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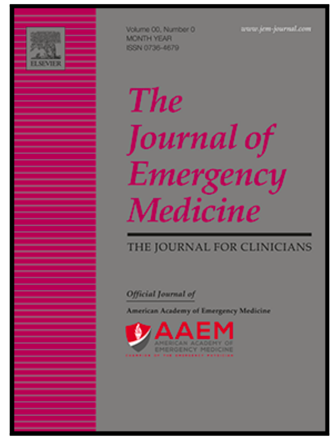

Complications of Ultrasound-Guided Peripheral Nerve Blocks in the Emergency Department: A Systematic Review and Meta-Analysis

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Complications of Ultrasound-Guided Peripheral Nerve Blocks in the Emergency Department: A Systematic Review and Meta-Analysis

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Keywords: ultrasound-guided peripheral nerve block, complications, emergency department

CRediT statement

- Joyce Hanyue Gu: Conceptualization, Methodology, Data Curation, Investigation, Formal analysis, Visualization, Writing - Original Draft
- Adrian Cotarelo: Conceptualization, Methodology, Data Curation, Investigation, Formal analysis
- Mark Samarneh: Writing - Review and Editing, Supervision

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Competing interests

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Abstract

Background: Ultrasound-guided nerve block (USGNB) is a technique which employs ultrasound guidance to improve the accuracy of anesthetic delivery in nerve block procedures, which leads to decreased analgesic use, fewer adverse effects, and increased patient satisfaction. While USGNB is traditionally administered by trained anesthesiologists in the perioperative setting, it also offers potential to improve pain management practices in the emergency department (ED).

Objective: Our objective is to assess the safety of USGNB in the ED setting.

Methods: We performed a systematic review and random effects model meta-analysis to estimate the complication rates of USGNB in the ED setting and the odds ratio of complication rates compared to standard of care analgesia. We searched records retrieved from PubMed and Google Scholar. Studies which examined ED-performed USGNB and reported adverse event statistics were included.

Results: Our systematic review screen yielded 179 retrievable studies, of which we included 53. A subset of 22 studies provided calculating odds ratios compared to standard analgesia. USGNB in the ED setting demonstrated a complication rate of 0.05 (95% CI [0.03, 0.07]) and a lower odds ratio 0.17 (95% CI 29 [0.08, 0.37]) of complications compared with standard analgesia.

Conclusion: Current evidence suggests that USGNB in the ED setting confers a low risk of complications and offers safety advantages over standard analgesia.

Introduction

Acute pain control is a primary concern for emergency department (ED) physicians, who encounter patients suffering from a wide range of traumatic injuries including fractures, dislocations, and blast injuries. Traditionally, severe pain in such settings is managed via intravenous administration of analgesics such as morphine [1]. However, such approaches can require large or sustained doses of analgesics to achieve adequate pain control, which can increase the risk of opioid-associated adverse effects, opioid dependency, and decreased patient satisfaction [1].

Ultrasound-guided nerve blocks (USGNB) have emerged as an effective strategy for enhancing pain management and reducing opioid use. As early as 1978, La Grange et al. proposed the use of doppler ultrasound to guide placement of supraclavicular brachial plexus blocks [2]. Similar techniques have since proliferated in anesthesiology practice, effectively decreasing the analgesic dosing, complications, and time to adequate anesthesia [1, 3]. The success of USGNB in anesthesiology has led to expand use in other settings, including the emergency department (ED) [4-5].

Despite potential benefits of USGNB, its adoption in the ED is hindered by its relative complexity. USGNB necessitates specialized training in ultrasound image acquisition and interpretation, as well as practiced motor skills to perform the nerve block [5]. Furthermore, USGNB poses potential risks, including hematomas, arterial puncture, other site complications and local systemic anesthetic toxicity (LAST) [1]. The objective of this study is to conduct a systematic review and meta-analysis of the existing literature on ED-performed USGNB to summarize the rates of procedural complications, both as a proportion of cases and as odds ratios compared to standard analgesia.

Methods

Study Selection

We performed a literature search on October 6, 2024 using the public research literature databases PubMed and Google Scholar. The search used the search query “ultrasound nerve block emergency" for both databases and restricted PubMed to clinical trials and randomized control trial filters. The Google Scholar search was limited to the first 100 articles returned. Other databases were excluded as a sufficient number of articles were identified using publicly accessible resources, and subscription-based services were not available to us.

We included case series, observational studies and randomized control trials involving USGNB performed in the ED setting that reported adverse event data. We excluded single case reports, studies which did not employ USGNB, studies in which USGNB were not performed by ED physicians or nurses, and studies that did not report complications of USGNB. The full text of all eligible studies was reviewed for inclusion by the first author. For each included study we extracted the digital object identifier

(DOI), authors, publication year, number of USGNB performed, type of USGNB, number of USGNB-associated complications, and the types of complications. A subset of the included publications also compared USGNB to a control of standard of care analgesia. For these publications we also extracted the number of patients received control analgesia, the number of complications associated with the control analgesia and the types of complications reported. All relevant study data was extracted and tabulated using Excel (Microsoft, Redmond, WA) by the first author. Automated data extraction tools were not used in this process.

Although a standardized risk of bias assessment tool for the estimation of complication rates does not exist to the best of our knowledge, we employed a subset of the Cochrane Risk of Bias 2 tool for randomized trials. The Cochrane Risk of Bias 2 tool for randomized trials evaluates the risk of bias of randomized trials based on five domains: (1) bias arising from the randomization process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in measurement of the outcome, and (5) bias in selection of the reported result. Of these, items (2) through (4) applied in our setting. This tool was employed by the first author for the evaluation of risk of bias.

In addition to our primary meta-analysis of complication rates, we also conducted a variety of sensitivity analyses by restricting the analysis to subsets of records. The first analysis restricts the records to only randomized control trials (RCTs), the second analysis excludes failed nerve blocks as a complication, and the third analysis restricts the records to only those with a low risk of bias. We also conducted a subgroup analysis to estimate the complication rate of the most common nerve block types, including femoral nerve/fascia iliaca compartment blocks, brachial plexus nerve blocks, and forearm nerve blocks.

Statistical Analysis

We carried out the meta-analysis using the R programming language version 4.4.1 (The R Foundation for Statistical Computing), a programming language for statistical computation, and the metafor package, which enables meta-analysis computations. We conducted a meta-analysis of proportions to estimate the complication rate of USGNB, and we conducted a meta-analysis of odds ratios to estimate the odds ratio of the complication rate of USGNB compared to standard analgesia. We used a random effects model, which assumes that the true effect size varies across the different studies considered, and measures both the variability within each study as well as the variability across the different studies. The meta-analysis of complication rates employed a logit transformation to maps proportions to logits, which are better suited for computing confidence intervals as they take values from negative infinity to infinity [7]. When the proportion is 0, as is the case in many of the articles included in our analysis, we used a 0.5 continuity correction [8]. The statistics across studies are combined by using inverse variance weighting. The between-study variance tau^2 parameter is estimated using the restricted maximum likelihood (REML) method, which is recommended over other methods such as the DerSimonian-Laird method [9].

Results

Our initial PubMed and Google Scholar searches yielded 93 and 100 studies, respectively, for a total of 193 studies screened. Finally, n = 5 other records identified through ad hoc means during early stages of the investigation were included in the study. After removal of duplicates, we identified 180 unique records, of which 179 were successfully retrieved for full review. Of these, 126 were excluded for not being performed in the ED (n = 64), not providing the required data (n = 27), being a review article (n = 21) or case report (n = 12), being an animal study (n = 1), or providing a citation only without a retrievable record (n = 1). for a total of 53 studies included in the analysis (Figure 1). [10-62] The included studies and relevant characteristics are displayed in Table 1.

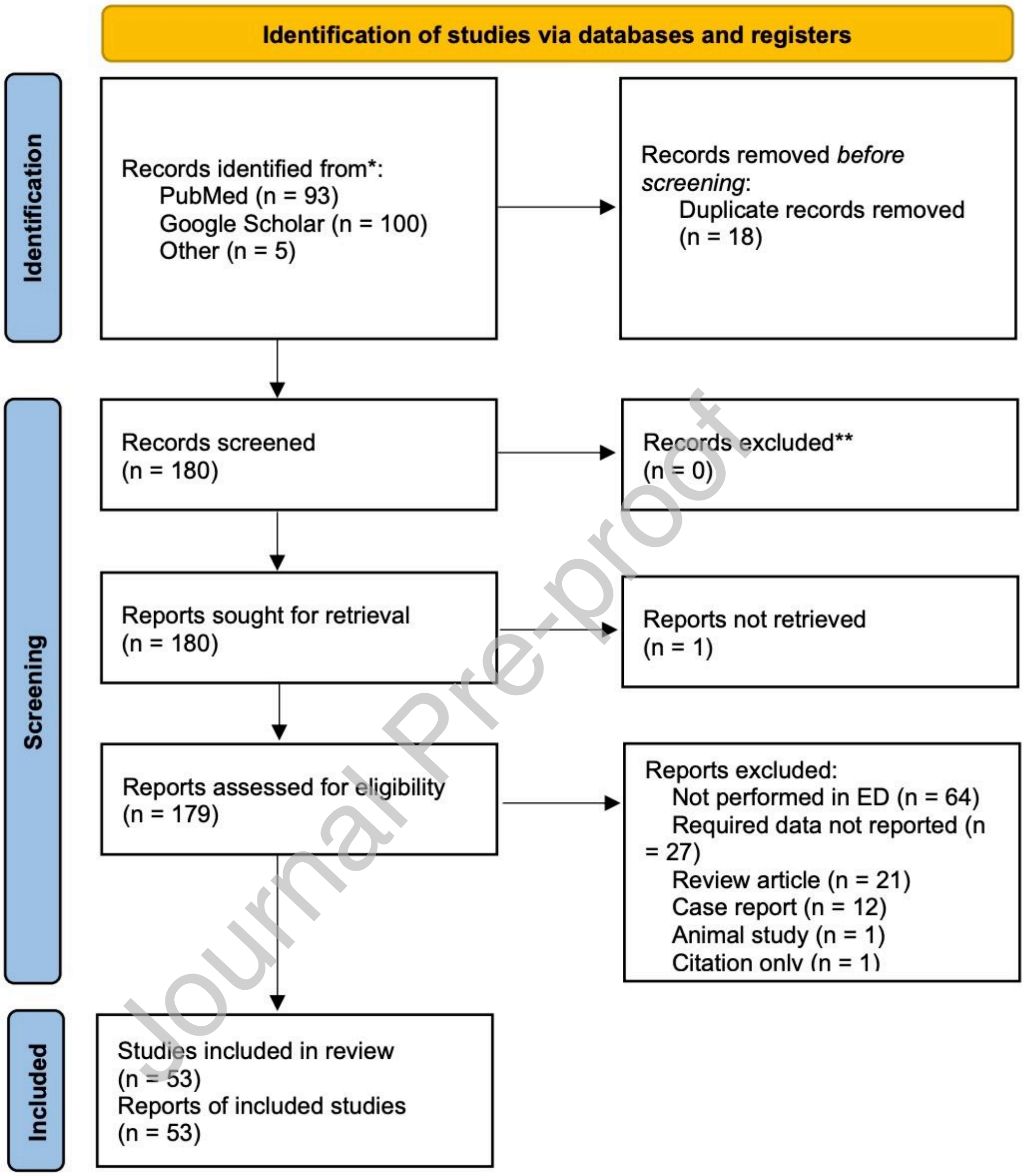

Figure 1: PRISMA flow diagram

Table 1: Studies included in meta-analysis.

Study	Block Type	N	Country	Study Design	Analgesic	Control Pain Management	Comparison to Standard Care Analgesia	Risk of Bias	Prospective or Retrospective
Armin et al., (2022)	Erector spinae	27	Iran	RCT	Lidocaine		no	Low bias	Prospective
Armin et al., (2022)	Intercostal	23	Iran	RCT	Lidocaine		no	Low bias	Prospective
Ashtari et al., (2023)	Periosteal	39	Iran	RCT	Lidocaine	IV Morphine	yes	Low bias	Prospective
Beaudoin et al., (2009)	Femoral	13	USA	Observational	Bupivacaine		no	Low bias	Prospective
Beaudoin et al., (2013)	Femoral	18	USA	RCT	Bupivacaine	IV Morphine	yes	Low bias	Prospective
Bhoi et al., (2012)	Sciatic	4	India	Observational	Lidocaine, Bupivacaine		no	Low bias	Prospective
Bhoi et al., (2012)	Femoral	7	India	Observational	Lidocaine, Bupivacaine		no	Low bias	Prospective
Bhoi et al., (2012)	Brachial	29	India	Observational	Lidocaine		no	Low bias	Prospective
Bhoi et al., (2012)	Forearm	8	India	Observational	Lidocaine		no	Low bias	Prospective
Blaivas et al., (2011)	Brachial	21	USA	RCT	Lidocaine	IV Etomidate	yes	Low bias	Prospective
Buttner et al., (2018)	Mixed	18	Germany	RCT	Prilocaine, Ropivacaine	IV Midazolam	yes	Low bias	Prospective
Chandra et al., (2010)	Brachial	6	India	Case Series	Lidocaine		no	Some concerns	Retrospective
Chandra et al., (2010)	Sciatic	1	India	Case Series	Lidocaine		no	Some concerns	Retrospective
Chandra et al., (2010)	Forearm	1	India	Case Series	Lidocaine		no	Some concerns	Retrospective
Chen	FICB	38	China	RCT	Ropivacain	IV	no	Low	Prospecti

et al., (2021)					e	Flurbiprofen		bias	ve
Cooper et al., (2018)	Femoral	48	Australia	RCT	Levobupivacaine		no	Some concerns	Prospective
Cooper et al., (2018)	FICB	52	Australia	RCT	Levobupivacaine		no	Some concerns	Prospective
David et al., (2024)	Erector spinae	30	India	RCT	Ropivacaine	IV Morphine	yes	Low bias	Prospective
Doost et al., (2017)	Brachial	30	Iran	RCT	Lidocaine	IV Propofol, Fentanyl	yes	Low bias	Prospective
Fletcher et al., (2003)	Femoral	26	UK	RCT	Bupivacaine	IV Morphine	no	Low bias	Prospective
Frenkel et al., (2015)	Forearm	10	Canada	Observational	Lidocaine, Bupivacaine		no	Low bias	Prospective
Gerlier et al., (2023)	Femoral	15	France	RCT	Ropivacaine	IV Morphine	yes	Low bias	Prospective
Groot et al., (2015)	FICB	43	Netherlands	Observational	Levobupivacaine		no	Some concerns	Prospective
Gullupinar et al., (2022)	Femoral	18	Turkey	RCT	Bupivacaine	IV paracetamol, tramadol	yes	Low bias	Prospective
Haines et al., (2012)	FICB	20	USA	Observational	Bupivacaine		no	Low bias	Prospective
Hao et al., (2019)	FICB	44	China	RCT	Ropivacaine	IM Fentanyl	yes	Some concerns	Prospective
Heffler et al., (2022)	Femoral/ FICB	85	USA	Observational	Ropivacaine		no	Some concerns	Retrospective
Herring et al., (2011)	Abdominal	4	USA	Case Series	Lidocaine, Bupivacaine		no	Low bias	Retrospective
Ho et al., (2024)	Erector spinae	19	Canada	RCT	Lidocaine, Bupivacaine		no	Low bias	Prospective
Isfahani et al., (2021)	Forearm	27	Iran	RCT	Lidocaine, Bupivacaine	IV Ketamine	yes	Some concerns	Prospective
Jang et al., (2018)	Femoral	16	Korea	RCT	Bupivacaine	IV Tramadol	yes	Low bias	Prospective
Kang	Mixed	20	Korea	RCT	Lidocaine,	Not	yes	Low	Prospecti

et al., (2017)					Ropivacaine	specified		bias	ve
Ketelaars et al., (2018)	FICB	13	Netherlands	Observational	Ropivacaine		no	Low bias	Prospective
Ketelaars et al., (2018)	Femoral	51	Netherlands	Observational	Ropivacaine		no	Low bias	Prospective
Lee et al., (2021)	Femoral	102	Canada	Observational	Bupivacaine		no	Low bias	Prospective
Lee et al., (2014)	Femoral	25	Korea	Case-Control	Bupivacaine	IV Morphine	yes	Low bias	Retrospective
Liebmann et al., (2006)	Forearm	11	USA	Observational	Lidocaine, Bupivacaine		no	Low bias	Prospective
Martin et al., (2022)	Brachial	2	USA	Case Series	Bupivacaine		no	Some concerns	Retrospective
Martin et al., (2022)	Sciatic	1	USA	Case Series	Bupivacaine		no	Some concerns	Retrospective
Merz-Herrala et al., (2023)	Femoral/ FICB	111	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Serratus anterior	69	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Erector spinae	45	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Sciatic	36	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Brachial	61	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al.,	Popliteal	20	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective

(2023)									
Merz-Herrala et al., (2023)	Forearm	48	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Abdominal	1	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Merz-Herrala et al., (2023)	Other	29	USA	Observational	Bupivacaine, Ropivacaine		no	Low bias	Retrospective
Mohanty et al., (2022)	Mixed	56	India	RCT	Ropivacaine	IV Ketamine	yes	Low bias	Prospective
Mohanty et al., (2023)	Suprascapular	10	India	Case Series	Lidocaine		no	Some concerns	Retrospective
Morrison et al., (2016)	Femoral	72	USA	RCT	Bupivacaine	Not specified	yes	Low bias	Prospective
Nejati et al., (2017)	Mixed	46	Iran	Case Series	Bupivacaine		no	Low bias	Retrospective
Ramesh et al., (2023)	Erector spinae	23	India	RCT	Bupivacaine	Placebo	yes	Low bias	Prospective
Reid et al., (2009)	Femoral	34	Australia	RCT	Bupivacaine	Fasical pop	yes	Low bias	Prospective
Rukerd et al., (2024)	Femoral	40	Iran	RCT	Lidocaine		no	Some concerns	Prospective
Rukerd et al., (2024)	FICB	47	Iran	RCT	Lidocaine		no	Some concerns	Prospective
Saga et al., (2024)	Femoral	21	Norway	RCT	Ropivacaine		no	Low bias	Prospective
Saglam et al., (2021)	Femoral	34	Turkey	RCT	Lidocaine		no	Some concerns	Prospective
Sahoo et al.,	Femoral	30	India	RCT	Bupivacaine	IV Nalbuphi	yes	Low bias	Prospective

(2024)						ne			
Sohoni et al., (2016)	Forearm	18	USA	Observational	Lidocaine		no	Low bias	Prospective
Stone et al., (2008)	Brachial	7	USA	RCT	Lidocaine	IV Propofol, Etomidate	yes	Low bias	Prospective
Stone et al., (2007)	Brachial	5	USA	Case Series	Lidocaine		no	Some concerns	Retrospective
Tekin et al., (2021)	Brachial	30	Turkey	RCT	Lidocaine	IV Propofol, Fentanyl	yes	Low bias	Prospective
Tezel et al., (2014)	Suprascapular	21	Turkey	RCT	Prilocaine	IV Ketamine	yes	Low bias	Prospective
Topal et al., (2020)	Femoral	40	Turkey	Observational	Prilocaine		no	Low bias	Prospective
Tsai et al., (2022)	Femoral	66	Taiwan	Observational	Lidocaine		no	Low bias	Retrospective
Turner et al., (2014)	Femoral	31	USA	Observational	Ropivacaine		no	Low bias	Retrospective
Unluer et al., (2016)	Forearm	15	Turkey	Observational	Lidocaine		no	Some concerns	Prospective
Vrablik et al., (2021)	Forearm	6	USA	RCT	Lidocaine, Bupivacaine	Not specified	yes	Low bias	Prospective
Wroe et al., (2021)	Forearm	4	USA	Observational	Not specified		no	Some concerns	Prospective
Xu et al., (2021)	Abdominal	60	USA	RCT	Ropivacaine		no	Some concerns	Prospective

Primary Meta-analysis: USGNB Complication Rate

The main meta-analysis to determine the pooled proportion of USGNB-associated complications encompassed a total of 2106 patients treated with ED-performed USGNB with 79 complications across the 53 included studies.

Reported complications included nausea/vomiting/dizziness, failed nerve block, respiratory depression (including hypoxia and desaturation), hypotension, bleeding (including hematoma, bruising, and arterial puncture), urinary retention, paresthesias, LAST, nerve injury, fall, agitation, pruritis, constipation, and seizure. The adverse effects of nausea, vomiting and dizziness were grouped together in multiple studies, so this grouping was maintained for the purpose of the analysis. The total complication counts and the corresponding number of studies reporting these complications are displayed in Figure 2.

The meta-analysis of overall complication rate is presented in Figure 3. The aggregate complication rate in patients undergoing USGNB was 0.05 (95% CI [0.03, 0.07]). Heterogeneity between studies was moderate ($I^2 = 65.66\%$, $p < 0.0001$) [63].

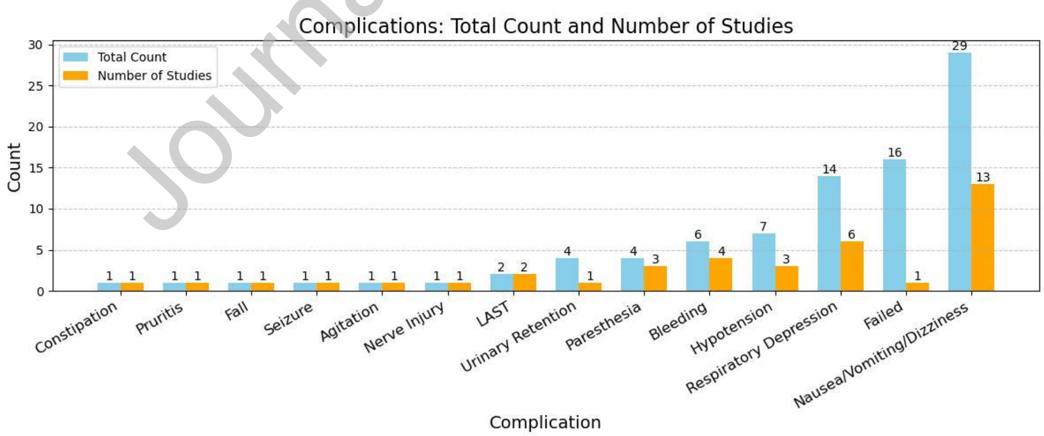

Figure 2: The total number of patients and the number of studies reporting complications of USGNB. RCT = randomized control trial

Study	Events	Total	Weights	Proportion [95% CI]
Fletcher et al. (2003)	0	26	1.5 %	0.02 [0.00, 0.24]
Liebmann et al. (2006)	0	11	1.4 %	0.04 [0.00, 0.42]
Stone et al. (2007)	0	5	1.4 %	0.08 [0.01, 0.62]
Stone et al. (2008)	0	7	1.4 %	0.06 [0.00, 0.54]
Beaudoin et al. (2009)	0	13	1.5 %	0.04 [0.00, 0.38]
Reid et al. (2009)	0	34	1.5 %	0.01 [0.00, 0.19]
Chandra et al. (2010)	2	8	2.4 %	0.25 [0.06, 0.62]
Blaivas et al. (2011)	0	21	1.5 %	0.02 [0.00, 0.28]
Herring et al. (2011)	0	4	1.4 %	0.10 [0.01, 0.67]
Bhoi et al. (2012)	0	48	1.5 %	0.01 [0.00, 0.14]
Haines et al. (2012)	0	20	1.5 %	0.02 [0.00, 0.29]
Beaudoin et al. (2013)	9	18	3.1 %	0.50 [0.28, 0.72]
Lee et al. (2014)	1	25	2.1 %	0.04 [0.01, 0.24]
Tezel et al. (2014)	0	21	1.5 %	0.02 [0.00, 0.28]
Turner et al. (2014)	3	31	2.8 %	0.10 [0.03, 0.26]
Frenkel et al. (2015)	0	10	1.4 %	0.05 [0.00, 0.45]
Groot et al. (2015)	0	43	1.5 %	0.01 [0.00, 0.16]
Morrison et al. (2016)	2	72	2.6 %	0.03 [0.01, 0.10]
Sohoni et al. (2016)	0	18	1.5 %	0.03 [0.00, 0.31]
Unluer et al. (2016)	0	15	1.5 %	0.03 [0.00, 0.35]
Doost et al. (2017)	1	30	2.1 %	0.03 [0.00, 0.20]
Kang et al. (2017)	0	20	1.5 %	0.02 [0.00, 0.29]
Nejati et al. (2017)	2	46	2.6 %	0.04 [0.01, 0.16]
Buttner et al. (2018)	0	18	1.5 %	0.03 [0.00, 0.31]
Cooper et al. (2018)	18	100	3.4 %	0.18 [0.12, 0.27]
Jang et al. (2018)	9	16	3.0 %	0.56 [0.32, 0.78]
Ketelaars et al. (2018)	0	64	1.5 %	0.01 [0.00, 0.11]
Hao et al. (2019)	3	44	2.8 %	0.07 [0.02, 0.19]
Topal et al. (2020)	0	40	1.5 %	0.01 [0.00, 0.17]
Chen et al. (2021)	3	38	2.8 %	0.08 [0.03, 0.22]
Isfahani et al. (2021)	0	27	1.5 %	0.02 [0.00, 0.23]
Lee et al. (2021)	0	102	1.5 %	0.00 [0.00, 0.07]
Saglam et al. (2021)	0	34	1.5 %	0.01 [0.00, 0.19]
Tekin et al. (2021)	5	30	3.0 %	0.17 [0.07, 0.34]
Vrablik et al. (2021)	1	6	1.9 %	0.17 [0.02, 0.63]
Wroe et al. (2021)	0	4	1.4 %	0.10 [0.01, 0.67]
Xu et al. (2021)	4	60	3.0 %	0.07 [0.03, 0.16]
Armin et al. (2022)	1	50	2.1 %	0.02 [0.00, 0.13]
Gullupinar et al. (2022)	0	18	1.5 %	0.03 [0.00, 0.31]
Heffler et al. (2022)	0	85	1.5 %	0.01 [0.00, 0.09]
Martin et al. (2022)	0	3	1.4 %	0.12 [0.01, 0.73]
Mohanty et al. (2022)	0	56	1.5 %	0.01 [0.00, 0.13]
Tsai et al. (2022)	0	66	1.5 %	0.01 [0.00, 0.11]
Ashtari et al. (2023)	0	39	1.5 %	0.01 [0.00, 0.17]
Gerlier et al. (2023)	8	15	3.0 %	0.53 [0.29, 0.76]
Merz–Herrala et al. (2023)	1	420	2.1 %	0.00 [0.00, 0.02]
Mohanty et al. (2023)	0	10	1.4 %	0.05 [0.00, 0.45]
Ramesh et al. (2023)	3	23	2.8 %	0.13 [0.04, 0.34]
David et al. (2024)	0	35	1.5 %	0.01 [0.00, 0.19]
Ho et al. (2024)	0	19	1.5 %	0.03 [0.00, 0.30]
Rukerd et al. (2024)	3	87	2.9 %	0.03 [0.01, 0.10]
Saga et al. (2024)	0	21	1.5 %	0.02 [0.00, 0.28]
Sahoo et al. (2024)	0	30	1.5 %	0.02 [0.00, 0.21]
Random effects model	79	2106	100%	0.05 [0.03, 0.07]

Heterogeneity: I^2 = 65.92%, Tau^2 = 1.4287, p <1e−04

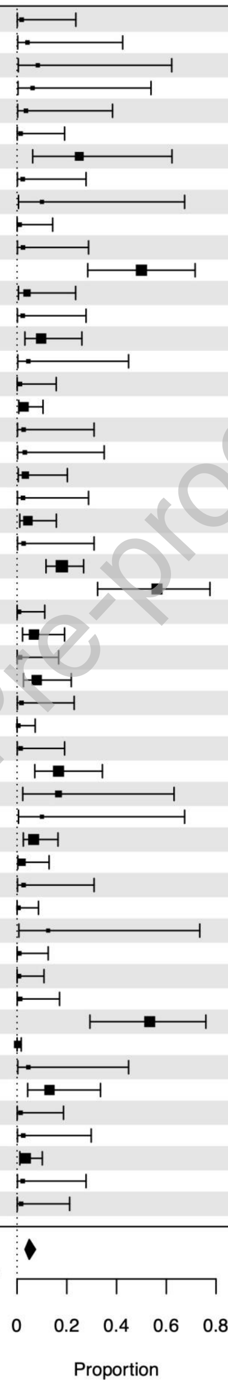

Figure 3: Meta-analysis of the proportion of complications.

Sensitivity analysis

Sensitivity analysis produced similar results to the main analysis (Figures 4-6). Restricting studies to RCTs only yielded an aggregate complication rate of 0.06 (95% CI 183 [0.04, 0.11]). Exclusion of failed nerve blocks as a complication yielded a complication rate of 0.05 (95% CI [0.03, 0.07]). Including only studies with a low risk of bias demonstrated an aggregate complication rate of 0.04 (95% CI [0.03, 0.08]).

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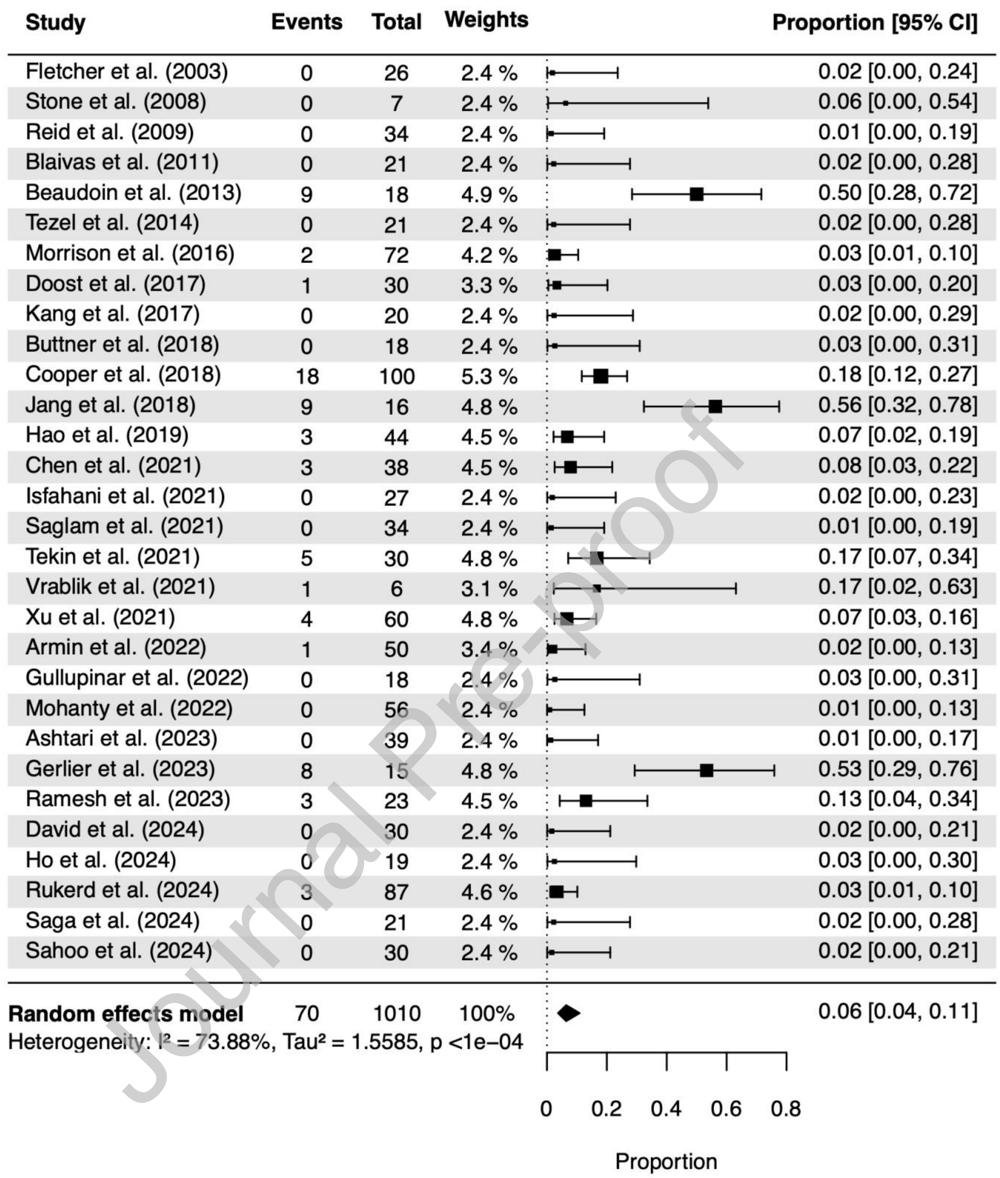

Figure 4: Meta-analysis of the proportion of complications, including only randomized control trials.

Study	Events	Total	Weights	Proportion [95% CI]
Fletcher et al. (2003)	0	26	1.5 %	0.02 [0.00, 0.24]
Liebmann et al. (2006)	0	11	1.5 %	0.04 [0.00, 0.42]
Stone et al. (2007)	0	5	1.4 %	0.08 [0.01, 0.62]
Stone et al. (2008)	0	7	1.4 %	0.06 [0.00, 0.54]
Beaudoin et al. (2009)	0	13	1.5 %	0.04 [0.00, 0.38]
Reid et al. (2009)	0	34	1.5 %	0.01 [0.00, 0.19]
Chandra et al. (2010)	2	8	2.4 %	0.25 [0.06, 0.62]
Blaivas et al. (2011)	0	21	1.5 %	0.02 [0.00, 0.28]
Herring et al. (2011)	0	4	1.4 %	0.10 [0.01, 0.67]
Bhoi et al. (2012)	0	48	1.5 %	0.01 [0.00, 0.14]
Haines et al. (2012)	0	20	1.5 %	0.02 [0.00, 0.29]
Beaudoin et al. (2013)	9	18	3.1 %	0.50 [0.28, 0.72]
Lee et al. (2014)	1	25	2.1 %	0.04 [0.01, 0.24]
Tezel et al. (2014)	0	21	1.5 %	0.02 [0.00, 0.28]
Turner et al. (2014)	3	31	2.9 %	0.10 [0.03, 0.26]
Frenkel et al. (2015)	0	10	1.4 %	0.05 [0.00, 0.45]
Groot et al. (2015)	0	43	1.5 %	0.01 [0.00, 0.16]
Morrison et al. (2016)	2	72	2.6 %	0.03 [0.01, 0.10]
Sohoni et al. (2016)	0	18	1.5 %	0.03 [0.00, 0.31]
Unluer et al. (2016)	0	15	1.5 %	0.03 [0.00, 0.35]
Doost et al. (2017)	1	30	2.1 %	0.03 [0.00, 0.20]
Kang et al. (2017)	0	20	1.5 %	0.02 [0.00, 0.29]
Nejati et al. (2017)	2	46	2.6 %	0.04 [0.01, 0.16]
Buttner et al. (2018)	0	18	1.5 %	0.03 [0.00, 0.31]
Cooper et al. (2018)	2	100	2.6 %	0.02 [0.01, 0.08]
Jang et al. (2018)	9	16	3.1 %	0.56 [0.32, 0.78]
Ketelaars et al. (2018)	0	64	1.5 %	0.01 [0.00, 0.11]
Hao et al. (2019)	3	44	2.9 %	0.07 [0.02, 0.19]
Topal et al. (2020)	0	40	1.5 %	0.01 [0.00, 0.17]
Chen et al. (2021)	3	38	2.9 %	0.08 [0.03, 0.22]
Isfahani et al. (2021)	0	27	1.5 %	0.02 [0.00, 0.23]
Lee et al. (2021)	0	102	1.5 %	0.00 [0.00, 0.07]
Saglam et al. (2021)	0	34	1.5 %	0.01 [0.00, 0.19]
Tekin et al. (2021)	5	30	3.1 %	0.17 [0.07, 0.34]
Vrablik et al. (2021)	1	6	1.9 %	0.17 [0.02, 0.63]
Wroe et al. (2021)	0	4	1.4 %	0.10 [0.01, 0.67]
Xu et al. (2021)	4	60	3.0 %	0.07 [0.03, 0.16]
Armin et al. (2022)	1	50	2.1 %	0.02 [0.00, 0.13]
Gullupinar et al. (2022)	0	18	1.5 %	0.03 [0.00, 0.31]
Heffler et al. (2022)	0	85	1.5 %	0.01 [0.00, 0.09]
Martin et al. (2022)	0	3	1.4 %	0.12 [0.01, 0.73]
Mohanty et al. (2022)	0	56	1.5 %	0.01 [0.00, 0.13]
Tsai et al. (2022)	0	66	1.5 %	0.01 [0.00, 0.11]
Ashtari et al. (2023)	0	39	1.5 %	0.01 [0.00, 0.17]
Gerlier et al. (2023)	8	15	3.0 %	0.53 [0.29, 0.76]
Merz−Herrala et al. (2023)	1	420	2.1 %	0.00 [0.00, 0.02]
Mohanty et al. (2023)	0	10	1.4 %	0.05 [0.00, 0.45]
Ramesh et al. (2023)	3	23	2.8 %	0.13 [0.04, 0.34]
David et al. (2024)	0	30	1.5 %	0.02 [0.00, 0.21]
Ho et al. (2024)	0	19	1.5 %	0.03 [0.00, 0.30]
Rukerd et al. (2024)	3	87	2.9 %	0.03 [0.01, 0.10]
Saga et al. (2024)	0	21	1.5 %	0.02 [0.00, 0.28]
Sahoo et al. (2024)	0	30	1.5 %	0.02 [0.00, 0.21]
Random effects model	63	2101	100%	0.05 [0.03, 0.07]

Heterogeneity: I^2 = 61.80%, Tau^2 = 1.4014, p <1e−04

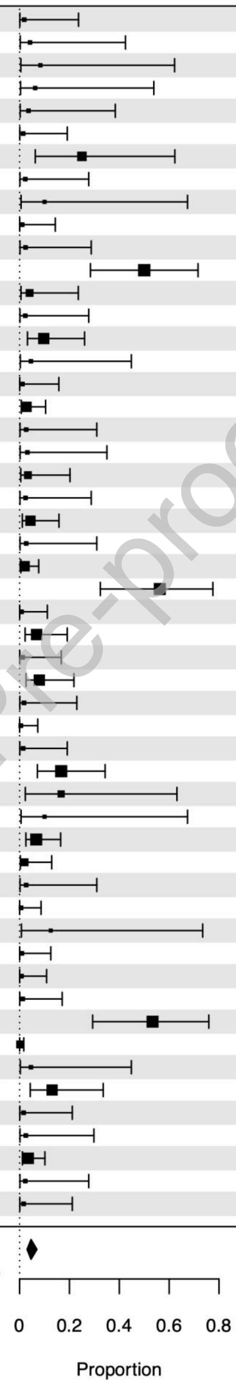

Figure 5: Meta-analysis of the proportion of complications, excluding failed blocks.

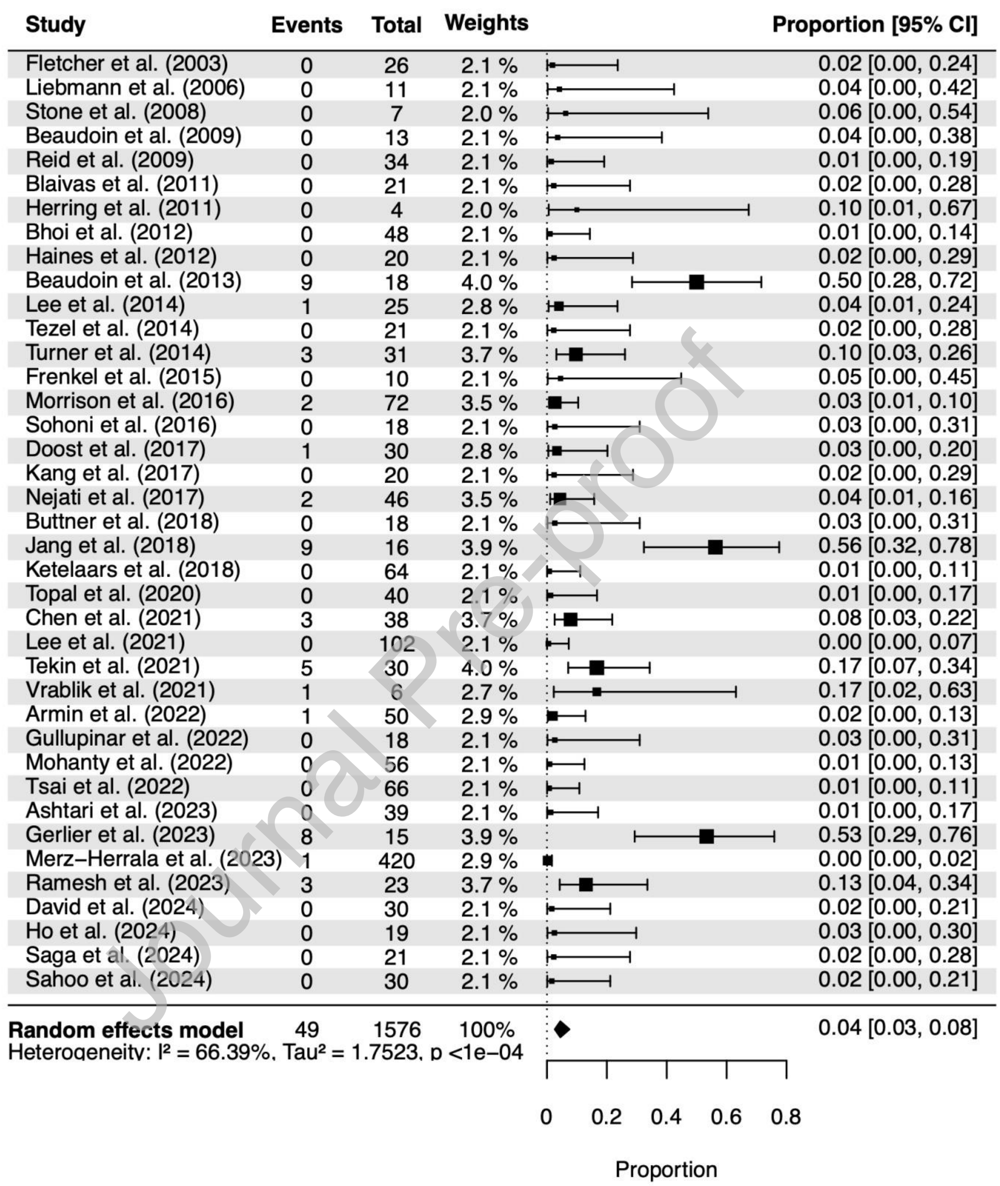

Figure 6: Meta-analysis of the proportion of complications, including only studies with low risk of bias.

Subgroup Meta-analysis: Type of Nerve Block

Subgroup analysis of the three most common types of nerve blocks yielded results similar to those of the main analysis. The largest subgroup, femoral nerve/fascia iliaca compartment blocks, encompassed 26 studies with 1160 patients. Repeat analysis of femoral nerve/fascia iliaca compartment blocks demonstrated an aggregate complication rate of 0.05 (95% CI [0.02, 0.09]) (Figure 7). The second largest subgroup, brachial plexus nerve blocks, was examined in 9 studies involving 191 patients and yielded an aggregate complication rate of 0.07 (95% CI [0.03, 0.15]) (Figure 8). Forearm nerve blocks (radial, median and ulnar nerves) constituted the third largest subgroup, reported in 10 studies with 148 patients and yielding an aggregate complication rate of 0.05 (95% CI [0.02, 221 0.11]) (Figure 9).

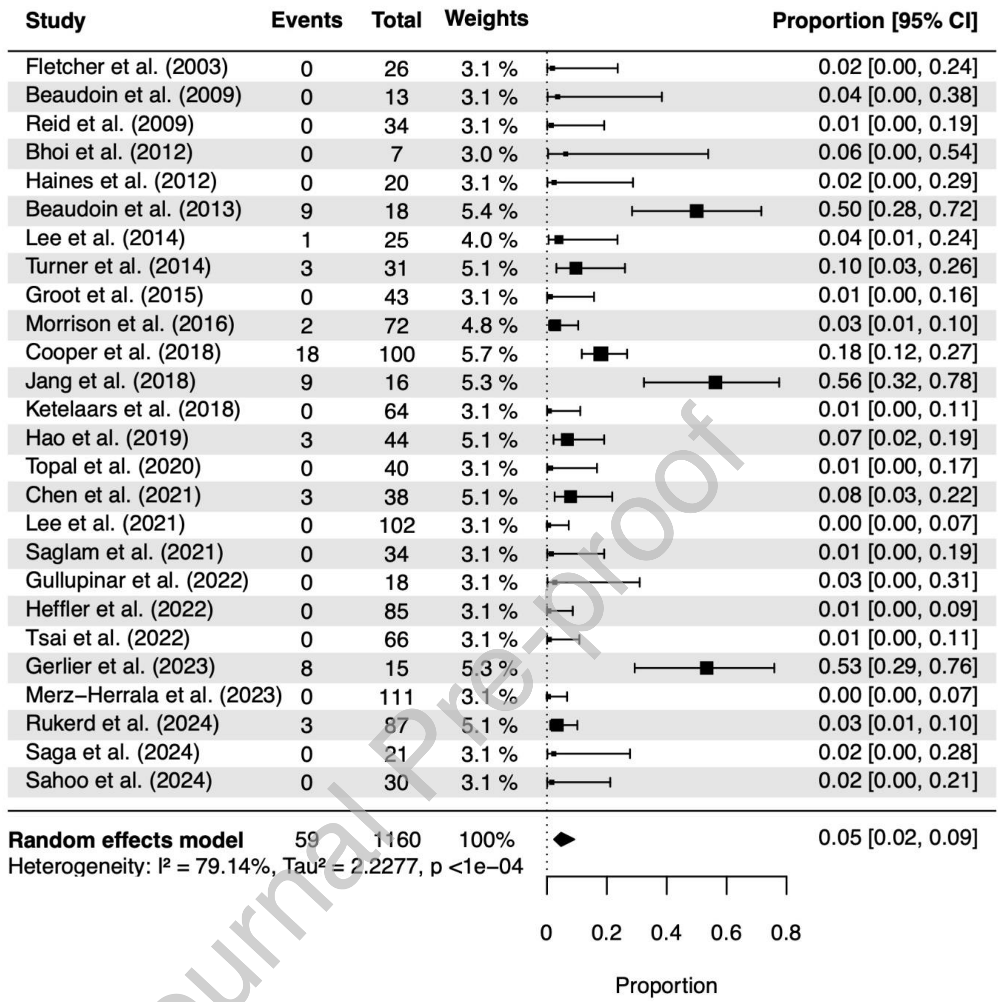

Figure 7: Meta-analysis of the proportion of complications, restricted to femoral nerve/fascia iliaca compartment blocks.

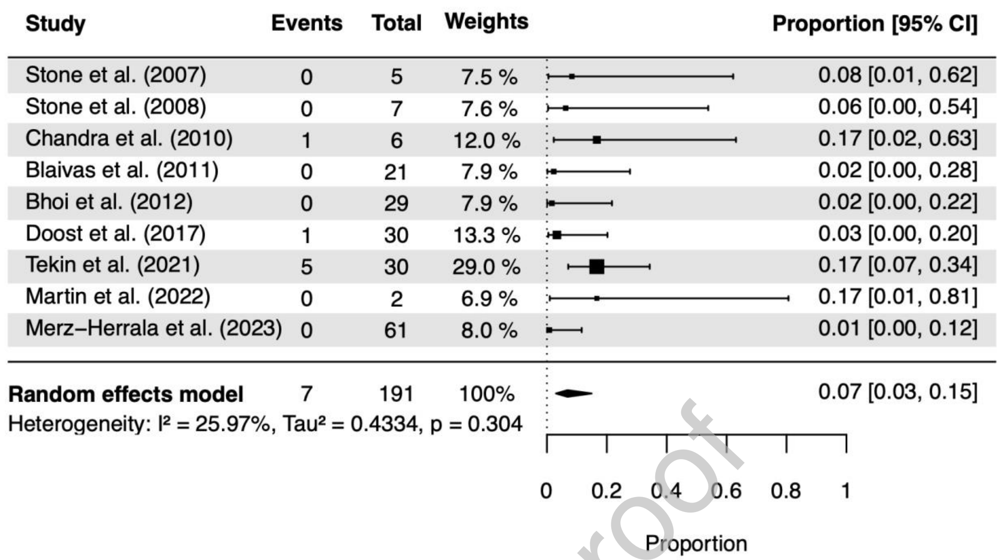

Figure 8: Meta-analysis of the proportion of complications, restricted to brachial plexus nerve blocks.

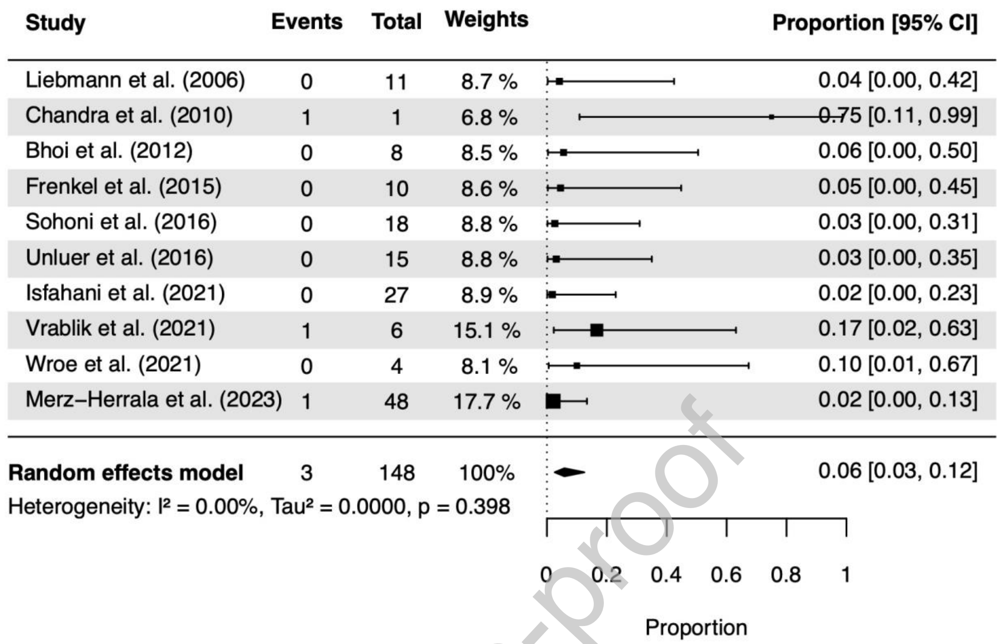

Figure 9: Meta-analysis of the proportion of complications, restricted to forearm nerve blocks.

Secondary Meta-analysis: USGNB Compared to Standard Analgesia

Of the 53 studies included in the meta-analysis, 22 studies compared USGNB complication rates to those of standard analgesia [13, 15, 17, 229 21, 23, 27, 30-31, 33, 35, 37, 40, 43-44, 48, 51, 53-54, 57-59, 62]. The standard analgesia control groups entailed administration of intravenous medications, including nalbuphine [62], morphine [53-54, 58], and ketamine [51]. Using this subset of studies, secondary meta-analysis demonstrated a lower rate of complications for USGNB compared to standard analgesia with an aggregate log OR of -1.73 (95% CI [-2.48, -0.99]) and corresponding OR of 0.18 (95% CI [0.08, 0.37]) (Figure 10). Most studies observed an equal or lower rate of complications for USGNB compared to the standard of care, the exceptions being Vrablik et al. (Log OR = 1.27, 95% CI [-2.13, 4.66]), Gullupinar et al. (Log OR = 0.15, 95% CI [-3.82, 4.12]) and Ramesh et al. (Log OR = 2.08, 95% CI [-0.94, 5.10]). [44, 48, 57].

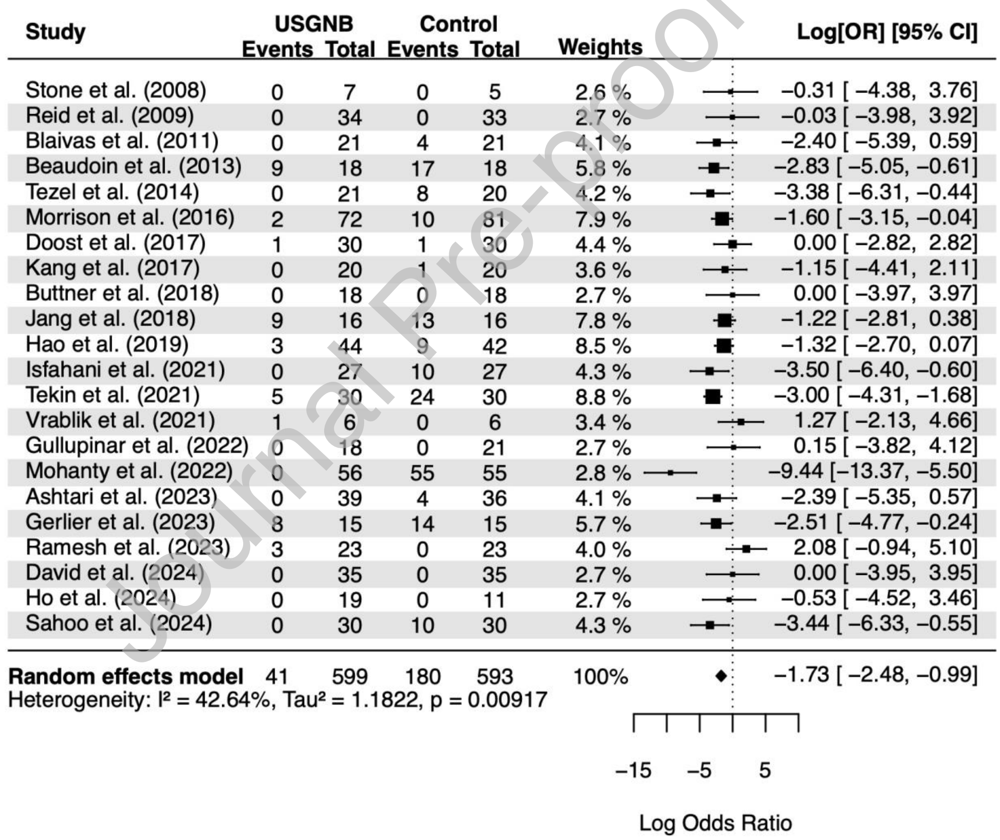

Figure 10: Meta-analysis of the odds ratio of the complication rates in USGNB versus standard care analgesia.

Discussion

The use of USGNB in the ED setting has the potential to substantially improve pain management and reduce the need for opioid analgesics. Aggregate data from 53 studies suggest a low overall rate of USGNB complications at approximately 5%. This complication rate did not change substantially when compared across different types of the most commonly studied blocks. In comparison to standard analgesia, USGNB was associated with a significantly lower risk of complications with an aggregate OR 0.17 (95% CI [0.08, 0.37]).

There have been several other systematic reviews of USGNB use in other settings. Exsteen et al. examined USGNB use by anesthesiologists in the preoperative setting and found USGNB to be associated with less pain, less analgesic use, and fewer adverse events. [66] A systematic review and meta-analysis of USGNB for shoulder dislocations in the ED demonstrated higher patient satisfaction and greater likelihood of successful reduction. [67] Our results build upon these prior publications by providing additional evidence as to the general safety of USGNB in the ED and use over a wide scope of applications.

There is good evidence for the safety of USGNB observed both in our study and others, but there remaining questions to be explored regarding how to best implement and utilize USGNB in the ED. The optimal approach to training ED physicians in USGNB is not well established. Initial work on this was conducted by Bretholz et al. and Pek et al. However, these studies only assessed trainee satisfaction, rather than clinical outcomes. [64-65] Future studies should focus on clinical outcomes of USGNB performed by ED physicians and trainees, as well as assessing the effectiveness of associated USGNB training.

Limitations

The current work has several limitations, which must be considered when interpreting the results. The studies included in the meta-analysis exhibited significant heterogeneity. Our aggregated results were pooled across studies with different nerve block types/indications, analgesics used, physician experience level, patient characteristics, and numerous other factors for which we were unable to control. There was also a wide range of different complication rates reported across the included studies, ranging from 0% up to 50%.

Additionally, our meta-analysis extracted data on complication rates of USGNB from studies in which adverse events were often not the primary outcome of interest. This could have led to under-recognition or under-reporting of such complications. Our investigation only included studies on USGNB which reported complication rates of the procedure. This may introduce bias towards USGNB procedures for which the operator has a particular awareness of or interest in complications of the procedure. Our initial literature search was not optimized in terms of rigor, was limited in terms of databases used and applied a cap on the number of returns considered. There may be additional relevant studies that were not identified, nor included in our analysis. Most of the included USGNB studies were small and might have employed a limited number of operators with particular interest or specialized training in the specific USGNB being examined. This could limit the generalizability of our findings for other ED physicians.

Conclusion

This systematic review and meta-analysis suggest that ultrasound-guided nerve blocks (USGNB) in the emergency department are associated with a low complication rate and a significantly lower risk of complications compared to standard analgesia. These findings support the broader implementation of USGNB in emergency care settings.

Article Summary

1. Why is this topic important? Ultrasound-guided peripheral nerve blocks (USGNB) are an emerging technology which has the potential to drastically improve patient outcomes during pain management in the ED.
2. What does this review attempt to show? This review attempts to show that USGNB is a safe technique for application in the ED.
3. What are the key findings? We find that complications of USGNB occur at a rate of roughly 5% and has an odds ratio of 0.17 compared to standard care analgesia.
4. How is patient care impacted? Our study enables greater transparency to patients and ED physicians on the complication rates of USGNB.

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