Received: 20 May 2022 | Revised: 13 July 2022 | Accepted: 20 July 2022

DOI: 10.1111/acem.14568

SYSTEMATIC REVIEWS (WITH OR WITHOUT META-ANALYSES)

CME

Comparative efficacy of sedation or analgesia methods for reduction of anterior shoulder dislocation: A systematic review and network meta-analysis

Minoru Hayashi MD[1] | Kenichi Kano MD[1] | Naoto Kuroda MD[2,3,4] | Norio Yamamoto MD[4,5,6] | Akihiro Shiroshita MD, MPH[4,7] | Yuki Kataoka MD, MPH, DrPH[4,8,9,10]

[1]Department of Emergency Medicine, Fukui Prefectural Hospital, Fukui City, Fukui, Japan

[2]Department of Pediatrics, Wayne State University, Detroit, Michigan, USA

[3]Department of Epileptology, Tohoku University Graduate School of Medicine, Sendai, Japan

[4]Scientific Research Works Peer Support Group (SRWS-PSG), Osaka, Japan

[5]Department of Orthopedic Surgery, Miyamoto Orthopedic Hospital, Okayama, Okayama, Japan

[6]Department of Epidemiology, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, Okayama, Japan

[7]Department of Respiratory Medicine, Ichinomiyanishi Hospital, Ichinomiya, Aichi, Japan

[8]Department of Internal Medicine, Kyoto Min-Iren Asukai Hospital, Kyoto, Japan

[9]Section of Clinical Epidemiology, Department of Community Medicine, Kyoto University Graduate School of Medicine, Kyoto, Japan

[10]Department of Healthcare Epidemiology, Kyoto University Graduate School of Medicine/Public Health, Kyoto, Japan

Correspondence
Norio Yamamoto, Department of Orthopedic Surgery, Miyamoto Orthopedic Hospital, 4-2-63, Kunitomi, Naka-ku, Okayama, Okayama 773-8236, Japan.
Email: lovescaffe@yahoo.co.jp

Abstract

Background: We performed a network meta-analysis (NMA) to compare the efficacy and safety of intravenous sedation (IVS), intraarticular anesthetic injection (IAA), and peripheral nerve block (PNB) as sedation or analgesia methods for the reduction of anterior shoulder dislocation.

Methods: We included randomized controlled trials (RCTs) comparing different sedation or analgesia methods for anterior shoulder dislocation reduction. The Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, ICTRP, ClinicalTrials.gov, and Google Scholar databases were searched in October 2021. We conducted a random-effects NMA within a frequentist framework. We evaluated the confidence in each outcome using the CINeMA tool.

Results: Sixteen RCTs (957 patients) were included. Regarding the primary outcomes, the three methods might result in little to no difference in the immediate success rate of reduction and patient satisfaction. The IAA method had a shorter emergency department length of stay than that of the IVS method (mean difference [MD] −107.88 min, 95% confidence interval [CI] −202.58 to −13.18). In the secondary outcomes, the IAA method had a lower pain score than that of the PNB method (standardized MD −1.83, 95% CI −3.64 to −0.02). The IAA and PNB methods might require a longer time for reduction than that of the IVS method (MD 5.3 min, 95% CI 2.4 to 10.36; MD 15.25, 95% CI 5.49 to 25.01). The three methods might result in little to no difference in the number of reduction attempts and total success rate of reduction. However, the confidence ratings for all treatment comparisons were very low. IAA and PNB had no adverse respiratory events.

Conclusions: The results of our NMA indicated that three sedation or analgesia methods (IVS, IAA, and PNB) might result in little to no difference in the success rate of reduction and patient satisfaction. IAA and PNB had no adverse respiratory events.

KEYWORDS
analgesia, conscious sedation, intraarticular injection, nerve block, shoulder dislocation

Supervising Editor: Dr. Paul Musey

INTRODUCTION

Shoulder dislocation accounts for 50% of all dislocations and is the most common type of dislocation.[1] Most shoulder dislocations are anterior (90%–98%).[1] Pain due to dislocation is severe, and the administration of sedatives and analgesics helps to relieve pain. However, pain also triggers muscle spasms around the shoulder. Therefore, for a successful shoulder dislocation reduction, it is important to relax the muscles surrounding the shoulder.[2]

Intravenous sedation (IVS) and intraarticular anesthetic injection (IAA) have been widely used as sedation or analgesia methods to reduce shoulder dislocation.[2–4] As for the comparative efficacy and safety between IVS and IAA, previous systematic reviews reported no significant differences in the success rate of reduction and patient satisfaction. These systematic reviews also revealed that IAA achieved fewer adverse events, shorter lengths of hospital stay, and lower medical costs than that of IVS.[2–4]

Recently, ultrasound-guided peripheral nerve blocks (PNB) have been used to reduce shoulder dislocations. Several randomized controlled trial (RCT) studies have compared the efficacy and safety of PNB and IVS, but the results have been controversial.[5–7] In addition, no systematic reviews have compared the efficacy and safety of these sedation or analgesia methods.

The best method of sedation and analgesia for the reduction of shoulder dislocation remains uncertain. Therefore, we conducted a systematic review and network meta-analysis (NMA) of RCTs to compare the efficacy and safety of IVS, IAA, and PNB for the reduction of anterior shoulder dislocation.

METHODS

Protocol and registration

We reported this systematic review and NMA of RCTs in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) extension statement for reporting systematic reviews incorporating network meta-analyses of health care interventions, including the checklist and explanations[8] (Table S1). In addition, we registered the protocol before starting this review.[9]

Inclusion criteria of the articles for the review

Type of studies

We included RCTs that assessed sedation or analgesia methods for the reduction of anterior shoulder dislocation and excluded crossover trials, quasi-experimental studies, and quasi-randomized trials. In addition, we included all reports, including published and unpublished articles, conference abstracts, and letters.

Study participants

We included participants older than 15 years and had a diagnosis of anterior shoulder dislocation based on physical examination or radiography of the shoulder. In addition, we included the intervention and comparator as IVS, IAA, PNB, placebo, or no sedation or analgesia (no drug). We defined IVS as intravenous injection of sedatives. Any types and dosages of sedatives and analgesics were acceptable. We defined IAA as the injection of local anesthetics into the glenohumeral joint. All medications and doses were acceptable. We defined PNB as the injection of local anesthetics into the brachial plexus in the interscalene or suprascapular nerves. All medications and doses were acceptable. The exclusion criteria were patients who could not obtain informed consent, allergies to any study medications, multiple traumas, associated fractures of the humerus (except Hill-Sachs and Bankart lesions), hemodynamic instability, or respiratory distress.

Outcomes of interest

The primary outcomes were the immediate success rate of the reduction, patient satisfaction, and emergency department (ED) length of stay (min). We chose three outcomes because the ideal shoulder dislocation reduction should be fast and effective and have high patient satisfaction.[10] Immediate success and ED length of stay (min) were defined by the authors. In addition, we assessed patient satisfaction with the shoulder reduction procedure. The secondary outcomes were adverse events, pain score, the time required for reduction (min), number of reduction attempts, and total success rate of the reduction. Secondary outcomes were defined by the authors of the study.

Search strategy

We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE via PubMed, EMBASE via Embase.com on October 31, 2021, and Google Scholar on November 12, 2021. We also searched the World Health Organization International Clinical Trials Platform Search Portal (ICTRP) and ClinicalTrials.gov for unpublished RCTs and ongoing RCTs on October 31, 2021 (Table S2).

Study selection and data extraction

Two independent reviewers (MH and KK) assessed all the identified publications for eligibility. If the study was abstract only and it was not clear whether it met the criteria for review, we contacted the original author. Two reviewers discussed and resolved any disagreements.

Data items

We extracted the following study characteristics:

1. Methods: study design, setting, and the number and country of study centers.
2. Participants: number, sex, age, and inclusion/exclusion criteria.
3. Interventions: sedative or analgesia methods and reduction techniques.
4. Outcomes: primary and secondary outcomes and the time points reported.

Geometry of the network

We demonstrated a network geometry that presented the nodes as direct comparisons as lines connecting these nodes. Nodes are used for sedation or analgesia. The numbers above the line represent the number of RCTs in direct comparisons.

Risk-of-bias assessment

Two reviewers (MH and KK) independently assessed the study level risk of bias using the risk-of-bias (ROB) 2 tool.[11] If necessary, the two reviewers discussed and resolved any disagreements with the third reviewer (NK).

Data synthesis and statistical analysis

Data synthesis

We pooled the relative risk ratios (RRs) for binary outcomes and the mean differences (MDs) or standardized mean differences (SMDs) for continuous outcomes. First, we conducted a pairwise meta-analysis for each treatment comparison using a random-effects model. Forest plots were used to visualize the effect of each treatment and assess heterogeneity. Second, we conducted a random-effects NMA within a frequentist framework. Because there were no direct comparisons between IAA and PNB, we only estimated the treatment effect comparison between IAA and PNB using NMA. In addition, we described a network plot to summarize the treatment effect and the study size of each comparison and league tables to summarize the results of pairwise meta-analyses and NMA. Third, we used the results from the intention-to-treat analysis and did not impute missing data based on the recommendation of the Cochrane Handbook.[12] Finally, we summarized adverse events based on the definition in the original article. However, we did not perform a meta-analysis because of nonstandardized definitions, inadequate monitoring, or possibly incomplete reporting.

Sensitivity analysis

We conducted the following sensitivity analysis for the primary outcomes.

1. Sensitivity analysis included only studies with a low overall assessment of ROB.
2. Sensitivity analysis included only studies that met the ideal outcome: at first attempt or first reduction technique for the immediate success rate of the reduction, most satisfied patient for patient satisfaction, and time from the beginning of the procedure to hospital discharge for the ED length of stay.

Statistical analysis

We used Review Manager software (RevMan V.5.4.1, The Nordic Cochrane Center, The Cochrane Collaboration) for pairwise meta-analyses and MetaInsight for frequentist NMA.[13] In addition, we used R software version 4.0.2 (R Foundation for Statistical Computing) and the packages "meta" (version 5. 2-0) and "pwr" (version 1. 3-0) for sample size calculations in future trials.

Assessment of the confidence for each outcome

Two reviewers (MH and NK) evaluated the confidence for each outcome using the CINeMA tool.[14,15] The CINeMA framework includes the following domains: within-study bias, across-studies bias, indirectness, imprecision, heterogeneity, and incoherence. For the domains of within-study bias and indirectness, we assessed the contribution of each study in each network estimate and combined these contributions with the study-specific ratings (very low, low, moderate, or high) to assess the relative effect for each comparison in the network. For the domains of imprecision, heterogeneity, and incoherence, we assessed major concerns, some concerns, and no concerns about how far the 95% confidence interval (CI) extend on both sides of the no effect line equal to the point estimate between the two interventions.

Sample size calculation for future trials

As there was no direct comparison between IAA and PNB, we performed a sample size calculation for a future trial targeting patients with anterior shoulder dislocation. We simulated a 1:1 RCT and set the following parameters: alpha of 0.05 and power of 0.8. We calculated the pooled immediate success rate of IAA using a random-effects model and then calculated the PNB using the RR from the NMA. Based on the estimated immediate success rates of IAA and PNB, we calculated the sample size.

RESULTS

Results of the search

We identified 1855 records during the search conducted in October 2021. Of these reports, 29 were considered for inclusion after reviewing their titles and abstracts. After a full-text review, 16 studies (957 patients) were included (Figure 1). Table S3 shows the list of studies excluded from this review and the reasons for exclusion. Table 1 presents the characteristics of the included studies. While lidocaine was administered using the IAA and PNB methods in most studies, various drugs were administered in the IVS group. In addition, the reduction techniques varied among the included studies. Eleven studies compared the efficacy and safety between IAA and IVS.[16–26] Four studies compared the efficacy and safety between PNB and IVS.[5–7,28] One study compared the efficacy and safety of IAA and no drugs.[27] To our knowledge, no study has compared the efficacy and safety of IAA and PNB. The ROB assessment is summarized in Figure S1. For the primary outcomes, six of the 10 included studies were assessed as having low ROB and the other four were assessed as having high ROB in the immediate success rate. However, patient satisfaction and ED length of stay were assessed as all high ROB. For the secondary outcomes, many outcomes were assessed as high or of some concerns for ROB. Most of the elevation in ROB was due to the unclear allocation sequence generation in Domain 1 and the lack of blinding of the outcome assessor, which might have influenced the outcomes in Domain 4.

Primary outcomes

Immediate success rate of the reduction

We included 10 studies[7,18–24,26,27] (Figure 2). The pairwise analysis is shown in Figure S3a. The IAA method might result in little to no difference in immediate success rate compared with the IVS method (eight studies, 408 patients; RR 0.93, 95% CI 0.84 to 1.02).[18–24,26] The evidence was very uncertain regarding the effect of the PNB method on the immediate success rate compared with the IVS method (one study, 41 patients; RR 1.13, 95% CI 0.84 to 1.52[7]; Figure 2). Other comparisons are shown in Figure 2 and Table S4a. The confidence ratings for all treatment comparisons are presented in Table S5a.

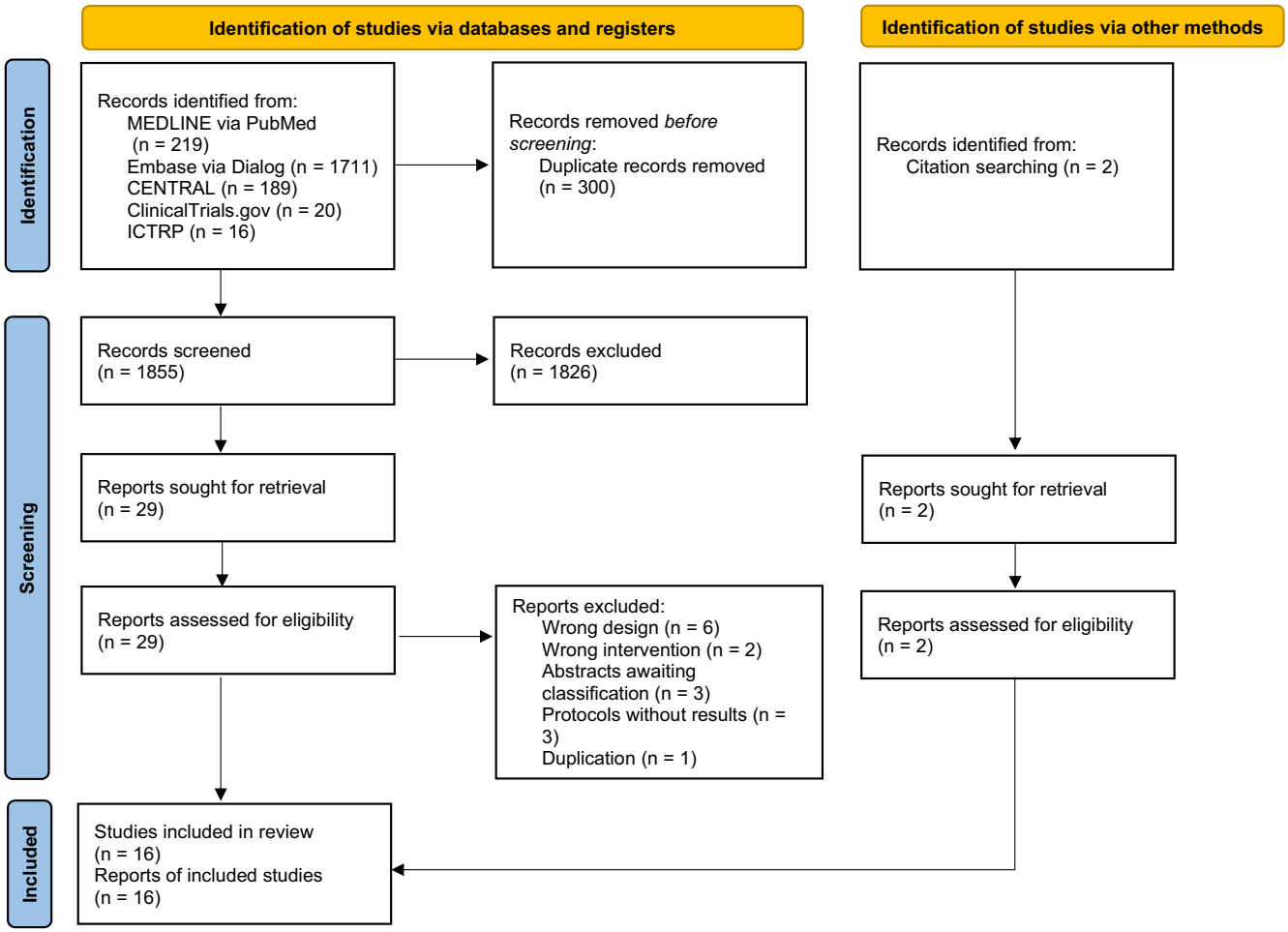

FIGURE 1 PRISMA flow diagram of the literature search results. We identified 1855 records during the search conducted in October 2021. Of these reports, 29 were considered for inclusion after review of titles and abstracts. After full-text review, 16 studies were included.

TABLE 1 Characteristics of included studies

Author, year, country	Intervention (I)	Control (C)	Patient number	Mean age (years)	Reduction technique
			I/C	I/C	
	IAA	IVS			
Suder, 1994, Denmark[16]	1% lidocaine 20 mL	Diazepam or pethidine discretion of the treating physician	33/35	48 (15–79)[a]	Kocher or Hippocratic method
Suder, 1995, Denmark[17]	1% lidocaine 20 mL	Diazepam or pethidine discretion of the treating physician	26/26	47 (18–89)[a]	Kocher or Hippocratic method
Matthews, 1995, USA[19]	1% lidocaine 20 mL	Midazolam 2 mg and morphine sulfate 10 mg	15/15	38/35.4	Traction–countertraction or Milch Or Scapular manipulation method
Kosnik, 1999, USA[20]	4 mg/kg (max 200 mg) of 1% lidocaine	Diazepam 5 mg and morphine sulfate 10 mg	29/20	41/41	Traction–countertraction method
Miller, 2002, USA[21]	1% lidocaine 20 mL	Midazolam 2 mg and fentanyl 100 μg	16/14	33/35	Modified Stimson or Scapular manipulation method
Orlinsky, 2002, USA[22]	1% lidocaine 20 mL	Diazepam 5–10 mg and meperidine 1–2 mg/kg	29/25	36/39	External rotation or traction–countertraction method
Moharari, 2008, Iran[23]	1% lidocaine 20 mL	Diazepam 5 mg and meperidine 25 mg	24/24	31.7/38.9	Traction–countertraction method
Cheok, 2011, Malaysia[24]	1% lidocaine 20 mL	Diazepam 0.1 mg/kg and meperidine 1 mg/kg	32/31	35.2/29.7	Traction–countertraction method
Hames, 2011, Canada[25]	4 mg/kg (max 200 mg) of 1% lidocaine	Discretion of the treating physician	25/19	43/27	Not stated
Ahmed, 2011, Iraq[26]	1% lidocaine 20 mL	Midazolam 2 mg and fentanyl 100 μg	15/15	32/35[b]	Modified Stimson or scapular manipulation method
Kashani, 2016, Iran[18]	1% lidocaine 20 mL	Midazolam 0.05 mg/kg and fentanyl 1 μg/kg	52/52	28.18/29.9	Leidelmeyer method
	IAA	No drug (no sedation or analgesia)			
Tamaoki, 2012, Brazil[27]	1% lidocaine 20 mL	No drug	22/20	39.1/32.6	Traction–countertraction method
	PNB (Interscalene nerve block)	IVS			
Blaivas, 2011, USA[5]	Lidocaine with epinephrine 20–30 mL	Etomidate. Dose was not stated	21/21	39/35.9	Not stated
Raeyat Doost, 2017, Iran[6]	1% lidocaine with epinephrine 15–25 mL	Propofol 1 mg/kg and fentanyl 2 μg/kg	30/30	28.5/28.9	Leidelmeyer or Milch or traction–countertraction method
	PNB (suprascapular nerve block)	IVS			
Tezel, 2014, Turkey[7]	2% prilocaine 5 mL	Ketamine 1–2 mg/kg	21/20	24/23.5	Modified Kocher method
Abbasi, 2020, Iran[28]	1% lidocaine 5–10 mL	Discretion of the treating physician	100/100	46.55 (20–91)[a]	Milch or traction–countertraction method

Abbreviations: IAA, intraarticular anesthetic injection; IVS, intravenous sedation; PNB, peripheral nerve block.

[a]Mean age, years (range).

[b]Median age.

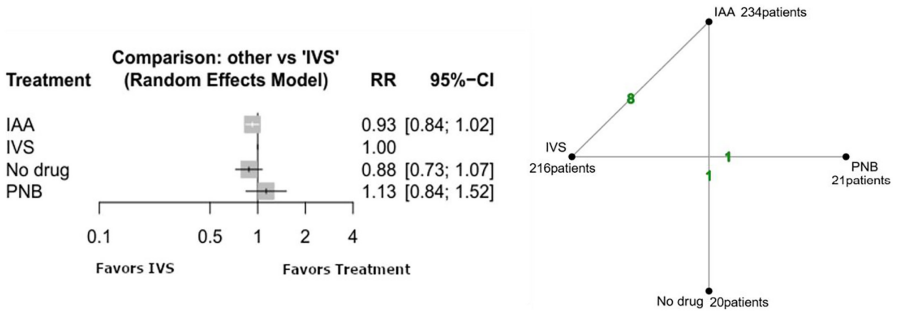

FIGURE 2 Forest plot and network plot for all interventions compared with IVS in the immediate success rate of reduction. The three methods might result in little to no difference in the success rate of reduction. CIs are slightly different in Figure 2 and S3a. This is because of the different statistical analysis software used. IAA, intraarticular anesthetic injection; IVS, intravenous sedation; no drug, no sedation or analgesia; PNB, peripheral nerve block; RR, risk ratio.

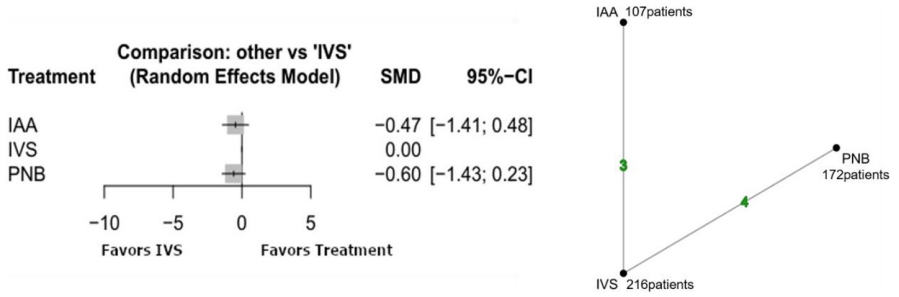

FIGURE 3 Forest plot and network plot for all interventions compared with IVS in patient satisfaction. The three methods might result in little to no difference in patient satisfaction. CIs are slightly different in Figure 3 and S3b. This is because of the different statistical analysis software used. IAA, intraarticular anesthetic injection; IVS, intravenous sedation; PNB, peripheral nerve block; SMD, standardized mean difference.

Patient satisfaction

We included seven studies[5–7,16,18,24,28] (Figure 3). The units of measurement for patient satisfaction were differed across studies; therefore, we converted the patient satisfaction reported in the survey scale to scores. Two studies reported patient satisfaction as yes or no; thus, we defined yes as 2 and no as 1.[16,24] In three studies, we changed the scores from 1 to 5 in the order of high patient satisfaction reported on a 5-level scale.[7,18,28] For example, quite satisfied 5 and complete dissatisfaction 1.[18] We pooled these scores using SMD according to the Cochrane Handbook.[12] In a study by Suder et al.,[17] the table of patient satisfaction may be incorrect. The total number of satisfied and unsatisfied patients in both groups differed from the number of included patients, but we could not contact the authors. Therefore, we excluded this study from the meta-analysis. The pairwise analysis is shown in Figure S3b. The evidence was very uncertain regarding the effect of the IAA method on patient satisfaction compared with the IVS method (three studies, 222 patients; SMD −0.47, 95% CI −1.41 to 0.48).[16,18,24] The evidence was uncertain regarding the effect of the PNB method on patient satisfaction compared with the IVS method (four studies, 273 patients; SMD −0.60, 95% CI−1.43 to 0.23)[5–7,28]; Figure 3. Other comparisons are presented in Table S4b. The confidence ratings for all treatment comparisons are presented in Table S5b.

ED length of stay (min)

Eleven studies were included[5–7,19,21–26,28] (Figure 4). Two studies assessed the time from entry into a room in the ED to discharge.[5,19] Two studies assessed the time from initial physician assessment to discharge.[24,25] Two studies assessed the time from the start of reduction to discharge.[7,21] Two studies assessed the time from the start of sedation or analgesia methods to discharge.[6,22] One study assessed the duration from reduction to discharge.[26] We could not determine the definition of the ED length of stay in two studies.[23,28] The pairwise analysis is shown in Figure S3c. The IAA method might have a shorter ED length of stay than that of the IVS method; however, the evidence was very uncertain (seven studies, 299 patients; MD −107.88 min, 95% CI −202.58 to −13.18).[19,21–26] The evidence was very uncertain about the effect of the PNB method on the ED length of stay compared with the IVS method (four studies, 343 patients; MD −26.23 min, 95% CI, −149.02 to 96.57)[5–7,28]; Figure 4. Other comparisons are presented

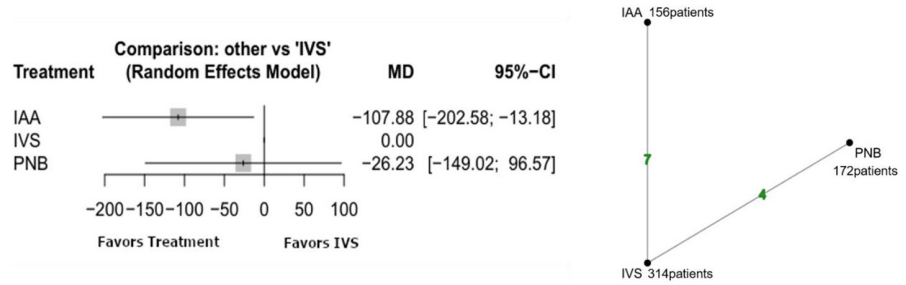

FIGURE 4 Forest plot and network plot for all interventions compared with IVS on the ED length of stay (min). The IAA method had a shorter ED length of stay than that of the IVS method (MD −107.88 min, 95% CI −202.58 to −13.18). IAA, intraarticular anesthetic injection; IVS, intravenous sedation; MD, mean difference; PNB, peripheral nerve block.

in Table S4c. The confidence ratings for all treatment comparisons are listed in Table S5c.

Secondary outcomes

All adverse events

Sixteen studies (957 patients) assessed the adverse events (Table 2). Two studies reported no adverse events.[25,27] Respiratory adverse events (hypoxia, hypoventilation, apnea, and respiratory depression) were common in the IVS group.[5–7,16–24,26,28] Nausea,[18,19,22,23,28] vomiting,[7,20,24] hypotension,[5,6,23] and headache[18,23] were also reported in the IVS group. Psychological agitation and drowsiness were reported in the IAA group,[22,23] and mild local anesthetic systemic toxicity was reported in the PNB group.[6]

Pain score

Eleven studies were included[5,6,17–21,23,24,26,27] (Figure S2a). Two studies assessed the pain scores after sedation or analgesia methods before reduction.[21,23] Two studies assessed the pain scores after reduction.[5,27] Six studies assessed the pain scores during reduction.[6,18–20,24,26] In the study by Ahmed et al.,[26] the standard deviation (SD) of the pain score was not reported. Hence, we adopted the SD as a substitute from the study by Miller et al.[21] because they used the same pain scale of 1 to 10, based on the Cochrane Handbook.[12] The pairwise analysis is shown in Figure S3d. The evidence was uncertain about the effect of the IAA method on the pain score compared with the IVS method (eight studies, 406 patients; SMD −0.56, 95% CI −1.36 to 0.25).[17–21,23,24,26] The evidence was very uncertain about the effect of the PNB method on the pain score compared with the IVS method. The IAA method might have a lower pain score than that of the PNB method; however, the evidence was very uncertain (no study, indirect comparison; SMD −1.83, 95% CI −3.64 to −0.02; Table S4d). The confidence ratings for all treatment comparisons are presented in Table S5d.

Time required for reduction (min)

We included six studies[17,21,23,26–28] (Figure S2b). Two studies assessed the period from the start of sedation or analgesia methods to the end of reduction.[17,28] Four studies assessed the period from the start to the end of reduction.[21,23,26,27] The pairwise analysis is shown in Figure S3e. The IAA method might require a longer time for reduction than that of the IVS method; however, the evidence was very uncertain (four studies, 160 patients; MD 5.3 min, 95% CI 0.24 to 10.36).[17,21,23,26] The PNB method might require a longer time for reduction than that of the IVS method; however, the evidence was very uncertain (one study, 200 patients; MD 15.25 min, 95% CI 5.49 to 25.01[28]; Figure S2b). Other comparisons are presented in Table S4e. The confidence ratings for all treatment comparisons are presented in Table S5e.

Number of reduction attempts

We included five studies[6,7,18,22,23] (Figure S2c). The pairwise analysis is shown in Figure S3f. The IAA method may result in little to no difference in the number of reduction attempts compared with the IVS method (3 studies, 172 patients) (MD: 0.18; 95% CI: −0.09 to 0.45).[18,22,23] The evidence was very uncertain regarding the effect of the PNB method on the number of reduction attempts compared with the IVS method (two studies, 101 patients; MD 0.07, 95% CI −0.23 to 0.36; Figure S2c).[6,7] Other comparisons are presented in Table S4f. The confidence ratings for all treatment comparisons are listed in Table S5f.

Total success rate of the reduction

Fifteen studies were included[5–7,16–27] (Figure S2d). The pairwise analysis is shown in Figure S3g. The IAA method may result in little to no difference in the total success rate compared with the IVS method (11 studies, 572 patients; RR 0.99, 95% CI 0.94 to 1.04).[16–26] The evidence was very uncertain about the effect of the PNB method on the total success rate compared with the IVS method (three studies, 143 patients; RR 1.00, 95% CI 0.92

TABLE 2 All adverse events

	Intervention (I)	Control (C)	Patient number	Adverse events (number)	
			I/C	I	C
Author, year	IAA	IVS			
Suder, 1994, Denmark[16]	1% lidocaine 20 mL	Diazepam or pethidine Discretion of the treating physician	33/35	0	10 respiratory depression
Suder, 1995, Denmark[17]	1% lidocaine 20 mL	Diazepam or pethidine Discretion of the treating physician	26/26	0	3 respiratory depression
Matthews, 1995, USA[19]	1% lidocaine 20 mL	Midazolam 2 mg and morphine sulfate 10 mg	15/15	0	2 required reversal agents, 3 nausea
Kosnik, 1999, USA[20]	4 mg/kg (max 200 mg) of 1% lidocaine	Diazepam 5 mg and morphine sulfate 10 mg	29/20	0	1 vomiting
Miller, 2002, USA[21]	1% lidocaine 20 mL	Midazolam 2 mg and fentanyl 100 μg	16/14	0	3 respiratory depression
Orlinsky, 2002, USA[22]	1% lidocaine 20 mL	Diazepam 5–10 mg and meperidine 1–2 mg/kg	29/25	1 psychological agitation	1 required reversal agents and nausea
Moharari, 2008, Iran[23]	1% lidocaine 20 mL	Diazepam 5 mg and meperidine 25 mg	24/24	3 drowsiness	14 (5 respiratory depression, 5 hypotension, 5 drowsiness, 2 headache, 2 nausea, 1 localized paresthesia)
Cheok, 2011, Malaysia[24]	1% lidocaine 20 mL	Diazepam 0.1 mg/kg and meperidine 1 mg/kg	32/31	0	9 (13 respiratory depression, 6 vomiting, 6 allergy, 20 thrombophlebitis)
Hames, 2011, Canada[25]	4 mg/kg (max 200 mg) of 1% lidocaine	Discretion of the treating physician	25/19	0	0
Ahmed, 2011, Iraq[26]	1% lidocaine 20 mL	Midazolam 2 mg and fentanyl 100 μg	15/15	0	1 serious cardiorespiratory complication
Kashani, 2016, Iran[18]	1% lidocaine 20 mL	Midazolam 0.05 mg/kg and fentanyl 1 μg/kg	52/52	0	11 (6 apnea, 5 hypoxia, 2 nausea, 2 headache)
	IAA	No drug (no sedation or analgesia)			
Tamaoki, 2012, Brazil[27]	1% lidocaine 20 mL	No drug	22/20	0	0
	PNB (interscalene nerve block)	IVS			
Blaivas, 2011, USA[5]	Lidocaine with epinephrine 20–30 mL	Etomidate. Dose was not stated	21/21	0	2 O_2 saturation < 95%, 2 hypotension
Raeyat Doost, 2017, Iran[6]	1% lidocaine with epinephrine 15–25 mL	Propofol 1 mg/kg and fentanyl 2 μg/kg	30/30	1 systemic toxicity	3 hypoventilation, 1 hypotension
	PNB (suprascapular nerve block)	IVS			
Tezel, 2014, Turkey[7]	2% prilocaine 5 mL	Ketamine 1–2 mg/kg	21/20	0	2 hypoxia, 3 vomit, 3 agitation
Abbasi, 2020, Iran[28]	1% lidocaine 5–10 mL	Discretion of the treating physician	100/100	1 blood pressure fluctuation, 1 heartbeat fluctuation, 4 hematoma	21 respiratory distress, 15 apnea, 4 blood pressure fluctuation, 4 heartbeat fluctuation, 1 nausea

Abbreviations: IAA, intraarticular anesthetic injection; IVS, intravenous sedation; PNB, peripheral nerve block.

to 1.08[5–7]; Figure S2d). Other comparisons are presented in Table S4g. The confidence ratings for all treatment comparisons are presented in Table S5g.

Additional analysis

We performed the NMA for the immediate success rate of the reduction by restricting the studies of the overall assessment of ROB to low,[18,20,22–24,27] one technique,[7,18,21–24,26,27] or first attempt.[7,18,22,23] The IAA method might result in a slightly reduced immediate success rate compared with the IVS method in the low ROB studies (RR 0.85, 95% CI 0.77 to 0.94; Figures S2e and S3h, Tables S4h and S5h).

The NMA for patient satisfaction by restricting the patients with the highest satisfaction scores in the studies[7,18,24,28] was similar to the original analysis (Figures S2f and S3i, Tables S4i and S5i). Two studies restricted the patients from the beginning of the procedure to ED discharge compared with the PNB and IVS groups.[6,7] The results of the comparisons were similar to those of the original analysis (Figures S2g and S3j, Tables S4j and S5j).

Sample size calculation for future trials

The random-effects model showed that the point estimate of the immediate success rate of IAA was 0.78. Based on the risk ratio (IAA vs. PNB) of 0.82 NMA, we estimated that the immediate success rate of PNB was 0.95. Our sample size calculation revealed that a total of 118 patients will be needed in a future RCT.

Difference between protocol and review

We could not perform subgroup analysis because none of the studies reported anterior shoulder dislocations separately for the first time or recurrent anterior shoulder dislocations. In addition, we could not perform a sensitivity analysis for double-blind studies and for exclusion of studies using imputed statistics because none of the studies were applicable. We did not present a summary of the findings regarding the primary outcomes.

DISCUSSION

This frequentist NMA included 16 RCTs that compared the efficacy and safety of IVS, IAA, and PNB as sedation or analgesia methods for reduction of anterior shoulder dislocation.[5–7,16–28] The three methods might result in little to no difference in the immediate success rate of reduction and patient satisfaction. The IAA method might result in a shorter ED length of stay than that of the IVS method; however, the evidence is very uncertain. The IAA method may have a lower pain score than that of the PNB method; however, the evidence is very uncertain. The IAA and PNB methods may require a longer time for reduction than that of the IVS method; however, the evidence is very uncertain. The three methods might result in little to no difference in the number of reduction attempts and the total success rate of the reduction. The confidence for each relative treatment effect in NMA was low or very low, and the results were uncertain.

Our results were in line with the previous systematic reviews comparing the IAA method with the IVS method.[2,4] To our knowledge, no systematic review has compared the PNB method with other methods. The three methods might result in little to no difference in the immediate success rate of reduction. As for the number of reduction attempts related to the immediate success rate, our results might also result in little or no difference among the three methods. The three methods might also result in little to no difference in the total success rate of the reduction. Previous studies have reported that the reduction techniques and experience of the operator are relevant in the success rate,[29] and it might be more relevant than the sedation or analgesic methods in the success rate and number of reduction attempts.

Lack of difference in patient satisfaction among the three sedation or analgesia methods might be interpreted as patient satisfaction being more affected by waiting time, the attitude of medical staff, and appropriate explanations than by sedation or analgesia methods.[30]

The IAA method might have a shorter ED length of stay than that of the IVS method (MD −107.88 min, 95% CI −202.58 to −13.18). Evidence for the effect of the PNB method on the ED length of stay was compared with the IVS method. One of the four included studies compared the PNB method with the IVS method. Abbasi et al.[28] reported that the PNB method succeeded in only 34% of the patients and administered sedatives because inadequate pain relief accounted for 66% of all cases using the PNB method. Thus, the PNB method had a longer ED stay than that of the IVS method.[28] Contrary to the results of the study by Abbasi et al., the PNB method had a shorter ED length of stay than that of the IVS method in three of the four included studies.[5–7] Therefore, the PNB method has the potential to achieve a shorter ED length of stay than that of the IVS method under adequate pain relief. The ROB was high in all included RCTs because there was a subjective decision of discharge by medical staff or there was no description of the discharge decision in the studies.[5–7,28] In the future, RCTs with a low ROB using appropriate discharge criteria are required. The results of this study suggest that IAA is a better method in terms of shorter ED length of stay than the IVS.

The IAA method may have a lower pain score than that of the PNB method. However, comparisons between the IAA and PNB methods were only indirect, and the confidence rating was very low. Hence, IAA may be a better method for those unfamiliar with PNB because operators need training for the success of PNB.[6] The evidence was very uncertain about the effect of the IAA method on the pain score compared with the IVS method. All RCTs included in our study were conducted using landmark-guided IAA, and pain scores varied from

0.29 (SD 0.67) to 7.1 (SD 2.6) in the IAA method.[18,26] This might be because IAA may not have been administered appropriately. A previous study reported that landmark-guided IAA administered local anesthetics to inappropriate points in 41.1% of cases, as assessed using ultrasound.[31] Moreover, ultrasound-guided IAA can be used to administer local anesthetics to the appropriate point.[31] Therefore, under conditions of adequate pain relief, the IAA method has the potential to achieve a lower pain score than that of the IVS method.

The IAA and PNB methods may require a longer time for reduction than that of the IVS method (MD 5.3 min, 95% CI 2.4 to 10.36; and MD 15.25 min, 95% CI 5.49 to 25.01). The IAA method might require little to no difference in the time for reduction compared with the PNB method, but the IAA method tended to require fewer minutes than that of the PNB method (MD −9.95 min, 95% CI −1.04 to 20.94). The IVS may have the advantage of being sedated, which allows operators to perform the procedure smoothly. In contrast, patients administered with IAA or PNB were awake during the shoulder reduction technique. Awake states may prolong the time because of hesitation or interruption of the procedure due to complaints of pain. A longer reduction time may decrease patient satisfaction; however, there was no difference among the three methods in this NMA.

IAA and PNB are safer than IVS in terms of fewer respiratory adverse events. Respiratory depression was defined as $SpO_2 < 92\%$ or end-tidal $CO_2 > 40$ in one study[23] and as a respiratory rate < 12 breaths/min in another study[24]; however, respiratory depression definition was unclear in four studies.[16,17,21,28] Therefore, respiratory depression assessment in the IVS group may be incorrect due to the assessor's subjective assessment and variation. In previous systematic reviews, the number of adverse events was less common in the IAA group than those in the IVS group (RR 0.15, 95% CI 0.07 to 0.32[2]; OR 0.16, 95% CI 0.06 to 0.43).[4] However, we did not perform a meta-analysis of all adverse events because the definitions of adverse events differed between the included studies. Patients sedated with IVS need to be monitored until they are awake for discharge[32]; IAA and PNB are good alternatives because these require less manpower although all of the evidence in this review is low to very low confidence.

From the safety and efficacy perspective, IAA may be a better choice when the patient cooperates during shoulder dislocation reduction. In contrast, IVS is a good alternative for uncooperative patients, as sedation facilitates the procedure for the operators.

STRENGTHS

To the best of our knowledge, this is the first NMA to compare the efficacy of sedation or analgesia methods for the reduction of anterior shoulder dislocation among IVS, IAA, and PNB. The strength of this NMA is the indirect comparison between IAA and PNB since there are no direct comparisons. Another strength is that we evaluated confidence in the evidence from NMA using CINeMA, which was described in the Cochrane Handbook.[12,14] Another strength of this study is the inclusion of unpublished data. Other strengths of this study are the inclusion of unpublished data and the sample size calculation for future RCTs with direct comparisons between IAA and PNB. The total number of participants required was 118.

LIMITATIONS

The NMA has some limitations. First, the number of RCTs that met the inclusion criteria was small, and the included RCTs were single-center studies with small numbers of patients. Therefore, the confidence for each relative treatment effect in NMA was very low, and the results were uncertain. Second, no studies have directly compared the IAA and PNB methods. RCTs with direct comparisons are needed in the future. At least one ongoing RCT is being conducted between the IAA and IVS methods[33] and two between the IVS and PNB methods.[34,35] In the future, updating the present systematic review and meta-analysis will improve the amount of evidence available and thus our confidence in the estimates. Third, benzodiazepines were used in most of the included studies as the IVS method compared to that in the IAA method. Short-acting sedatives such as propofol, etomidate, or propofol and ketamine (ketofol) were not used as sedatives, which may not reflect the current practice.[36] The use of short-acting sedatives may shorten ED length of stay and reduce respiratory adverse events in the IVS group. Fourth, depth of sedation was not included in many RCTs. For this reason, standardization by the depth of sedation and subgroup analysis could not be performed. Fifth, the quality of the reduction techniques and physicians varied among the studies and could not be standardized. Sixth, the definitions of the outcome periods varied among the studies. In particular, various outcome periods influence the ED length of stay and the time required for reduction. Finally, these results apply to patients with similar characteristics of the included studies because most patients were young adults.

CONCLUSIONS

The results of our network meta-analysis indicated that three sedation or analgesia methods (intravenous sedation, intraarticular anesthetic injection, and peripheral nerve block) might result in little to no difference in the success rate of reduction and patient satisfaction. Intraarticular anesthetic injection and peripheral nerve block had no adverse respiratory events. No randomized controlled trials compared the intraarticular anesthetic injection method with the peripheral nerve block method; therefore, high-quality randomized controlled trials are needed.

AUTHOR CONTRIBUTIONS

Minoru Hayashi, Naoto Kuroda, Norio Yamamoto, Akihiro Shiroshita, and Yuki Kataoka participated in the conception and design of the study. Minoru Hayashi, Kenichi Kano, and Naoto Kuroda conceived the study and acquired and interpreted the data. Minoru Hayashi

and Akihiro Shiroshita performed the analyses. Minoru Hayashi drafted the manuscript. All authors revised and approved the final version of the manuscript.

ACKNOWLEDGMENTS

The authors thank Dr. Tunku Sara Ahmad for providing us with the definition of the length of hospital stay in their study. This work was supported by the Systematic Review Workshop Peer Support Group (SRWS-PSG). We also appreciate Editage (www.editage.com) for English language editing.

CONFLICT OF INTEREST

The authors report no conflict of interest.

ORCID

Minoru Hayashi https://orcid.org/0000-0002-0160-6288
Naoto Kuroda https://orcid.org/0000-0003-1977-4893
Norio Yamamoto https://orcid.org/0000-0002-7902-9994
Akihiro Shiroshita https://orcid.org/0000-0003-0262-459X
Yuki Kataoka https://orcid.org/0000-0001-7982-5213

REFERENCES

1. Guler O, Ekinci S, Akyildiz F, et al. Comparison of four different reduction methods for anterior dislocation of the shoulder. *J Orthop Surg Res*. 2015;10:80.
2. Jiang N, Hu YJ, Zhang KR, Zhang S, Bin Y. Intra-articular lidocaine versus intravenous analgesia and sedation for manual closed reduction of acute anterior shoulder dislocation: an updated meta-analysis. *J Clin Anesth*. 2014;26:350-359.
3. Fitch RW, Kuhn JE. Intraarticular lidocaine versus intravenous procedural sedation with narcotics and benzodiazepines for reduction of the dislocated shoulder: a systematic review. *Acad Emerg Med*. 2008;15:703-708.
4. Wakai A, O'Sullivan R, McCabe A. Intra-articular lignocaine versus intravenous analgesia with or without sedation for manual reduction of acute anterior shoulder dislocation in adults. *Cochrane Database Syst Rev*. 2011;4:CD004919.
5. 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;18:922-927.
6. Raeyat Doost E, Heiran MM, Movahedi M, Mirafzal A. Ultrasound-guided interscalene nerve block vs procedural sedation by propofol and fentanyl for anterior shoulder dislocations. *Am J Emerg Med*. 2017;35:1435-1439.
7. Tezel O, Kaldirim U, Bilgic S, et al. A comparison of suprascapular nerve block and procedural sedation analgesia in shoulder dislocation reduction. *Am J Emerg Med*. 2014;32:549-552.
8. Hutton B, Salanti G, Caldwell DM, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. *Ann Intern Med*. 2015;162:777-784.
9. Hayashi M, Kano K, Kuroda N, Yamamoto N, Shiroshita A, Kataoka Y. Protocol: comparative efficacy of sedation or analgesia methods for reduction of anterior shoulder dislocation: a systematic review and network meta-analysis. 2021; https://www.protocols.io/view/protocol-comparative-efficacy-of-sedation-or-analg-81wgb7jbnvpk/v3. Accessed 21 Apr 2022.
10. Baykal B, Sener S, Turkan H. Scapular manipulation technique for reduction of traumatic anterior shoulder dislocations: experiences of an academic emergency department. *Emerg Med J*. 2005;22:336-338.
11. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*. 2019;366:l4898.
12. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). *Cochrane Handbook for Systematic Reviews of Interventions* version 6.3 (updated February 2022). Cochrane, 2022. Available from www.training.cochrane.org/handbook. Accessed 1 Aug 2022.
13. Owen RK, Bradbury N, Xin Y, Cooper N, Sutton A. MetaInsight: an interactive web-based tool for analyzing, interrogating, and visualizing network meta-analyses using R-shiny and netmeta. *Res Synth Methods*. 2019;10(4):569-581.
14. Nikolakopoulou A, Higgins JPT, Papakonstantinou T, et al. Cinema: an approach for assessing confidence in the results of a network meta-analysis. *PLoS Med*. 2020;17:1-19.
15. Papakonstantinou T, Nikolakopoulou A, Higgins JPT, Egger M, Salanti G. CINeMA: software for semiautomated assessment of the confidence in the results of network meta-analysis. *Campbell Syst Rev*. 2020;16:1-15.
16. Suder PA, Mikkelsen JB, Hougaard K, Jensen PE. Reduction of traumatic, primary anterior shoulder dislocations with local anesthesia. *J Shoulder Elbow Surg*. 1994;3:288-294.
17. Suder PA, Mikkelsen JB, Hougaard K, Jensen PE. Reduction of traumatic secondary shoulder dislocations with lidocaine. *Arch Orthop Trauma Surg*. 1995;114:233-236.
18. Kashani P, Asayesh Zarchi F, Hatamabadi HR, Afshar A, Amiri M. Intra-articular lidocaine versus intravenous sedative and analgesic for reduction of anterior shoulder dislocation. *Turk J Emerg Med*. 2016;16:60-64.
19. Matthews DE, Roberts T. Intraarticular lidocaine versus intravenous analgesic for reduction of acute anterior shoulder dislocations. A prospective randomized study. *Am J Sports Med*. 1995;23:54-58.
20. Kosnik J, Shamsa F, Raphael E, Huang R, Malachias Z, Georgiadis GM. Anesthetic methods for reduction of acute shoulder dislocations: a prospective randomized study comparing intraarticular lidocaine with intravenous analgesia and sedation. *Am J Emerg Med*. 1999;17:566-570.
21. Miller SL, Cleeman E, Auerbach J, Flatow EL. Comparison of intra-articular lidocaine and intravenous sedation for reduction of shoulder dislocations: a randomized, prospective study. *J Bone Joint Surg Am*. 2002;84:2135-2139.
22. Orlinsky M, Shon S, Chiang C, Chan L, Carter P. Comparative study of intra-articular lidocaine and intravenous meperidine/diazepam for shoulder dislocations. *J Emerg Med*. 2002;22:241-245.
23. Moharari RS, Khademhosseini P, Espandar R, et al. Intra-articular lidocaine versus intravenous meperidine/diazepam in anterior shoulder dislocation: a randomised clinical trial. *Emerg Med J*. 2008;25:262-264.
24. Cheok CY, Mohamad JA, Ahmad TS. Pain relief for reduction of acute anterior shoulder dislocations: a prospective randomized study comparing intravenous sedation with intra-articular lidocaine. *J Orthop Trauma*. 2011;25:5-10.
25. Hames H, McLeod S, Millard W. Intra-articular lidocaine versus intravenous sedation for the reduction of anterior shoulder dislocations in the emergency department. *CJEM*. 2011;13:378-383.
26. Ahmed ZABMBCH, Surgery FO. Intra-articular lidocaine compared to intravenous sedation for reduction of shoulder dislocation. *Tikrit Med J*. 2011;17:138-45.
27. Tamaoki MJ, Faloppa F, Wajnsztejn A, et al. Effectiveness of intra-articular lidocaine injection for reduction of anterior shoulder dislocation: randomized clinical trial. *Sao Paulo Med J*. 2012;130:367-372.
28. Abbasi S, Karbor R, Farsi D, et al. A comparison of the procedural sedation and analgesia (PSA) and ultrasound-guided suprascapular nerve block techniques in shoulder reduction. *J Crit Rev*. 2020;7:599-602.

29. Alkaduhimi H, van der Linde JA, Willigenburg NW, van Deurzen DFP, van den Bekerom MPJ. A systematic comparison of the closed shoulder reduction techniques. *Arch Orthop Trauma Surg*. 2017;137:589-599.
30. Driesen BEJM, van Riet BHG, Verkerk L, Bonjer HJ, Merten H, Nanayakkara PWB. Long length of stay at the emergency department is mostly caused by organisational factors outside the influence of the emergency department: a root cause analysis. *PLoS One*. 2018;13:e0202751.
31. Omer T, Perez M, Berona K, et al. Accuracy of landmark-guided glenohumeral joint injections as assessed by ultrasound in anterior shoulder dislocations. *West J Emerg Med*. 2021;22:1335-1340.
32. Green SM, Roback MG, Krauss BS, et al. Unscheduled procedural sedation: a multidisciplinary consensus practice guideline. *Ann Emerg Med*. 2019;73:e51-e65.
33. Kendall Healthcare Group, Ltd.IAA vs PS for Anterior Shoulder Dislocations. Accessed Apr 27, 2022. https://clinicaltrials.gov/ct2/show/record/NCT03625076
34. Tel-Aviv Sourasky Medical Center. Interscalene nerve block vs. Sedation for Shoulder Dislocation Reduction Accessed Apr 27, 2022. https://clinicaltrials.gov/ct2/show/NCT03041506
35. Iran University of Medical Sciences. Shoulder dislocation treatment under the anesthetic with sedation for performing the procedure and suprascapular nerve block. Accessed Apr 27, 2022. https://trialsearch.who.int/Trial2.aspx?TrialID=IRCT20151003024317N5
36. Godwin SA, Burton JH, Gerardo CJ, et al. American College of Emergency Physicians. Clinical policy: procedural sedation and analgesia in the emergency department. *Ann Emerg Med*. 2014;63:247-258.

SUPPORTING INFORMATION

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

How to cite this article: Hayashi M, Kano K, Kuroda N, Yamamoto N, Shiroshita A, Kataoka Y. Comparative efficacy of sedation or analgesia methods for reduction of anterior shoulder dislocation: A systematic review and network meta-analysis. *Acad Emerg Med*. 2022;29:1160-1171. doi: 10.1111/acem.14568