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SYSTEMATIC REVIEW-META-ANALYSIS

Pain Management and Sedation

Procedural sedation and analgesia versus nerve blocks for reduction of fractures and dislocations in the emergency department: A systematic review and meta-analysis

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Abstract

Background: Procedural sedation and analgesia (PSA) and peripheral nerve blocks (NBs) are techniques to manage pain and facilitate reduction of dislocated joints or fractures. However, it is unclear if either approach provides any distinct advantage in the emergency department (ED). The aim of this systematic review is to compare these 2 techniques on pain scores, adverse events, patient satisfaction, and length of stay (LOS) in the ED.

Methods: We performed an electronic search of MEDLINE, EMBASE, and the Cochrane Library, and references were hand-searched. Randomized controlled trials (RCTs) comparing PSA with NBs for orthopedic reductions in the ED were included. Outcomes of interest included pain scores, adverse events, patient satisfaction, and LOS in the ED. A total of 2 reviewers independently screened abstracts and extracted data into a standardized form. The Cochrane risk-of-bias tool was used to evaluate study quality. The Grading of Recommendation Assessment Development and Evaluation approach was used to assess the certainty and strength of the evidence. Data on pain scores were pooled using a random-effects model and are reported as standardized mean differences (SMDs) with 95% confidence intervals (CIs).

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Results: A total of 6 RCTs (n = 256) were included in a qualitative review, and 4 RCTs (n = 101) were included in the meta-analysis. There was no significant difference in pain scores between the PSA and NB groups ($P = 0.47$; SMD, 0.45; 95% CI, −0.78 to 1.69; $I^2 = 0.94$). There were less adverse events in the NB group (0%–3.3%) compared with the PSA group (0%–20%; n = 256). LOS times were consistently shorter in the NB group (n = 215). Patient satisfaction was comparable in both groups (n = 196).

Conclusion: Based on the available evidence, NBs performed by emergency physicians are as effective as PSA in managing pain during orthopedic reductions in the ED. NBs are associated with fewer adverse events and shorter LOS in the ED. The quality of evidence is low.

KEYWORDS
adverse event, analgesia, dislocation, emergency (medicine), fracture, length of stay, nerve block, pain, (procedural) sedation, patient satisfaction

1 | INTRODUCTION

1.1 | Background

Joint dislocations and displaced fractures requiring reduction are extremely painful conditions that frequently present in the emergency department (ED). Optimized pain management in trauma patients increases both patient comfort and decreases morbidity.[1] However, undertreatment of pain still occurs in EDs worldwide, especially in children and elderly patients.[2,3] This is mostly attributed to a lack of trained staff familiar with the use of potent analgesics and/or sedation techniques.[3]

Procedural sedation and analgesia (PSA) is an effective method to facilitate the reduction and manage the pain in patients undergoing these procedures. It is increasingly popular as it is considered very safe in trained hands and uses many of the skills and tools that emergency physicians are familiar with. There are some rare associated adverse events, including respiratory depression, hypoxia, nausea, aspiration, hypotension, and agitation.[4,5] Adverse events can be minimized when using standardized procedures that include patient screening, selection, and monitoring. This requires additional resources and time, including trained personnel and 1-on-1 care to perform continuous vital sign and event monitoring. This can be challenging, especially when staffing problems exist and with the increasing volumes and crowding seen in many EDs worldwide. In addition, for some patients, PSA may not be suitable due to certain comorbidities or facial anatomy that might make airway management difficult. An alternative is to use peripheral nerve blocks (NBs). NBs may also provide some potential advantages over PSA, as they can be performed on a wider scope of patients, including those for which PSA may not be a suitable option. NBs also do not require continuous monitoring of the patients during the procedure and recovery phases. NBs are traditionally performed by anesthesiologists, and there is good evidence for the safety and efficacy in a wide scope of patients and procedures.[6,7] However, just as with procedural sedation, anesthesiologists are not always available to come to the ED for acute procedures. Consequently, more and more emergency physicians are learning NB skills.

1.2 | Importance

Emergency physicians must work swiftly and efficiently while providing the safest and most comfortable care for their patients. The ideal intervention is quick and safe to perform while also painless and allows for prompt disposition from the ED. Orthopedic injuries are a common and painful presenting complaint in the ED, and the reduction treatment can be very painful. It is unclear if NBs provide a distinct advantage over PSA in the ED.

1.3 | Goals of this investigation

The goal of this systematic review and meta-analysis is to compare analgesic effect, adverse events, patient satisfaction, and LOS between PSA and NB, in patients who require a reduction of a fracture or dislocation in the ED.

2 | METHODS

2.1 | Study design and registration

This systematic review and meta-analysis was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[8] A predetermined protocol was used to perform a systematic search of the MEDLINE (PubMed), EMBASE (OVID), and Cochrane Library databases for studies published through August 2022. The World Health Organization Interna-

tional Clinical Trials Registry Platform (www.who.int/ictrp/en/) and US National Institutes of Health (https://clinicaltrials.gov/) were searched to identify any unpublished ongoing trials. The search protocol for this systematic review was registered with the University of York Center for Reviews and Dissemination and the National Institute for Health Research PROSPERO database (registration no. CRD42019123194).

2.2 | Search strategy

The search strategy was developed by 2 authors (M.I.K. and A.R.) in conjunction with a health sciences librarian and last updated August 23, 2022. The search and Medical Subject Headings terms used are shown in Appendix 1. The Population, Intervention, Comparison, and Outcome framework[9] was used to address the following question: "Are NBs as effective in analgesia as PSA for reduction of dislocated joints/fractures in the ED setting?"

We identified all studies comparing PSA and peripheral NBs used for extremity fracture/dislocation procedures in the ED. The studies in our review met the following criteria: the study included data comparing pain scores and/or adverse events, and/or patient satisfaction, and/or length of stay (LOS) in the ED. Adverse events were defined as airway obstruction, apnea (>20 seconds), hypoxia (oxygen saturation <90% for >60 seconds), hypotension (systolic blood pressure <90 mmHg), bradycardia (<50/min), agitation, aspiration, and/or intervention or hospital admission. Only published randomized and quasi-randomized controlled trials (RCTs) in the English language were included. There was no restriction on age. Hematoma and articular blocks were excluded. Only studies performed in the ED by emergency physicians were included. Studies that were unpublished or for which full-text articles could not be obtained were excluded from the systematic review. Those that did not have data reported as the mean and SD or median and range were excluded from the meta-analysis.

2.3 | Selection and quality assessment of studies

A total of 2 reviewers (M.I.K. and A.R.) independently screened all articles for title and abstract and then full text. References were assessed to identify any missed articles. Disagreement was resolved by discussion with a third reviewer (W.A.H.M.T.) until consensus was reached. Hereafter, M.I.K. and L.I.V. evaluated the study quality according to the Cochrane risk-of-bias tool.[10] In case of disagreement, a third researcher (F.B.P.) had the decisive vote. The Grading of Recommendation Assessment Development and Evaluation (GRADE)[11] methodology was used to assess the quality of evidence across studies and grade the quality of the study.

2.4 | Data extraction and synthesis

A total of 2 investigators (A.R., L.I.V.) independently extracted data from the included studies. A predesigned data collection form was used. The following data were abstracted: study design, setting (adult/pediatric ED), location of the NB, type of guidance used for the NB, anesthetic used, sedative and analgetic medication used, and type of pain score used. Primary and secondary outcomes included pain score, adverse events, patient satisfaction, and LOS. Group consensus of all authors was used to resolve any conflicts regarding the extracted data.

2.5 | Data analysis

For the primary outcome, we compared validated pain scores, which were recorded during or immediately after the repositioning of the dislocated joint/fracture in the ED. We focused on the maximum pain score that was reported of the orthopedic procedure by the patient. For the adverse events, we compared the incidence of any reported adverse events caused by either NBs or PSA. Patient satisfaction was compared for both groups as reported by the patient after the procedure. For LOS in the ED, we compared the duration of the PSA and NB patients stay in the ED. We performed a meta-analysis on the primary outcome of pain, as it was the only outcome for which standardized and validated scores were used and the SD was reported.

The standardized mean difference (SMD) was used to construct a forest plot to evaluate the differences in pain between the groups. A P value <0.05 was considered statistically significant, and 95% confidence intervals (CIs) were reported. To test for heterogeneity, we calculated I^2. Depending on heterogeneity, the results of comparable studies were pooled using fixed-effect or random-effect models. Data were not pooled in a fixed-effect model if there was considerable heterogeneity (I^2 >75%) that could not be explained by the diversity of methodological or clinical features between the trials. Synthesis was done using Review Manager (RevMan) [Computer Program]. Version 5.1, The Cochrane Collaboration, 2011. For the secondary outcomes adverse events, patient satisfaction, and LOS, we performed a descriptive analysis.

3 | RESULTS

3.1 | Search and selection

Our search identified 1799 articles. After removing duplicates, a total of 1462 articles were identified through database searching. Based on the title and abstract, 1452 studies were excluded. Of the remaining 10 studies, full texts were assessed, and 4 additional articles were excluded.[12–15] One was performed in a prehospital setting by consultant anesthesiologists, and 3 other studies compared hematoma blocks to PSA. No additional studies were included after cross-referencing. A search in trial registry platforms yielded 2 potential trials; however, the inclusion of patients had not yet started. As a result, 6 RCTs were included in the systematic review[16–21] with a total of 256 participants, of which 127 received PSA and 129 received NBs. A total of 4 studies were included in a meta-analysis on the primary outcome on pain[16,17,18,20] (n = 101). A PRISMA flow chart demonstrating the search results is presented in Figure 1.

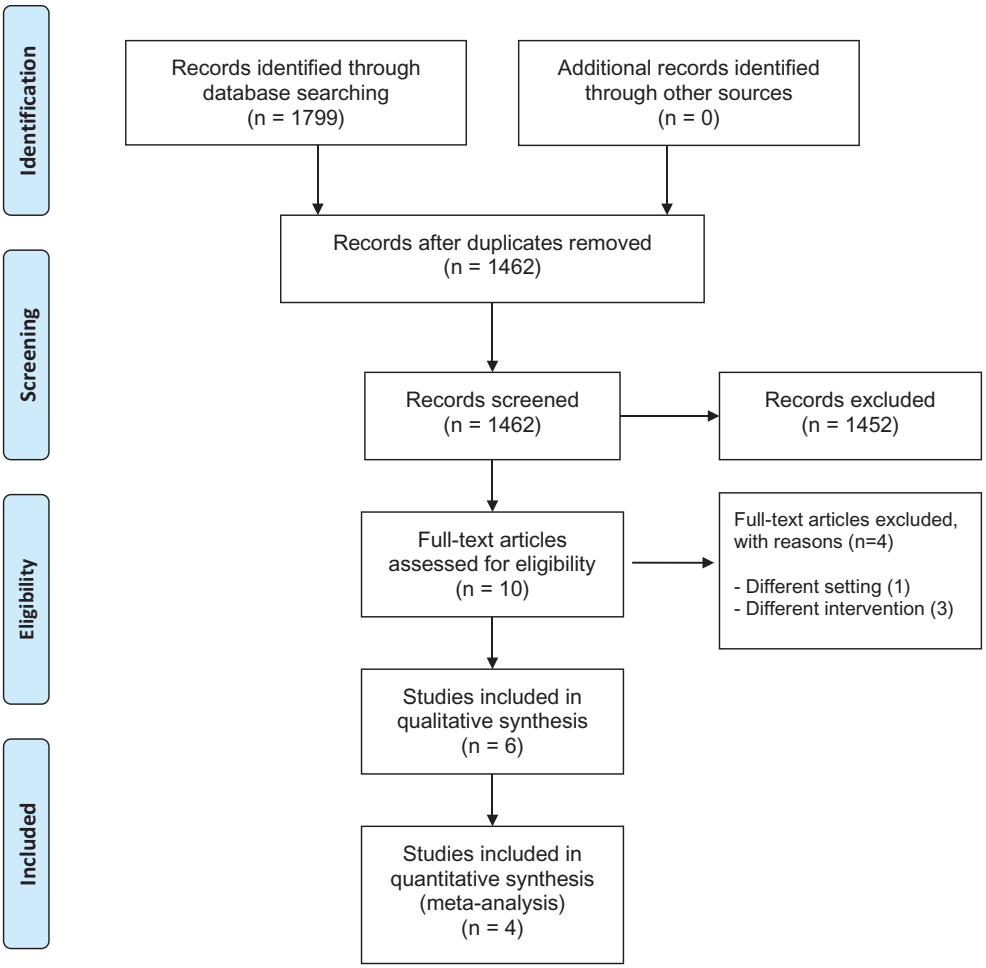

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram

3.2 | Study characteristics

The studies were all published between 2006 and 2017. Table 1 shows the main study characteristics. All studies enrolled ED patients with upper extremity fracture/dislocation requiring reduction. Stone et al[21] also included 4 patients with a shoulder abscess that required incision and drainage. Kriwanek et al[18] was the only study that included pediatric patients (aged >7 years).

3.3 | Quality assessment

The risk of bias of the included studies for this review is presented in Figure 2. Considering the nature of the intervention and the study design, blinding of participants was not possible, resulting in a high risk of performance bias. Most studies used convenience samples, adding to the risk of selection bias. Some studies randomized in blocks, increasing the risk of allocation bias. The GRADE assessment of evidence quality across studies used for the meta-analysis on pain scores is presented in Table 2.

3.4 | Pain scores

Of the 6 studies, 4 compared pain scores.[16,17,18,20] In the analyses, we found very high heterogeneity ($I^2 = 94\%$); this can be attributed to the difference in methodological and clinical features of the trials. Due to the extreme heterogeneity, the random-effect model was applied. The analysis demonstrated no significant difference in pain scores between PSA and NBs for reductions of fractures or dislocations in the ED, and the SMD was 0.45 (95% CI, −0.78 to 1.69) ($P = 0.47$). Figure 3 shows the Forest plot illustrating the random-effects meta-analysis.

3.5 | Secondary outcomes

Because of high degree of bias, heterogeneity, and lack of standardization, we performed a descriptive analysis of the secondary outcomes adverse events (n = 6 studies), patient satisfaction (n = 5 studies) and LOS (n = 5 studies).

All 6 studies described the severity and number of adverse events for both groups (Table 3). The adverse events were reported more

TABLE 1 Characteristics of studies included in the systematic review and meta-analysis

Study	Year of publi-cation	Country	Study design	Number of patients included	Setting	Type of reduction	Inter-vention group NB, n	Type of NB	Nerve	Guidance used for NB	Anesthetic used for NB	Control group PSA, n	Sedative(s) and analgesics used for PSA	Primary outcome	Pain score used to compare NBs and PSA
Alimohammadi et al[16a]	2013	Iran	RCT	60	Adult ED	Upper extremity fracture reduction	30	Axillary NB	Brachial plexus	Nerve stimulator	Lidocaine 1% (maximum 4 mg/kg)	30	Midazolam 0.05–0.1 mg/kg and fentanyl 1–3 mcg/kg	Pain	VAS
Blaivas et al[17a]	2011	USA	RCT	42	Adult ED	Shoulder dislocation	21	Interscalene NB	Brachial plexus	Ultrasound	Lidocaine 20–30 mL with epinephrine	21	Etomidate (dose not reported)	Length of stay	NRS
Doost et al[20a]	2017	Iran	RCT	60	Adult ED	Anterior shoulder dislocation	30	Interscalene NB	Brachial plexus	Ultrasound	Lidocaine 1% 15–25 mL with epinephrine	30	Fentanyl 2 mcg/kg and propofol 1 mg/kg	Pain	NRS
Kriwanek et al[18a]	2006	USA	RCT	41	Pediatric ED	Forearm fractures reduction	20	Axillary NB	Brachial plexus	Trans-arterial/ landmark	Morphine (0.1 mg/kg) and lidocaine 1% (0.7 mL/kg)	21	Morphine (0.1 mg/kg) and Ketamine (1 mg/kg) and midazolam (0.1 mg/kg)	Pain	CHEOPS
Stone et al[21]	2008	USA	RCT	12	Adult ED	Upper extremity disloca-tion/abscess	7	Supraclavicular NB	Brachial plexus	Ultrasound	Lidocaine 1% (30 mL)	5	Propofol (1 mg/kg) or etomidate (0.05–0.1 mg/kg)	Satisfaction	N/A
Tezel et al[19]	2014	Turkey	RCT	41	Adult ED	Shoulder dislocation	21	Suprascapular NB	Suprascapu nerve	Ultrasound	Prilocaine 2%, 5 mL	20	Ketamine 1–2 mg/kg	Reduction success	N/A

Abbreviations: CHEOPS, Children's Hospital of Eastern Ontario Pain Scale; ED, emergency department; N/A, not available; NB, nerve block; NRS, Numeric Rating Scale; PSA, procedural sedation and analgesia; RCT, randomized controlled trial; VAS, visual analog scale.

[a]Included in the meta-analysis.

Author [reference]	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias	Overall risk-of-bias
Alimohammadi [16]	Random number table	Not described	No	No	?	No	Selection bias - convenience sample	High
Blaivas [17]	Random number generator	Not described	No	No	?	No	Selection bias - convenience sample	Medium
Doost [20]	Block randomization	Not described	No	No	No	No	Selection bias - convenience sample	Medium
Kriwanek [18]	Computer Block randomization	Not described	No	No	?	Possible	Selection bias - convenience sample Author is only performer	High
Stone [21]	Even/odd medical record numbers	No	No	No	?	No	Selection bias - convenience sample	High
Tezel [19]	Randomization table	Not described	No	No	?	No	Sampling not well described	High

Key

	Low risk of bias
	Unclear risk of bias
	High risk of bias
?	Not reported/unknown

FIGURE 2 Risk-of-bias summary

frequently in the PSA group (range, 0%–20%) compared with the NB group (range, 0%–3.3%). The only adverse event in the NB group was a temporary systemic toxicity that did not need any additional therapy or intervention. In the PSA group, the most common adverse event was hypoventilation with oxygen desaturation. A total of 3 patients in the PSA group required intervention with a brief period of bag valve mask ventilation. Other adverse events consisted of agitation, nausea, and temporary hypotension. Rescue medication was not needed in any patient. There were no serious adverse events or sentinel outcomes.

A total of 5 articles described patient satisfaction (Table 4), and only 3 reported the mean and SDs.[17,20,21] All studies used different rating scales. Doost et al[20] was the only study to report a significant difference, where the PSA group scored higher on a 4-point rating scale. However, both PSA and NBs were in the good to excellent scoring range. Kriwanek et al[18] reported 13/18 (72.2%) patients in the NB group and 18/20 (90%) of the patients in the PSA group were satisfied with their treatment ($P = 0.65$). Tezel et al[19] reported no significant difference between patient satisfaction ($P = 0.198$) but did not clarify how this was scored or analyzed. Stone et al[21] reported average patient satisfaction scores of 8.2 ± 3.1 for the brachial plexus NB group and 9.0 ± 1.2 for the PSA group on a 10-point scale ($P > 0.5$).

Table 5 shows the 5 studies that reported LOS. The start and end times were all defined in a different manner; however, all showed a shorter LOS in favor of the NB group. Blaivas et al[17] also reported a shorter 1-on-1 time with the NB group of 5 ± 0.7 minutes versus 47.1 ± 9.8 minutes when the patient received PSA. Alimohammadi et al[16] also measured the onset of analgesia, which was faster in the PSA group at 8 ± 1 minutes versus 15 ± 2 minutes for NBs.

4 | LIMITATIONS

The strengths of this review include a comprehensive search with predefined criteria and an assessment of the literature by 2 independent reviewers. We used the GRADE approach, which provides a transparent framework to assess the quality of evidence. However, there are several limitations worth mentioning. The RCTs were few and small. Even when pooled, they provide a small total number of patients. There was significant bias in most of the studies. The causes of suspected bias included the lack of blinding (patient and caregiver), lack of random sequence generation, lack of allocation concealment, and the use of convenience samples. In 1 study,[18] one of the authors was the only physician performing the NB intervention, which may have led to other conscious or unconscious bias by the author. The outcome on pain scores had an extremely high heterogeneity value, and this may limit the applicability of our findings. The significant heterogeneity between studies can be attributed to the difference in study populations as well as the methods used. A total of 3 studies focused on the reduction of shoulder dislocations, whereas the others focused on the reductions on forearm fractures or a mix of upper extremity injuries requiring a surgical or orthopedic procedure in the ED. Different anesthetics and sedatives were used in different dosages across all studies, and not all NBs were performed with ultrasound guidance. Of the 6 studies, 5 were conducted in adults. However, the findings in the pediatric study mirror the adult findings. Younger male patients predominate in the adult studies, and there are not enough women or elderly patients to determine a subgroup difference. One could argue more adverse events could be expected in the PSA group for elderly patients who tend to have more comorbidities and less cardiovascular reserves. More problematic is the use of different sedatives

TABLE 2 GRADE assessment of quality of evidence across studies used for meta-analysis

Study	Study design	Score[a]	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Large effect	Dose response	Plausible confounding	GRADE total score	GRADE level
Alimohammadi et al[16]	RCT	4	−2	?	0	?	?	0	0	?	2	Low
Blaivas et al[17]	RCT	4	−1	?	−1	?	?	0	0	?	2	Low
Doost et al[20]	RCT	4	−1	−1	0	?	?	+1	0	?	3	Moderate
Kriwanek et al[18]	RCT	4	−2	?	0	?	?	0	0	?	2	Low

Note: ? = unknown or inconclusive.

Abbreviations: GRADE, Grading of Recommendation Assessment Development and Evaluation; RCT, randomized controlled trial.

[a]Scoring system: high level of evidence, ≥4 points; moderate level of evidence, 3 points; low level of evidence, 2 points; very low level of evidence, ≤1 point.

and analgesic medication or premedication for the procedural sedation. The impact of this is unclear, especially when comparing the LOS between different studies. It is important to highlight that both PSA and NBs are procedures that require advanced training. Emergency physicians with different levels of training and experience performed PSA and NBs in these studies. In the study by Kriwanek et al,[18] only a single board-certified, fellowship-trained, pediatric emergency physician investigator performed the NB. It was not clearly reported what the level of training was in most of the studies, and therefore it is unclear how this may have influenced the outcome or generalizability.

5 | DISCUSSION

As emergency physicians, it is incumbent on us to be looking for the most effective, safe, comfortable, and quickest methods to provide care. This is the first systematic review and meta-analysis comparing PSA and NBs for the reduction of orthopedic injuries in the ED, a common presenting complaint.

We observed no difference in analgesic efficacy measured with pain scores between PSA and NBs for the reductions of fractures or dislocations in the ED. We also observed fewer adverse events as well as shorter LOS with NBs, suggesting that NBs are a potentially safer and faster alternative option for the emergency physician. Despite the limitations due to bias and the small cohort, the results are intriguing and likely valid.

A recently published meta-analysis of 12 RCT articles with a total of 630 patients comparing intra-articular lidocaine (IAL) and intravenous sedation for the reduction of acute anterior shoulder dislocations in the ED found similar results.[22] Although there was no difference in reduction success between IAL and intravenous sedation, there also seemed to be fewer adverse effects and a shorter LOS with IAL, just as when NBs are used. However, there was less patient satisfaction with IAL compared with intravenous sedation, a difference that was not seen with between PSA and NBs.

Because of the nature of the procedure and medications used (local anesthetic vs. central acting sedatives/analgesics), NBs likely require fewer resources than PSA. This is potentially a very important finding given the staffing shortages, ED overcrowding, and access block that is taking place in many EDs around the world. In departments that have the facilities and trained personnel to perform NBs, they should be considered as an alternative solution to manage pain in the ED.

When PSA was introduced in the Netherlands, NBs were not routinely performed by emergency physicians, and ultrasound was not available in the ED; hence, NBs were not a viable option. However, the equipment and experience in monitoring ED patients, administering intravenous medications, and performing airway management made PSA feasible.[23] In a recent cross-sectional survey in Belgium,[24] although 84% of the hospitals performed peripheral NBs on trauma patients, the clear majority (68%) still took place in the operating theater, whereas only 18% of the NBs were performed in the ED. The main (68%) reason given for this was the lack of adequately trained personnel. Anesthesiologists performed 90% of the NBs, showing that this

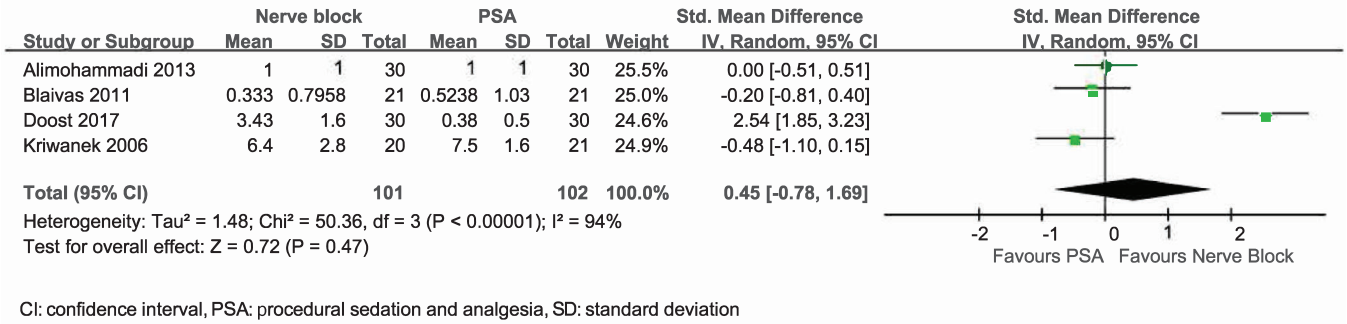

FIGURE 3 Forest plot showing pain scores during repositioning of joint/fracture in the emergency department under nerve block versus PSA. CI, confidence interval; PSA, procedural sedation and analgesia; Std., standardized

TABLE 3 Adverse events

Study	Nerve block	Procedural sedation and analgesia	*P* value
Alimohammadi et al[16]	None	None	N/A
Blaivas et al[17]	None	2/21 (9.5%) oxygen saturation decline	0.49
Doost et al[20]	1/30 (3.3%) systemic toxicity	2/21 (9.5%) hypotension	N/A
		3/30 (10%) hypoventilation requiring need for bag valve mask	
Kriwanek et al[18]	None	None	N/A
Stone et al[21]	None	1/5 (20%) self-limiting apneic event	N/A
Tezel et al[19]	None	3/20 (15%) nausea	0.01
		2/20 (10%) hypoxia	
		3/20 (15%) agitation	

Abbreviation: N/A, not available.

TABLE 4 Patient satisfaction

Study	Satisfaction scoring method	Satisfaction Score PSA (mean ± SD)	Satisfaction Score NB, (mean ± SD)	*P* value
Blaivas et al[17]	Not described	(8.2 ± 1.3)	(8.3 ± 1.1)	0.9275
Doost et al[20]	1 poor, 2 intermediate, 3 good, 4 excellent	(3.6 ± 0.4)	(3.0 ± 0.6)	0.001
Kriwanek et al[18]	Binary (satisfied yes/no)	18 of 20 satisfied	13 of 18 satisfied	0.652
Stone et al[21]	10-point visual analog scale	(9.0 ± 1.2)	(8.2 ± 3.1)	>0.5
Tezel et al[19]	5-step classification	Very good 12, good 6, satisfactory 2, poor 0, very poor 0	Very good 17, good 4, satisfactory 0, poor 0, very poor 0	0.198

Abbreviations: NB, nerve block; PSA, procedural sedation and analgesia.

may not be a skill yet mastered by all emergency physicians. The main indication for NBs was hip fracture, and ultrasound guidance was used in 71%. However, as ultrasound becomes more accepted worldwide for use by emergency physicians, this situation may change. Recently, Shteyman et al[25] performed a study demonstrating that emergency residents are easily proficient in the ultrasound identification of the nerves of the brachial plexus at the level of the interscalene space after 2 supervised examinations. Tucker et al[26] published an ultrasound-guided regional anesthesia curriculum for emergency medicine in 2020, and this may help set the quality standard and implementation on a wider scale.

For future studies, although blinding may not be feasible, replication of RCTs with prestandardized parameters (pain scores, satisfaction scores, adverse events, and LOS definitions) and treatment protocols (medications used, equipment [i.e., ultrasound, nerve stimulators]) are needed. Research with a focus on extremes of age, comorbidities, and types of injury are also needed to better understand if there are any distinct advantages between the 2 techniques for certain subgroups.

TABLE 5 Mean LOS in the ED

Study	LOS description	Time PSA, minutes; mean ± SD, average (95% CI), or mean (range)	Time NB, minutes; mean ± SD, average (95% CI), or mean (range)	*P* value
Alimohammadi et al[16]	Mean ± SD total time of procedure from start to "full recovery"	29 ± 4	26 ± 3	<0.001
Blaivas et al[17]	Mean ± SD from entry into the ED room to discharge	177.3 ± 37.9	100.3 ± 28.2	<0.0001
Doost et al[20]	Mean ± SD times from start of procedure to discharge	108.6 ± 42.1	80.2 ± 25.2	0.005
Stone et al[21]	Average times from enrollment to discharge	285 (95% CI, 228–343)	106 (95% CI, 57–155)	<0.001
Tezel et al[19]	Mean (range) times from start of procedure to discharge	125 (range, 120–138)	25 (range, 21–36)	<0.001

Abbreviations: CI, confidence interval; ED, emergency department; LOS, length of stay; NB, nerve block; PSA, procedural sedation and analgesia.

Selection bias can be reduced with the use of computerized random sequence generators, allocation concealment, and convenience sampling avoidance. All patients who are not included due to convenience sampling and dropouts should be described in future articles for transparency and to reduce the risk of selection and attrition bias. Excluded patients need to be reported and based on predefined exclusion criteria.

In this systematic review and meta-analysis, we found no significant difference in pain scores between PSA and NBs for reductions of fractures or dislocations in the ED. NBs appear to be associated with fewer adverse events and a shorter LOS in the ED. Due to the high risk of bias, the quality of the evidence is low. More RCTs with prestandardized parameters and methods are needed to compare the risks and benefits of NBs and PSA. Research with a focus on pediatric and elderly ED populations should help identify specific advantages of PSA or NBs in these subgroups.

AUTHOR CONTRIBUTIONS

Maybritt I. Kuypers and Wendy A.H.M Thijssen were responsible for the study concept and design. Maybritt I. Kuypers, Anne van Riel, and Lars I. Veldhuis were responsible for the study selection and data extraction. Maybritt I. Kuypers, Lars I. Veldhuis, and Ellen Tromp were responsible for the data analysis. Maybritt I. Kuypers, Frans B. Plötz, and Lars I. Veldhuis drafted the manuscript, and all authors contributed substantially to its revision. Maybritt I. Kuypers takes responsibility for the article as a whole.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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