial summaries. When percentages rather than counts were reported, integer events were reconstructed using the published group denominator and checked against the stated proportion. Morphine-equivalent values were retained for narrative comparison only because conversion methods, routes, and observation windows were not sufficiently uniform. A patient was classified as an event for the primary endpoint if the report indicated any post-allocation opioid or rescue opioid administration. This approach favors interpretability but does not distinguish one small rescue dose from repeated high-dose treatment. Discordant definitions were recorded as a source of clinical heterogeneity rather than forced into a continuous-dose model.

2.5 Statistical analysis. For each study, the effect measure was a risk ratio (RR) comparing the probability of receiving any rescue/systemic opioid in the block group with the comparator group. Log risk ratios were pooled with a DerSimonian-Laird random-effects model. Statistical heterogeneity was summarized with Cochran's Q, I^2, and tau^2; I^2 was interpreted as the proportion of observed dispersion not readily attributable to sampling error [47]. Leave-one-out analyses tested dependence on any single study. Because only four studies were pooled, funnel-plot inspection was considered exploratory and no formal test for small-study effects was performed.

2.6 Risk of bias and certainty. Randomization, allocation concealment, blinding, missing data, selective reporting, and outcome measurement were considered using domains aligned with contemporary Cochrane risk-of-bias concepts [48]. Performance bias was expected in comparisons where clinicians and patients could not be blinded to an active block. Certainty was downgraded for inconsistency, indirectness to multiple-extremity trauma, and imprecision. Safety interpretation emphasized local-anesthetic systemic toxicity (LAST), vascular puncture, infection, nerve injury, motor weakness, falls, anticoagulation, and the possibility that analgesia might complicate serial examination. A current LAST checklist was treated as an essential implementation safeguard [50].

Table 2. Principal controlled and comparative evidence informing the synthesis.

Study	Design/population	Comparison	Key outcome

Study	Design/population	Comparison	Key outcome
Beaudoin 2013 [13]	ED RCT; hip fracture; n=36	US-guided 3-in-1 FNB vs parenteral opioids	Rescue analgesia 5/18 vs 14/18; lower 4-h pain; median rescue morphine 0 vs 5 mg.
Unneby 2017 [14]	RCT; geriatric hip fracture; n=266	FNB vs standard analgesia	Any opioid about 39% vs 84%; mean IV opioid 2.3 vs 5.7 mg.
Altunbas 2026 [15]	Double-blind RCT; hip fracture; n=104	FNB vs IV fentanyl	Rescue analgesia 21.1% vs 61.5%; greater pain reduction; no FNB complication reported.
O'Connor 2025 [16]	Double-blind placebo RCT; hip fracture; n=53	US-guided FICB vs saline sham	Median 6-h morphine demand 3 vs 3 mg; opioid-free 24% vs 4%; later first request favored FICB.
Pasquier 2019 [17]	Double-blind RCT after prehospital morphine; n=30	Landmark FICB vs sham	No significant 24-h morphine or pain-trajectory difference.
Gerlier 2024 [18]	ED RCT; hip fracture; n=30	Early US-guided FNB vs morphine titration	Median preoperative opioid exposure 6 vs 15 MME; faster/stronger opioid-sparing signal.
Morrison 2016 [21]	Programmatic RCT; hip fracture; n=161	Regional block pathway vs conventional analgesia	Lower parenteral morphine equivalents and fewer opioid-related side effects.
Buttner 2018 [24]	Prehospital RCT; dislocated extremity injury; n=30	US-guided PNB vs systemic analgosedation	Improved feasibility of painful reduction procedures with less reliance on systemic sedation.

3. Results

3.1 Evidence profile. The evidence map was dominated by isolated hip and proximal-femur injuries. Beaudoin et al. randomized 36 ED patients and found fewer rescue-analgesia recipients after ultrasound-guided three-in-one FNB than after parenteral opioids alone [13]. Unneby et al. enrolled 266 older patients and reported a marked reduction in both intravenous opioid exposure and the proportion receiving opioids [14]. Altunbaş et al. compared FNB with intravenous fentanyl in 104 patients and observed lower rescue-analgesia use after the block [15]. In the placebo-controlled FICB trial by O'Connor et al., median six-hour morphine demand was similar, although more block recipients remained opioid-free and the time to first request favored active treatment [16].

Neutral or context-dependent findings were also important. Pasquier et al. administered prehospital morphine before randomization; their landmark FICB did not significantly reduce 24-hour morphine consumption, suggesting that timing, background therapy, and technique can attenuate a block's measurable incremental benefit [17]. Gerlier et al. reported substantially lower preoperative opioid consumption after early ultrasound-guided FNB [18], whereas Mayel et al. found broadly comparable early analgesia between FNB and fentanyl with fewer opioid-type adverse effects in the block pathway [19]. A continuous femoral catheter strategy in the FINOF trial did not improve its primary dynamic-pain or ambulation outcomes despite some rest-pain benefit

[20]. Morrison et al. demonstrated that a structured regional-analgesia program could reduce parenteral morphine equivalents and opioid-related side effects, highlighting the value of implementation systems rather than isolated technical competence [21].

Table 3. Study-level binary data used in the rescue-opioid meta-analysis.

Study	Block events	Control events	RR	95% CI	Design
Beaudoin et al., 2013	5/18	14/18	0.36	0.16-0.78	Randomized controlled
Unneby et al., 2017	54/137	108/129	0.47	0.38-0.59	Randomized controlled
Altunbaş et al., 2026	11/52	32/52	0.34	0.19-0.61	Randomized controlled
O'Connor et al., 2025	22/29	23/24	0.79	0.63-0.99	Randomized controlled

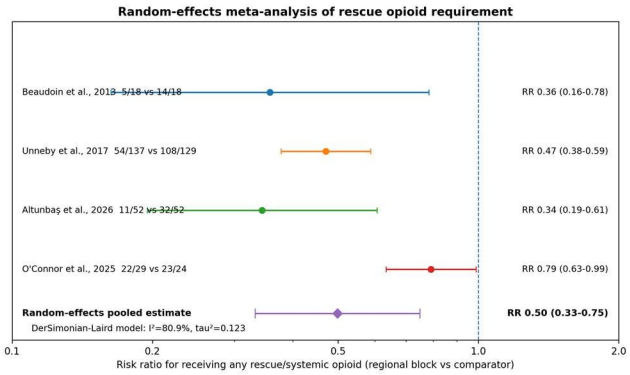

Figure 2. Random-effects meta-analysis of the probability of receiving rescue/systemic opioid.

Additional studies broadened the trauma context without providing compatible binary data. FNB and FICB have been compared directly for femoral fractures [22]; observational ED data support lower opioid exposure after FNB in geriatric hip fracture [23]; and a prehospital randomized trial found that ultrasound-guided blocks facilitated reduction of dislocated extremity injuries compared with systemic analgosedation [24]. Pediatric femur-fracture evidence, shoulder-reduction trials, forearm blocks, and popliteal-sciatic blocks demonstrate that the opioid-sparing concept is anatomically transferable, although the outcome and procedural contexts differ [25-28]. Newer PENG studies compare block families rather than regional anesthesia with systemic opioids, so they refine technique selection more than they establish the overall opioid-sparing effect [29-32].

3.2 Primary meta-analysis. Across four studies, 92 of 236 participants assigned to a regional block and 177 of 223 assigned to a comparator received rescue or systemic opioids. The random-effects pooled RR was 0.50 (95% CI 0.33-0.75), indicating an estimated 50% relative reduction in the probability of opioid administration. Heterogeneity was substantial ($Q=15.71$, $df=3$; $I^2=80.9\%$; $tau^2=0.123$). The direction of effect favored regional blockade in every study, but the magnitude ranged from a large reduction in early FNB trials to a smaller effect in the placebo-controlled FICB trial.

3.3 Sensitivity and small-study assessment. Leave-one-out pooled estimates ranged from RR 0.44 to 0.55 and all confidence intervals remained below 1.00. Excluding the placebo-controlled O'Connor trial removed statistical heterogeneity, which indicates that its low overall opioid demand, sham control, and event definition differed materially from the other studies. The funnel plot appeared asymmetrical, but four points cannot distinguish publication bias from chance, clinical heterogeneity, or different comparator intensity. Formal regression tests would be underpowered and potentially misleading.

3.4 Pain, adverse effects, and operational outcomes. Most controlled studies reported clinically meaningful early pain reduction or longer time to rescue analgesia, although measurement times varied from 15 minutes to 48 hours. Interpretation considered that a statistically significant score change is not automatically meaningful to patients and should be judged against established concepts of clinically important pain improvement [49]. Reduced nausea, sedation, or other opioid-related effects were reported in several trials, while serious block-related complications were uncommon. This should not be interpreted as proof of zero risk because trial samples were small and often excluded anticoagulated, unstable, cognitively impaired, or anatomically complex patients. Evidence from systematic reviews supports lower pain and opioid consumption, but certainty remains low to moderate because of lack of blinding and high clinical heterogeneity [7-12,33-36].

3.5 Risk-of-bias pattern and certainty. Random sequence generation was generally adequate in the pooled trials, but concealment procedures were not always described in enough detail to rule out selection bias. Blinding was strongest in the sham-controlled and double-blind comparisons; open comparisons of an invasive block with routine systemic analgesia were intrinsically vulnerable to co-intervention and expectation effects. The binary rescue-opioid endpoint was objective once medication administration was recorded, although the

clinical threshold for giving rescue medication could still be influenced by knowledge of allocation. Missing outcome data were limited in the principal trials, but small samples widened confidence intervals and reduced the ability to detect rare adverse events. The overall certainty for an opioid-sparing effect was judged low to moderate: the direction was consistent, but inconsistency was substantial and indirectness to multiple-extremity resuscitation was serious. Certainty for safety in unstable polytrauma was very low because the relevant patients were largely excluded rather than demonstrated to have equivalent outcomes.

Table 4. Quantitative synthesis and sensitivity analyses.

Analysis	Evidence	Pooled RR (95% CI)	Heterogeneity	Interpretation
Primary random-effects model	4 studies; n=459	0.50 (0.33-0.75)	I^2 80.9%; tau² 0.123	Substantial heterogeneity; all studies favored blocks.
Excluding Beaudoin et al., 2013	3 studies	0.53 (0.34-0.83)	I^2 86.0%	Direction and statistical significance retained.
Excluding Unneby et al., 2017	3 studies	0.49 (0.26-0.94)	I^2 79.9%	Direction and statistical significance retained.
Excluding Altunbaş et al., 2026	3 studies	0.55 (0.35-0.87)	I^2 83.7%	Direction and statistical significance retained.
Excluding O'Connor et al., 2025	3 studies	0.44 (0.36-0.54)	I^2 0.0%	Direction and statistical significance retained.
Small-study effects	4 studies	Not formally tested	Funnel plot only	Too few studies for a reliable regression test.

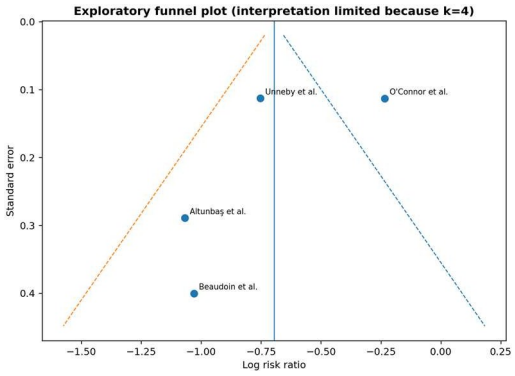

Figure 3. Exploratory funnel plot; interpretation is limited by the small number of studies.

4. Discussion

The pooled analysis supports a meaningful opioid-sparing association for ED-initiated regional nerve blocks in acute extremity trauma. A risk ratio near 0.50 is clinically attractive because it represents fewer patients crossing the threshold for systemic rescue medication, not merely a small difference in mean dose. The result also remained directionally stable when each trial was removed in turn. Nevertheless, the high I^2 value shows that the pooled number should be understood as an average across dissimilar protocols rather than a universal treatment effect.

Several mechanisms explain the heterogeneity. First, comparator intensity differed: some control groups received titrated opioids as the primary strategy, whereas others received sham injection plus patient-controlled rescue. Second, blocks ranged from landmark FICB to ultrasound-guided FNB, with variation in local-anesthetic agent, concentration, volume, operator experience, and confirmation of success. Third, studies measured opioid use over different windows and enrolled populations with different frailty and baseline exposure. Finally, the binary outcome can magnify small differences when nearly everyone in both groups receives at least one opioid dose, as occurred in the placebo-controlled trial. These factors support random-effects modeling but also limit direct bedside translation.

The result is consistent with earlier hip-fracture trials and reviews. Landmark and ultrasound-guided FNB/FICB studies have repeatedly demonstrated lower pain or analgesic requirements [37-41]. Prehospital FICB has also been performed by trained paramedics, indicating that an organized protocol can extend beyond anesthesia-led practice [42]. Yet national and institutional audits reveal uneven adoption, often because credentialing, equipment access, documentation, and quality assurance lag behind

technical enthusiasm [43,44]. Regional analgesia is therefore best treated as a clinical service line with training, supervision, dose tracking, and follow-up rather than as an occasional procedure.

The choice of a binary rescue-opioid endpoint deserves additional interpretation. It is less sensitive to incompatible dose-conversion practices and is easy to communicate, but it may understate a clinically important reduction in total exposure when both groups receive at least one dose. Conversely, it may exaggerate a difference when a single rescue dose moves a patient from the opioid-free category to the event category. A complete evaluation should therefore triangulate three measures: whether any opioid was needed, the cumulative morphine-equivalent dose, and the time until first rescue. Pain during movement should be measured separately from pain at rest because transfers and radiography often reveal inadequate coverage that a resting score misses. Patient satisfaction and ability to complete procedures without deep sedation are also meaningful, especially in a crowded ED where delayed imaging or reduction can prolong suffering and resource use.

Implementation may produce benefits that are not captured in efficacy trials. A reliable block pathway can standardize reassessment, reduce variation in opioid titration, and create an explicit handover between emergency medicine, trauma surgery, orthopedics, and anesthesia. It can also fail if the department lacks protected training, supervised early cases, ultrasound access, or a method to track complications after admission. Quality indicators should include block success, time from decision to injection, cumulative local-anesthetic dose documentation, rescue-opioid exposure, LAST preparedness, repeat neurovascular examination, and unplanned consultation. These measures make the program auditable and help distinguish a technically successful injection from a clinically effective analgesic episode.

For multiple-extremity trauma, the main challenge is not whether an individual block works; it is how to combine regional techniques without compromising resuscitation or diagnostic surveillance. Two or more blocks may require larger cumulative volumes, and local-anesthetic dose must be calculated across all sites and clinicians. Bilateral lower-limb blocks can create motor weakness that complicates transfer or later mobilization. A dense block may make an evolving nerve lesion harder to characterize if a baseline examination was not documented. Acute compartment syndrome remains a clinical diagnosis requiring repeated assessment of pain pattern, swelling, neurological findings, and perfusion; a nerve block should never become a reason to stop surveillance. Reviews of trauma anesthesia outside the operating room emphasize the need to select techniques that are anatomically focused, titratable, and compatible with serial assessment [1,45].

Hemodynamic instability introduces additional uncertainty. Severe shock may alter absorption and distribution of local anesthetic, while acidosis and hypoproteinemia can increase the unbound fraction. The immediate priorities remain hemorrhage control, transfusion, airway management, warming, and correction of reversible physiology. A block can be performed after these priorities are organized, particularly when repeated painful procedures are expected, but the decision should be individualized. Trials contributing to this meta-analysis do not establish safety or efficacy during uncontrolled hemorrhage.

Block choice should follow the dominant pain generator rather than the radiographic label alone. FNB is technically direct and effective for anterior thigh and much of the proximal femur but may spare obturator contributions. Infrainguinal or suprainguinal FICB can provide broader fascial spread, although block success is volume- and technique-dependent. PENG targets articular branches to the anterior hip capsule and may preserve quadriceps strength, yet ED trials comparing PENG with FICB show that superiority is not consistent and rescue-opioid differences may be small [29-32]. Upper-extremity injuries require a similar site-specific approach: interscalene blockade can expedite shoulder reduction but carries phrenic-nerve and airway considerations; supraclavicular or infraclavicular techniques cover more distal injuries; selective forearm blocks may avoid proximal motor and respiratory effects [26,27]. Popliteal-sciatic blockade is useful below the knee but does not cover the saphenous territory [28].

The most defensible resuscitation-bay endpoint is not complete opioid avoidance. Instead, success means achieving tolerable pain with the lowest systemic exposure compatible with safe care. A patient may still need small, titrated opioid doses for uncovered injuries, anxiety, visceral pain, or an incomplete block. Multimodal co-analgesia with acetaminophen, judicious nonsteroidal anti-inflammatory therapy, immobilization, ice, elevation, and communication should continue. The block creates an opioid-sparing platform; it does not replace compassionate reassessment.

External validity also depends on who performs the block and when it is delivered. A procedure completed

soon after the primary survey can reduce pain during the most manipulation-intensive part of care, whereas a block placed after several opioid doses may show less incremental benefit even if it remains clinically useful. Operator learning curves influence needle visualization, spread, procedure time, and the probability of incomplete coverage. Departments should define minimum training standards through simulation, supervised cases, image review, and periodic competency assessment. They should also agree on escalation rules for patients with altered anatomy, severe coagulopathy, pre-existing neuropathy, vascular injury, or anticipated operative nerve examination. In a multiple-injury patient, consultation with anesthesia or an acute-pain service may be appropriate when several high-volume blocks are considered. Shared decision-making is especially important because the optimal plan can involve a deliberately partial block that controls the dominant pain source while preserving motor function and diagnostic information elsewhere. Such pragmatism is more realistic than pursuing complete sensory abolition in every injured limb.

The findings also suggest priorities for future research. A pragmatic multicenter trial should enroll patients with at least two acutely injured extremities and stratify by shock, head injury, age, and anticoagulation. A standardized primary endpoint could be cumulative intravenous morphine equivalents from block completion to six hours, with secondary outcomes including proportion opioid-free, pain during movement, respiratory events, delirium-free days, time to imaging and reduction, block failure, compartment-syndrome recognition, and patient-reported quality of analgesia. Cluster or stepped-wedge implementation designs may be more feasible than individual randomization because regional-analgesia capability is often delivered as a departmental protocol.

5. Clinical Implications for the Resuscitation Bay

A practical protocol begins after immediate life threats are addressed. The clinician documents pre-block sensation, motor function, pulses, capillary refill, swelling, and pain characteristics for every injured limb. Contraindications and relative risks are reviewed, including refusal, infection at the injection site, true local-anesthetic allergy, inability to monitor, distorted anatomy, relevant anticoagulation, and pre-existing neurological deficit. The team then maps each major pain generator to the smallest number of blocks likely to produce useful coverage.

Safety depends on process discipline. Ultrasound visualization, incremental injection, repeated aspiration, continuous cardiorespiratory observation, labeled syringes, and an explicit cumulative milligram calculation are required when several blocks are contemplated. Lipid emulsion and a current LAST response checklist should be immediately available [50]. The post-block record should state the agent, concentration, volume, time, operator, ultrasound findings, neurological reassessment, pain response, and handover plan.

Reassessment at 15-30 minutes determines whether the block succeeded and whether systemic rescue is still needed. Failure should prompt anatomical review rather than automatic repeat dosing. Pain that becomes disproportionate, returns abruptly, or is accompanied by tense swelling or neurological change requires urgent evaluation rather than attribution to an incomplete block. This structured approach preserves the principal benefit identified by the meta-analysis while addressing the diagnostic and pharmacological risks unique to multiple-injury care.

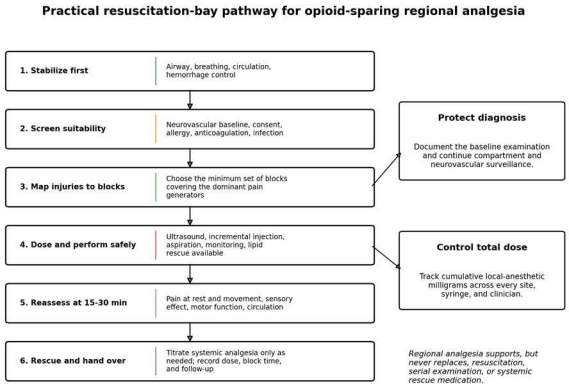

Figure 4. Protocol pathway for resuscitation-bay regional analgesia.

6. Limitations

This synthesis has important limitations. It was a rapid review without protocol registration, duplicate screening, or a fully reproducible database export. The quantitative analysis used aggregate data and a binary endpoint that was not identically defined across trials. One study's event counts were reconstructed from published percentages. Only four studies were compatible, so heterogeneity estimates are imprecise and publication bias cannot be assessed reliably. Most participants had isolated hip or femur fractures, and many were older but hemodynamically stable; direct

applicability to young polytrauma patients, bilateral injuries, open fractures, vascular injury, or shock is uncertain. Safety events were too uncommon to estimate rare harms. The pooled result should therefore be considered hypothesis-strengthening evidence for a protocol, not definitive proof for every resuscitation-bay scenario.

7. Conclusion

Emergency department-initiated regional nerve blocks reduce the likelihood that patients with acute traumatic extremity pain will require systemic or rescue opioids. In four controlled studies, the pooled risk ratio was 0.50, although heterogeneity was high and the evidence was concentrated in hip and femur fractures. The appropriate clinical interpretation is that regional anesthesia can materially lower opioid exposure when embedded in multimodal care, not that it eliminates the need for systemic analgesia or is already proven in unstable multiple-extremity trauma. Protocolized patient selection, baseline neurovascular documentation, cumulative local-anesthetic dose control, continued compartment-syndrome surveillance, and prompt rescue treatment are essential for safe translation.

Table 5. Operational checklist for multiple-extremity regional analgesia.

Phase	Required actions
Before block	Complete primary resuscitation priorities; identify dominant pain generators; obtain consent where possible; document baseline sensory, motor, pulse, capillary refill, swelling, and compartment findings.
Contraindication screen	Injection-site infection, local-anesthetic allergy, inability to monitor, unacceptable anticoagulation risk, distorted anatomy, uncertain neurological baseline, or refusal.
Dose governance	Record agent, concentration, planned volume, patient weight, maximum dose, and cumulative milligrams from all blocks and infiltrations.
Technique	Use ultrasound when available; maintain sterile technique; inject incrementally with repeated aspiration; stop for pain, resistance, tinnitus, metallic taste, agitation, seizure, or cardiovascular change.
Monitoring	Continuous pulse oximetry and ECG during/after block according to local policy; resuscitation drugs and lipid emulsion immediately available.
Outcome assessment	Record pain at rest and movement at 15-30 min, sensory distribution, motor effect, procedure tolerance, and systemic rescue medication.
Serial surveillance	Continue neurovascular and compartment assessments; urgently evaluate disproportionate breakthrough pain, tense swelling, or new deficit.
Handover	Communicate block type/time, expected duration, cumulative local-anesthetic dose, motor limitations, rescue plan, and next examination time.

Conflict of interest – Authors declare no conflict of interest
Funding - None

References

1. Mirea L, Dumitriu AM, Cobilinschi C, Ene R, Ungureanu R. Integrating peripheral nerve blocks in multiple trauma care: current evidence and clinical challenges. J Clin Med. 2025;14(15):5598. doi:10.3390/jcm14155598.
2. American College of Surgeons Trauma Quality Programs. Best practices guidelines for acute pain management in trauma patients. Chicago: American College of Surgeons; 2020.
3. European Society for Emergency Medicine. Guidelines for the management of acute pain in emergency situations. Brussels: EUSEM; 2025.
4. Barnett ML, Olenski AR, Jena AB. Opioid-prescribing patterns of emergency physicians and risk of long-term use. N Engl J Med. 2017;376(7):663-673. doi:10.1056/NEJMsa1610524.
5. Morrison RS, Magaziner J, Gilbert M, Koval KJ, McLaughlin MA, Orosz G, et al. Relationship between pain and opioid analgesics on the development of delirium following hip fracture. J Gerontol A Biol Sci Med Sci. 2003;58(1):76-81. doi:10.1093/gerona/58.1.M76.
6. American Academy of Orthopaedic Surgeons. Management of hip fractures in older adults: evidence-based clinical practice guideline. Rosemont (IL): AAOS; 2021.

7. Guay J, Kopp S. Peripheral nerve blocks for hip fractures in adults. Cochrane Database Syst Rev. 2020;11:CD001159. doi:10.1002/14651858.CD001159.pub3.
8. Exsteen OW, Svendsen CN, Rothe C, Lange KHW, Lundstrom LH. Ultrasound-guided peripheral nerve blocks for preoperative pain management in hip fractures: a systematic review. BMC Anesthesiol. 2022;22:192. doi:10.1186/s12871-022-01720-7.
9. Zaki HA, Iftikhar H, Shallik N, Elmoheen A, Bashir K, Shaban EE, et al. Ultrasound-guided regional anesthesia versus parenteral opioids alone for analgesia in emergency department patients with hip fractures: a systematic review and meta-analysis. Heliyon. 2022;8(12):e12413. doi:10.1016/j.heliyon.2022.e12413.
10. Abu Halimah J, Zalah AA, Alammari AH, Basowed SB, et al. Regional nerve blocks for trauma pain in the emergency department: a systematic review of efficacy and safety. Cureus. 2025;17(4):e82073. doi:10.7759/cureus.82073.
11. Gupta S, Ganti L. Ultrasound-guided femoral nerve block for hip fracture pain management in the emergency department: a systematic review. Acad Anesth. 2026. doi:10.62186/001c.156358.
12. Liu C, Han S, Wei A, Yang L, Yang M. Ultrasound-guided fascia iliaca compartment block versus intravenous analgesia in geriatric hip fractures: a systematic review and meta-analysis. Front Med (Lausanne). 2025;12:1611618. doi:10.3389/fmed.2025.1611618.
13. Beaudoin FL, Haran JP, Liebmann O. A comparison of ultrasound-guided three-in-one femoral nerve block versus parenteral opioids alone for analgesia in emergency department patients with hip fractures: a randomized controlled trial. Acad Emerg Med. 2013;20(6):584-591. doi:10.1111/acem.12154.
14. Unneby A, Svensson O, Gustafson Y, Olofsson B. Femoral nerve block in a representative sample of elderly people with hip fracture: a randomised controlled trial. Injury. 2017;48(7):1542-1549. doi:10.1016/j.injury.2017.04.043.
15. Altunbas E, Kudu E, Unal E, Sanri E, Karacabey S, Gunduz OH. Femoral nerve block versus intravenous fentanyl for hip fracture pain in the emergency department: a randomized double-blind clinical trial. Am J Emerg Med. 2026;99:359-364.
16. O'Connor RD, Postma S, Van Kamp D, Benraad ACE, Lommen A, Korver S, et al. Effect of ultrasound-guided fascia iliaca compartment block on pain management in hip fracture patients: a double-blind placebo-controlled randomized clinical trial. Medicine (Baltimore). 2025;104(40):e44622. doi:10.1097/MD.0000000000044622.
17. Pasquier M, Taffe P, Hugli O, Borens O, Kirkham KR, Albrecht E. Fascia iliaca block in the emergency department for hip fracture: a randomized, controlled, double-blind trial. BMC Geriatr. 2019;19:180. doi:10.1186/s12877-019-1193-0.
18. Gerlier C, Mijahed R, Fels A, Bekka S, Courseau R, Singh AL, et al. Effect of early ultrasound-guided femoral nerve block on preoperative opioid consumption in emergency patients with hip fracture: a randomized trial. Eur J Emerg Med. 2024;31(1):18-28. doi:10.1097/MEJ.0000000000001075.
19. Mayel M, Foroughian M, Zamani N, Shahabinejad N, Hassanian-Moghaddam H. Ultrasound-guided femoral nerve block and intravenous fentanyl in pain management of patients with hip fracture: a prospective randomized single-blinded clinical trial. Acute Med Surg. 2022;9:e804. doi:10.1002/ams2.804.
20. Rowlands M, Walt G van de, Bradley J, Mannings A, Armstrong S, Bedforth NM, et al. Femoral nerve block intervention in neck of femur fracture (FINOF): a randomised controlled trial. BMJ Open. 2018;8:e019650. doi:10.1136/bmjopen-2017-019650.
21. Morrison RS, Dickman E, Hwang U, Akhtar S, Ferguson T, Huang J, et al. Regional nerve blocks improve pain and functional outcomes in hip fracture: a randomized controlled trial. J Am Geriatr Soc. 2016;64(12):2433-2439. doi:10.1111/jgs.14386.
22. Rukerd MRZ, Erfaniparsa L, Movahedi M, Mirkamali H, Alizadeh SD, Ilaghi M, et al. Ultrasound-guided femoral nerve block versus fascia iliaca compartment block for femoral fractures in the emergency department: a randomized controlled trial. Acute Med Surg. 2024;11:e936. doi:10.1002/ams2.936.
23. Tsai TY, Mun CK, Su YC, Shih MC, Chau SW, Chen MW, et al. Ultrasound-guided femoral nerve block in geriatric patients with hip fracture in the emergency department. J Clin Med. 2022;11(10):2778. doi:10.3390/jcm11102778.
24. Buttner B, Mansur A, Kalmbach M, Hinz J, Volk T, Szalai K, et al. Prehospital ultrasound-guided nerve blocks improve reduction-feasibility of dislocated extremity injuries compared with systemic analgesia: a randomized controlled trial. PLoS One. 2018;13(7):e0199776. doi:10.1371/journal.pone.0199776.
25. Wathen JE, Gao D, Merritt G, Georgopoulos G, Battan FK. A randomized controlled trial comparing a fascia iliaca compartment nerve block to a traditional systemic analgesic for femur fractures in a pediatric emergency department. Ann Emerg Med. 2007;50(2):162-171.
26. Blaivas M, Adhikari S, Lander L. A prospective comparison of procedural sedation and ultrasound-

guided interscalene nerve block for shoulder reduction in the emergency department. Acad Emerg Med. 2011;18(9):922-927.

27. Liebmann O, Price D, Mills C, Gardner R, Wang R, Wilson S, et al. Feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves for hand procedures in the emergency department. Ann Emerg Med. 2006;48(5):558-562.
28. Herring AA, Stone MB, Fischer J, Frenkel O, Nagdev A. Ultrasound-guided distal popliteal sciatic nerve block for emergency department anesthesia. Am J Emerg Med. 2011;29(6):697.e3-697.e5.
29. Di Pietro S, Maffeis R, Jannelli E, Mascia B, Resta F, De Silvestri A, et al. Comparing the pericapsular nerve group block and fascia iliaca block for acute pain management in patients with hip fracture: a randomised clinical trial. Anaesthesia. 2025;80(12):1484-1492. doi:10.1111/anae.16695.
30. Koh WU, Kim HJ, Park HS, et al. Comparison of analgesic effect of pericapsular nerve group block and supra-inguinal fascia iliaca compartment block on dynamic pain in patients with hip fractures: a randomized controlled trial. Reg Anesth Pain Med. 2025;50:635-640. doi:10.1136/rapm-2024-105627.
31. Fahey A, Cripps E, Ng A, Sweeny A, Snelling PJ. Pericapsular nerve group block for hip fracture is feasible, safe and effective in the emergency department: a prospective observational comparative cohort study. Emerg Med Australas. 2022;34(6):884-891.
32. Morrison C, Brown B, Lin DY, Jaarsma R, Kroon H. Analgesia and anesthesia using the pericapsular nerve group block in hip surgery and hip fracture: a scoping review. Reg Anesth Pain Med. 2021;46(2):169-175.
33. Ritcey B, Pageau P, Woo MY, Perry JJ. Regional nerve blocks for hip and femoral neck fractures in the emergency department: a systematic review. CJEM. 2016;18(1):37-47. doi:10.1017/cem.2015.75.
34. Riddell M, Ospina M, Holroyd-Leduc JM. Use of femoral nerve blocks to manage hip fracture pain among older adults in the emergency department: a systematic review. CJEM. 2016;18(4):245-252. doi:10.1017/cem.2015.94.
35. Steenberg J, Moller AM. Systematic review of the effects of fascia iliaca compartment block on hip fracture patients before operation. Br J Anaesth. 2018;120(6):1368-1380.
36. Skjold C, Moller AM, Wildgaard K. Pre-operative femoral nerve block for hip fracture: a systematic review with meta-analysis. Acta Anaesthesiol Scand. 2020;64(1):23-33.
37. Fletcher AK, Rigby AS, Heyes FL. Three-in-one femoral nerve block as analgesia for fractured neck of femur in the emergency department: a randomized, controlled trial. Ann Emerg Med. 2003;41(2):227-233.
38. Foss NB, Kristensen BB, Bundgaard M, Bak M, Heiring C, Virkelyst C, et al. Fascia iliaca compartment blockade for acute pain control in hip fracture patients: a randomized, placebo-controlled trial. Anesthesiology. 2007;106(4):773-778.
39. Haines L, Dickman E, Ayvazyan S, Pearl M, Wu S, Rosenblum D, et al. Ultrasound-guided fascia iliaca compartment block for hip fractures in the emergency department. J Emerg Med. 2012;43(4):692-697.
40. Beaupre LA, Menon MR, Almaazmi K, Kang SH, Dieleman S, Tsui B. Preoperative nerve blocks for hip fracture patients: a pilot randomized trial. Injury. 2021;52(3):548-553.
41. Uysal A, Altiparmak B, Yasar E, Turan M, Canbek U, Yilmaz N, et al. The effects of early femoral nerve block intervention on preoperative pain management and postoperative delirium in geriatric patients undergoing trochanteric femur fracture surgery: a randomized controlled trial. Ulus Travma Acil Cerrahi Derg. 2020;26(1):109-114.
42. McRae PJ, Bendall JC, Madigan V, Middleton PM. Paramedic-performed fascia iliaca compartment block for femoral fractures: a controlled trial. J Emerg Med. 2015;48(5):581-589.
43. Mittal R, Vermani E. Femoral nerve blocks in fractures of femur: variation in current UK practice and a review of the literature. Emerg Med J. 2014;31(2):143-147.
44. Haskins SC, Fiasconaro M, Wilson L, Poeran J, Liu J, Memtsoudis S. Ultrasound guidance for peripheral nerve blocks: an observational trend study of national data. Reg Anesth Pain Med. 2020;45(9):681-683.
45. Choi JJ, Lin E, Gadsden J. Regional anesthesia for trauma outside the operating theatre. Curr Opin Anaesthesiol. 2013;26(4):495-500.
46. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71.
47. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557-560. doi:10.1136/bmj.327.7414.557.
48. Sterne JAC, Savovic J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.
49. Farrar JT, Portenoy RK, Berlin JA, Kinman JL, Strom BL. Defining the clinically important difference in pain outcome measures. Pain. 2000;88(3):287-294.

50. Neal JM, Neal EJ, Weinberg GL. American Society of Regional Anesthesia and Pain Medicine local anesthetic systemic toxicity checklist: 2020 version. Reg Anesth Pain Med. 2021;46(1):81-82. doi:10.1136/rapm-2020-101986.