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Comparative efficacy and safety of local anesthesia combinations for labor pain relief: a network meta-analysis

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Abstract

Background Epidural anesthesia stands out as the most commonly employed approach for labor analgesia, frequently complemented by various local anesthetics, and the analgesic effectiveness and safety profiles of distinct local anesthetic regimens are different. To compare the efficacy and adverse reactions of different local anesthetic regimens in relieving labor pain by performing a network meta-analysis.

Methods We systematically searched four electronic databases (PubMed, EMBASE, Web of Science, and Cochrane Library) for randomized controlled trials from the inception of the databases up to March 3, 2025. Included in the study were patients aged 18 to 35 years who underwent painless delivery under epidural anesthesia.

Results The meta-analysis included a total of 59 studies involving 6972 patients. The combination of Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) was the most effective and fast in reducing Visual Analog Scale (VAS) scores at 30 min after block, compared to most other anesthesia schemes. Labor pain lasted for the longest time with Ropivacaine_Dexmedetomidine(Rop_Dex). Meanwhile, Bupivacaine_Pethidine(Bpv_Pet), Bupivacaine_Dexmedetomidine(Bpv_Dex), Fentanyl(Fen), and Bupivacaine_Diamorphine(Bpv_DiaMor) had the lowest incidence of nausea, vomiting, hypotension, and pruritus. Besides, Bupivacaine_Dexmedetomidine(Bpv_Dex), Ropivacaine_Dexmedetomidine(Rop_Dex), and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) have demonstrated outstanding analgesic efficacy and safety.

Conclusions Our study demonstrates that the combination of ropivacaine, dexmedetomidine, and sufentanil is the most effective regimen for alleviating labor pain. Nonetheless, given the limited number of studies on certain protocols, additional high-quality, large-scale randomized controlled trials (RCTs) are anticipated to substantiate our conclusion in the future.

PROSPERO registration number CRD42023459538.

Clinical trial number Not applicable.

Keywords Local anesthesia adjuvants, Labor pain, Pregnant women, Network meta-analysis

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Background

Labor pain is regarded as a challenging and intense pain experience in a woman's life. Pain during childbirth can have a significant impact on the mother's body and mind. In recent years, an array of strategies has been employed for labor analgesia, encompassing drug, physical, and psychological interventions. Although these methods are generally safe for both mothers and infants, the analgesic effects of methods such as physical and psychological interventions are often limited [1]. In contrast, drug-based epidural anesthesia stands out as the most widely used method in labor analgesia due to its notable analgesic effectiveness and high safety profile [2]. Notably, different epidural analgesic drugs have different analgesic effects and side effects, which have potential impacts on the health of offspring. Therefore, it is imperative to identify effective and safe epidural analgesic drugs.

Currently, anesthetic regimens application of different local anesthetics includes lidocaine, ropivacaine, chloroprocaine, and bupivacaine, either administered alone or in combination. Due to the limitations of single drugs, such as safe dosage, contraindications, the combined use of different types of drugs for epidural analgesia is often more beneficial to patients. For example, Zhou et al. demonstrated that ropivacaine combined with dexmedetomidine was superior to ropivacaine alone for analgesia and sedation, but there were no significant differences in motor block and neonatal asphyxia and hypoxia [3]. Guo et al. found that the incidence of motor block was significantly lower with ropivacaine combined with fentanyl than with ropivacaine alone, although there were no significant differences in analgesic effects and cesarean section rates [4]. Although multiple studies have demonstrated evidence of good analgesic effects for these local anesthetics, differences in conclusions have also been reported when comparing different local anesthetics [5].

A previous network meta-analysis compared six anesthetic regimens for cesarean section and found that lidocaine 2% with bicarbonate yielded the best analgesic effect [6]. In addition, a study comparing various concentrations of local anesthetics for epidural analgesia in labor concluded that ultra-low concentrations of local anesthetics were associated with reduced motor block and itching, although no differences in analgesic effects were observed among the concentrations [7]. While these findings address gaps in the research on different local anesthetics for epidural analgesia during labor, there is currently no comprehensive comparison of such local anesthetics for this purpose. Hence, the objective of this network meta-analysis is to consolidate information on commonly used anesthetics and different epidural analgesic drug strategies in epidural labor analgesia, aiming to provide a more comprehensive reference for the clinical use of anesthetics in the future.

Methods

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and their specifications for Network Meta-Analysis (NMA). The protocol has been registered with the International Prospective Systematic Evaluation Registry (CRD42023459538).

Search strategy

We conducted a comprehensive search on PubMed, Embase, Cochrane Library, and Web of Science, covering the period from the inception of the databases to March 3, 2025, to collect relevant English literature. The search strategy involved a combination of subject terms and free words. Medical subject terms included "epidural analgesia," "delivery," "labor," and "randomized controlled trial." Additionally, the references of published systematic reviews were manually searched to ensure the inclusiveness of retrieved literature.

Inclusion and exclusion criteria

Articles meeting the following criteria were included in this study: (1) women in labor undergoing epidural analgesia; (2) intervention and control groups receiving different adjunctive anesthetics; (3) the study type was a randomized controlled trial (RCT); (4) the primary outcome was the VAS pain score at 30 min after block, time to take effect (VAS score of lower than 4), duration of analgesia (calculated from the time of pain relief [VAS < 4] to the time to the first topup dose), and secondary outcomes included hypotension, nausea, vomiting, and itching.

The following articles were excluded: (1) animal or cell experiments, case reports, scientific experimental plans, reviews, letters, editorials, conference papers, etc.; (2) anesthesia protocols with only one article; (3) duplicate publications; (4) full text not found: (5) studies on the combined spinal-peridural technique.

Data extraction

The retrieved documents were imported into EndNote. Two researchers (P. Li, X.T. Ma) independently screened the papers based on titles and abstracts according to the inclusion and exclusion criteria, and then conducted a second screening by reading the full text. Any disagreements during the review process were resolved through discussion or consultation with a third researcher (M. Zhang). Two investigators independently used Excel 2016 to extract data from the finally included literature, including the first author, publication year, country, randomized and blinded design, intervention and control measures, patient sample size, age, BMI, gestational age, and outcome indicators.

Quality assessment

Included studies were assessed using the Cochrane Bias Risk Assessment Tool (RoB2.0) [8] in five domains: bias in randomization, bias from defined interventions, bias in missing outcome data, bias in outcome measurement, and bias in selective reporting of results. For each study, two investigators (P. Li, X. T Ma) independently assessed the study's quality in the above five aspects as "low risk", "high risk", and "possible risk". Any disagreements during the review process were resolved through discussion or consultation with a third researcher (M. Zhang).

Statistical analysis

Dichotomous outcomes included hypotension, nausea, vomiting and itching, which were displayed as risk ratio (RR) with 95% confidence interval (CI). Continuous outcomes included VAS pain score, which were displayed as weighted mean differences (MD) with 95% CI. Given the heterogeneity between trials, the Bayesian hierarchical random-effects model was first fitted for multiple comparisons of different treatment options. On the one hand, all the calculations and graphs were generated using the R 4.2.1 software and Stata 15.1 software. Based on the theory of likelihood function and some prior assumptions, Markov chain Monte Carlo (MCMC) simulation was conducted using Bayesian inference with R 4.2.1 software, and 500,000 in iterations and 20,000 in annealing were set, to investigate the posterior distributions of the interrogated nodes [9]. The node splitting method was used to evaluate local inconsistency for outcomes with closed loops. The relationships among the different treatments were presented as a network graph; meanwhile, a comparison-adjusted funnel plot was utilized to test for potential publication bias. Moreover, we utilized surface under the cumulative ranking probabilities (SUCRA) values to rank the examined treatments, with SUCRA values ranging from 0 to 1. A higher SUCRA value corresponds to a higher ranking compared with other treatments [10]. A league table was generated to present the comparisons between each pair of interventions within each outcome.

Results

Literature search and screening process

A total of 9,832articles were retrieved, of which 4,660 duplicates were subsequently eliminated. After reviewing the titles and abstracts, an additional 5,113 articles were excluded. Upon thorough examination of the full texts, the remaining articles were rigorously included or excluded based on the predetermined criteria. Ultimately, 59 papers met the inclusion criteria. The detailed screening process is illustrated in Fig. 1.

Basic characteristics of included studies

The 59 studies [5, 11–68] encompassed a total of 6,972 patients, originating from single centers across 18 countries. The mean ages of the participants ranged from 20.8 to 31 years, while their mean body weights varied from 62.8 to 93.6 kg. Additionally, the mean gestational ages spanned from 36.9 to 40.05 weeks. Detailed characteristics of the included studies are presented in Table S1.

The results of the methodological quality assessment of the included studies

The results of the risk of bias assessment for the 59 included studies are depicted in Fig. 2. Among the biases introduced during the randomization process, all studies were considered to have conducted allocation concealment and were assessed as low risk, although randomization was unclear in 20 studies [11–20, 22–24, 28, 30, 43, 55–58]. Concerning the bias in deviating from established intervention measures, all studies did not use additional labor analgesia measures and were assessed as low risk. All studies exhibited low-risk bias in terms of missing outcome data and measurements. The selective reporting was unknown in all studies, posing a potential risk of bias. Overall, the included literature demonstrated a low risk of bias.

Network meta-analysis results

Network graph

The included 59 studies encompassed 30 different interventions. The network structure among these different interventions is illustrated in Fig. 3. In the graph, the line thickness indicates the number of studies comparing different local anesthetic regimens, and the circle diameter corresponds to the number of participants included in the intervention. The node splitting method was utilized to analyze outcomes with closed loops, revealing local inconsistency only in the time to take effect when Bpv combined with Fentanyl(Fen) and Bpv ($P<0.05$). However, for all other outcomes, P-values were >0.05, indicating the absence of local inconsistency (Figure S1).

VAS pain score

A total of 25 studies involving 3,229 patients reported VAS scores at 30 min after block. The VAS scores of Bpv_Alf (MD=-2.62, 95% CI: -5.19, -0.32), Bpv_Fen (MD=-1.22, 95% CI: -2.63, -0.06), Bpv_Suf (MD=-1.28, 95% CI: -2.67, -0.03), and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) (MD=-2.68, 95% CI: -5.11, -0.33) were significantly lower than that of Bpv. Pain score at 30 min after block of Bpv_Alf was markedly lower than that of Bupivacaine_Pethidine(Bpv_Pet) (MD=-3.38, 95% CI: -6.63, -0.41). Pain score at 30 min after block of Ropivacaine_Dexmedetomidine(Rop_Dex) (MD=-1.07, 95% CI: -1.97,

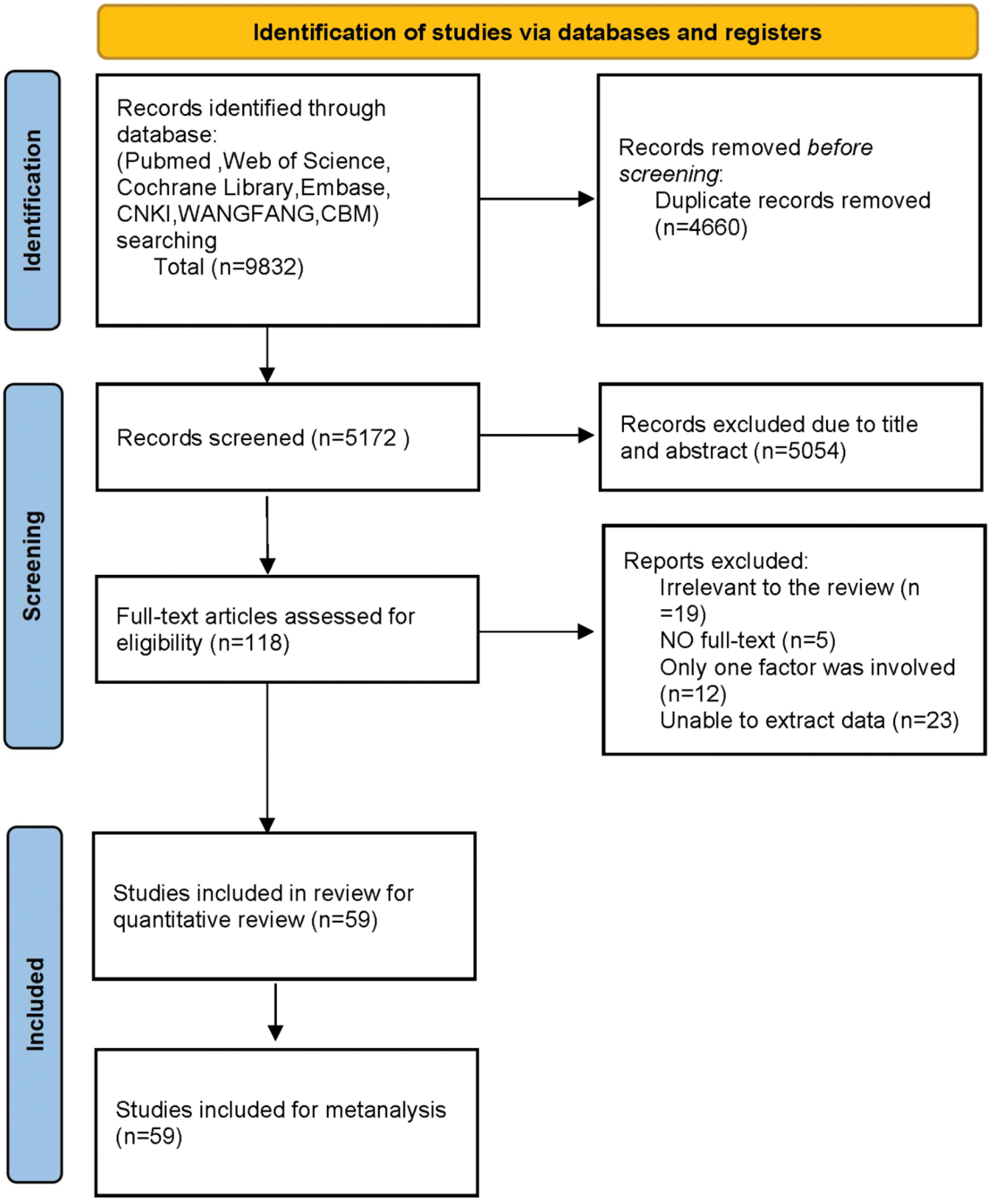

Fig. 1 PRISMA Flowchart of the depicted studies

-0.18) and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) (MD=-2.01, 95% CI: -3.89, -0.15) were also noticeably lower than that of Rop, and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) also had a significantly lower VAS score than Bupivacaine_Pethidine(Bpv_Pet) (MD=-3.44, 95% CI: -6.55, -0.41). There were no statistically significant differences in VAS scores between other pairwise interventions. After cumulative probability ranking, the top three measures for reducing VAS scores at 30 min after block were Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) (SUCRA = 0.89), Bpv_Alf (SUCRA = 0.87), and Ropivacaine_Dexmedetomidine(Rop_Dex) (SUCRA = 0.74) (Table S2 and Figure S2A).

Time to take effect

A total of 25 studies involving 2,136 patients reported the time to take effect. The results showed that the time

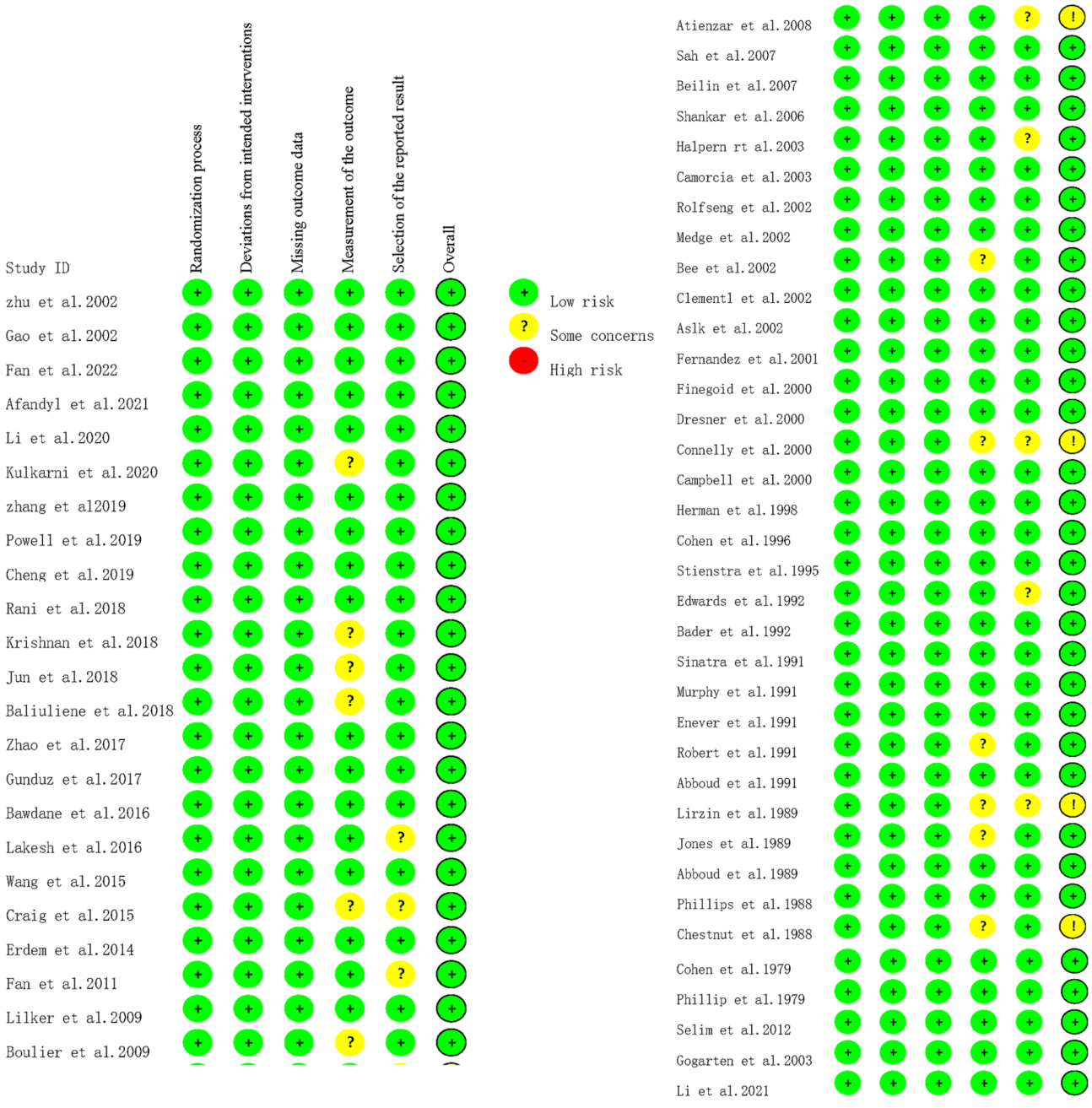

Fig. 2 Study quality evaluation

to take effect of Bupivacaine_Dexmedetomidine(Bpv_Dex) (MD=-4.88, 95% CI: -7.98, -1.61) and Chlo (MD=-4.59, 95% CI: -6.99, -1.55) was significantly shorter than that of Bpv. The time to take effect of Bupivacaine_Dexmedetomidine(Bpv_Dex) was visibly shorter than that of BPV _ Lido (MD=-4.29, 95% CI: -8.08, -0.04), and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) also required overtly shorter time to take effect than ROP _ dex (MD=-5.15, 95% CI: -8.52, -1.74) and Rop_Suf (MD=-4.03, 95% CI: -7.42, -0.6). There was no significant difference in the time to take effect between other pairwise interventions. Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) (SUCRA = 0.88), Bupivacaine_Dexmedetomidine(Bpv_Dex) (SUCRA = 0.81), and Chlox (SUCRA = 0.77) ranked as the top three in the cumulative probability ranking (Table S3 and Figure S2B).

A total of 15 studies involving 1,249 patients reported the duration of analgesia. Cumulative probability ranking revealed that the top three analgesic durations were Ropivacaine_Dexmedetomidine(Rop_Dex) (SUCRA = 0.99), Rop_Suf (SUCRA = 0.86), and LevoBpv_Suf (SUCRA = 0.83). The league table results show that

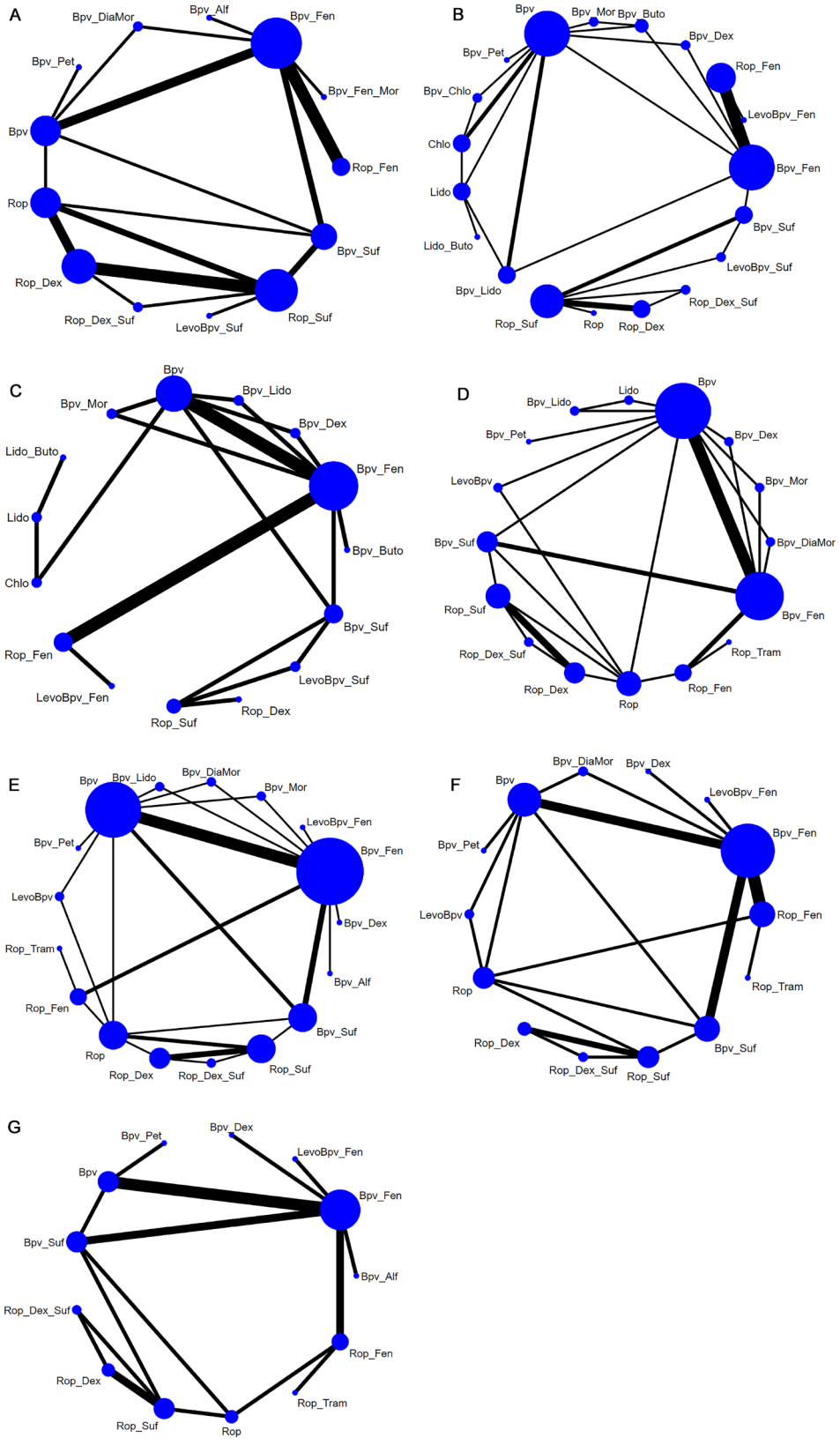

Fig. 3 Network diagram for VAS (**A**), time to take effect (**B**), duration of analgesia (**C**), hypotension (**D**), pruritus (**E**), nausea (**F**), vomiting (**G**)

Ropivacaine_Dexmedetomidine(Rop_Dex) has a superior analgesic duration compared to all other measures except Bupivacaine_Dexmedetomidine(Bpv_Dex). Rop_Suf had an obviously longer duration of analgesia than Bpv (MD = 76.32, 95% CI: 24.7, 128.38), Bpv_Lido (MD = 71.52, 95% CI: 14.34, 128.2), Bpv_Mor (MD = 63.71, 95% CI: 8.42, 118.42), Bpv_Suf (MD = 29.31, 95% CI: 4.92, 53.39), Chlo (MD = 113.71, 95% CI: 58.39, 169.66), Lido (MD = 137.96, 95% CI: 79.72, 196.53), and Lido_Buto (MD = 114.18, 95% CI: 50.73, 177.35). LevoBpv_Suf had an apparently longer analgesic duration than Bpv (MD = 71.98, 95% CI: 21.12, 123.1), Bpv_Lido (MD = 67.25, 95% CI: 11.3, 123.27), Bpv_Mor (MD = 59.35, 95% CI: 4.69, 113.54), Bpv_Suf (MD = 24.96, 95% CI: 2.34, 47.07), and Chlo (MD = 109.42, 95% CI: 54.92, 164.38). Other pairwise interventions showed no statistically significant differences. (Table S4 and Figure S2C)

Hypotension was reported in 20 studies involving 2,571 patients. The league tables showed that there was no statistically significant difference in the incidence of hypotension among all interventions. Cumulative probability results revealed that the top three interventions were Fentanyl(Fen) (SUCRA = 0.77), Bupivacaine_Dexmedetomidine(Bpv_Dex) (SUCRA = 0.73), and Levobupivacaine_Fentanyl(LevoBpv_Fen) (SUCRA = 0.68). (Table S5 and Figure S2D)

Pruritus

A total of 24 studies involving 2,832 patients reported pruritus. Bpv_Mor had a significantly higher incidence of pruritus than Bupivacaine_Diamorphine(Bpv_DiaMor) (RR = 21.52, 95% CI: 1.84, 1013), Fentanyl(Fen) (RR = 5.77, 95% CI: 1.07, 37.15), LevoBpv (RR = 5.51, 95% CI: 1, 33.21), Levobupivacaine_Fentanyl(LevoBpv_Fen) (RR = 4.94, 95% CI: 1, 29.62), Ropivacaine_Dexmedetomidine(Rop_Dex) (RR = 6.19, 95% CI: 1.08, 41.52), and Ropivacaine_Sufentanil(Rop_Suf) (RR = 5.48, 95% CI: 1.04, 33.07). Other pairwise interventions showed no statistically significant differences. Cumulative probability results showed that the top three interventions were Bupivacaine_Diamorphine(Bpv_DiaMor) (SUCRA = 0.91), Ropivacaine_Dexmedetomidine(Rop_Dex) (SUCRA = 0.68), and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) (SUCRA = 0.67). (Table S6 and Figure S2E)

Nausea

Nausea was reported in 1,956 patients across 20 studies. The league table revealed that the incidence of nausea with Ropivacaine_Dexmedetomidine(Rop_Dex) was significantly lower than that of ROP _ SUF (RR = 0.24, 95% CI: 0.05, 0.93), and there was no significant difference between other pairwise interventions. Cumulative probability results showed that the top three interventions were Bupivacaine_Pethidine(Bpv_Pet) (SUCRA = 0.68), Bupivacaine_Dexmedetomidine(Bpv_Dex) (SUCRA = 0.80), and LevoBpv (SUCRA = 0.76). (Table S7 and Figure S2F)

Vomiting

A total of 17 studies involving 1,747 patients reported vomiting. The league tables indicated no statistically significant differences in vomiting rates among all interventions. Cumulative probability results show that the top three interventions were Bupivacaine_Dexmedetomidine(Bpv_Dex) (SUCRA = 0.79), LevoBpv (SUCRA = 0.76), and Ropivacaine_Dexmedetomidine(Rop_Dex) (SUCRA = 0.74) (Table S8 and Figure S2G).

Cluster analysis

The outcomes were categorized into three groups: time to take effect and duration of analgesia, hypotension and itching, nausea and vomiting. Cluster analysis was conducted for these groups. The figure is based on the SUCRA value of each intervention, and different points represent different interventions. The intervention located at the upper right of each chart is the most recommended measure to improve the two outcomes in this group. Cluster analysis showed that Bupivacaine_Dexmedetomidine(Bpv_Dex) was superior to other anesthetics in time to take effect and duration of analgesia. Bupivacaine_Dexmedetomidine(Bpv_Dex) also outperformed other anesthetics in nausea and vomiting, while Fentanyl(Fen) seemed to be the best anesthetic in hypotension and itching. (Table S9 and Fig. 4).

Publication bias

Figure 5 displays a funnel plot of all outcomes, and it is observed that all data points are evenly and symmetrically distributed, suggesting a lower likelihood of bias.

Discussion

Labor analgesia is increasingly prevalent worldwide. The techniques for labor analgesia include epidural analgesia, combined spinal plus epidural analgesia, and continuous spinal anesthesia, among which epidural anesthesia is the most widely used [69, 70]. However, the comparative effects of different drug combinations are still unclear. The main content of our meta-analysis is to compare the application of different analgesic combinatiosn in epidural labor analgesia. Despite numerous head-to-head comparisons in previous studies, there is currently no consistent clinical recommendation due to the diverse and inconsistent combinations of local anesthetics. Therefore, we conducted a comprehensive review of all randomized controlled studies comparing

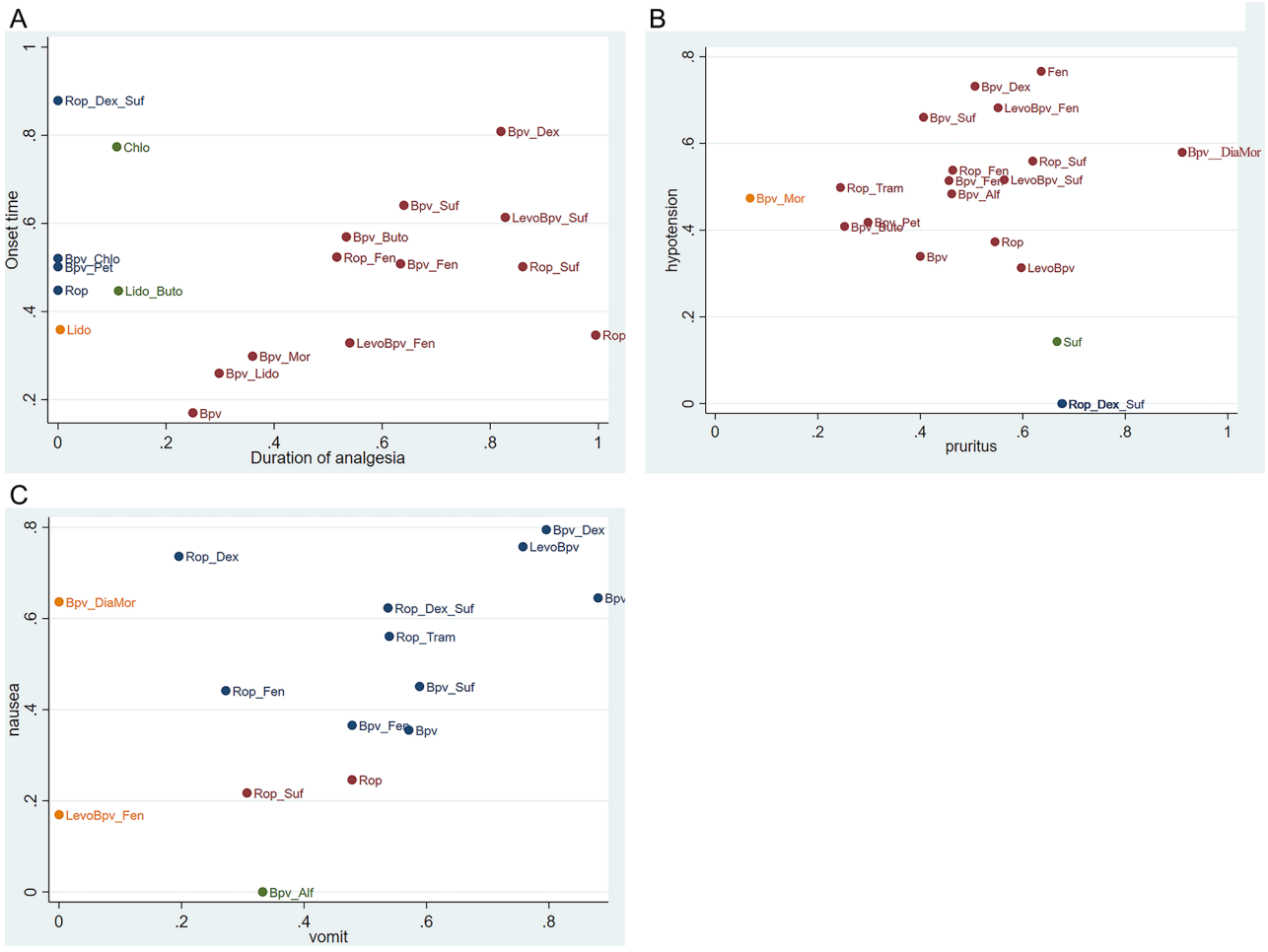

Fig. 4 Cluster diagram for duration of analgesia and time to take effect (**A**), hypotension and pruritus (**B**), nausea and vomiting (**C**)

various anesthesia schemes to identify potential differences in analgesic effects (VAS pain score, time to take effect, and duration of analgesia) and adverse reactions (nausea, vomiting, hypotension, and itching). The analysis included 59 studies involving 6,972 patients. Our findings indicate that Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) was the most effective measure for the time to take effect and postoperative VAS score, while Ropivacaine_Dexmedetomidine(Rop_Dex) ranked highest for the duration of analgesia when considering individual outcomes. Regarding the incidence of nausea, vomiting, hypotension, and pruritus, Bupivacaine_Pethidine(Bpv_Pet), Bupivacaine_Dexmedetomidine(Bpv_Dex), Fentanyl(Fen), and Bupivacaine_Diamorphine(Bpv_DiaMor) had the lowest incidence, respectively.

We found that Bupivacaine_Dexmedetomidine(Bpv_Dex) emerged as the most effective measure in terms of both the time to take effect and duration of analgesia. Specifically, Bupivacaine_Dexmedetomidine(Bpv_Dex) demonstrated significant superiority over Bupivacaine_Fentanyl(Bpv_Fen), Bupivacaine_Lidocaine(Bpv_Lido), Bupivacaine_Morphine(Bpv_Mor), Chloroprocaine(Chlo), Levobupivacaine_Fentanyl(LevoBpv_Fen), Lidocaine(Lido), Lidocaine_Butorphanol(Lido_Buto), and Ropivacaine_Fentanyl(Rop_Fen) in the duration of analgesia, and only outperformed Bpv_Lido in the time to take effect. Furthermore, no significant differences were observed between Bupivacaine_Dexmedetomidine(Bpv_Dex) and any other measures in the four safety outcomes, supporting the clinical recommendation of Bupivacaine_Dexmedetomidine(Bpv_Dex) as an adjunct to epidural analgesia.

However, in reducing VAS after delivery, we observed that Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) is the most effective measure in this study, which is also only used in one study. In the study, the postoperative VAS score of Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) group was significantly lower than dexmedetomidine + ropivacaine or sufentanil + ropivacaine group. However, no differences were

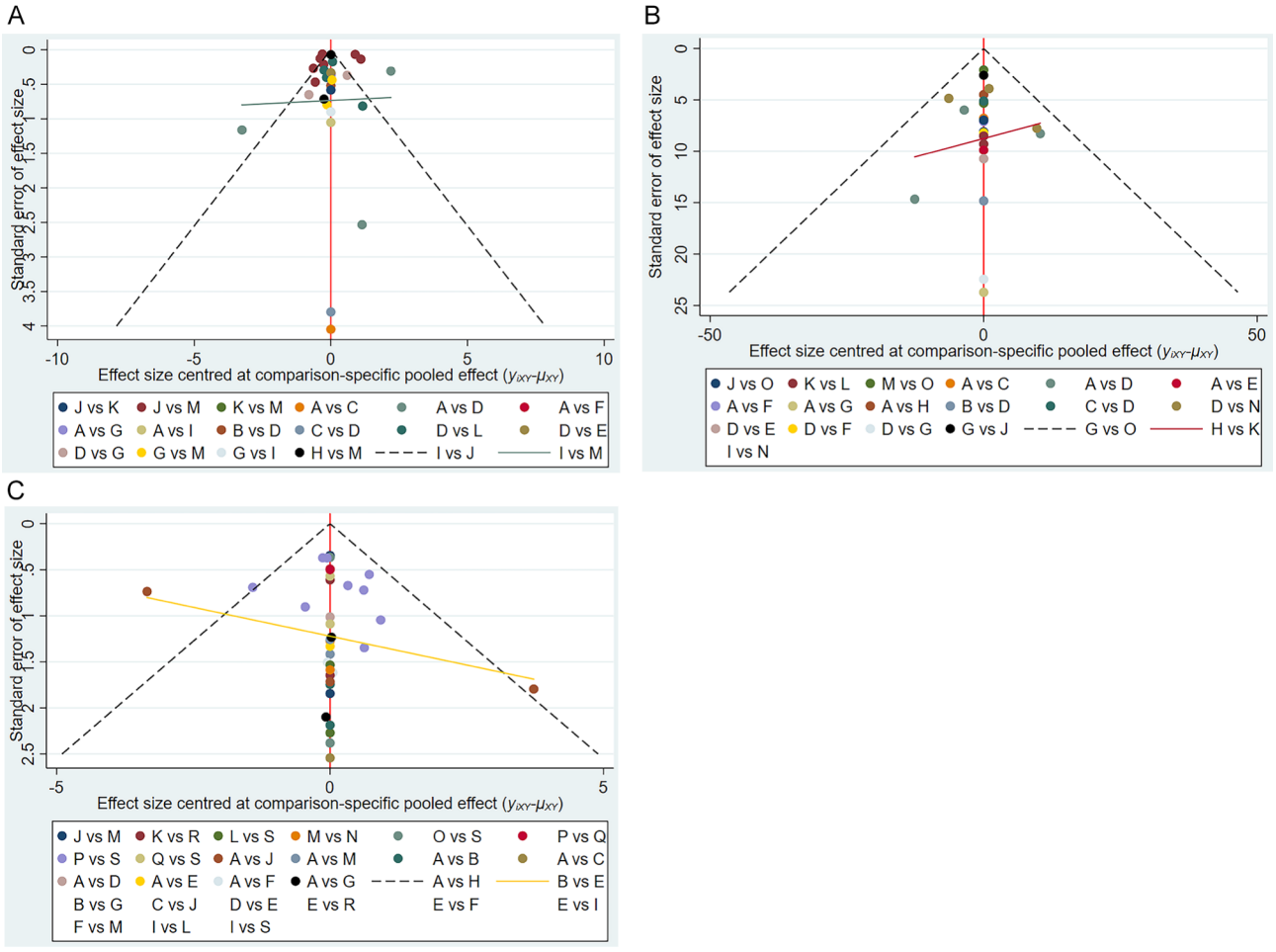

Fig. 5 Funnel plot for VAS (**A**), duration of analgesia, (**B**), time to take effect (**C**)

observed in other analgesic outcomes or adverse reactions compared to the control group [62].

Combined with other cumulative ranking results, the use of dexmedetomidine in combination demonstrated superior rankings in analgesic effect, suggesting that dexmedetomidine itself possesses certain advantages. This aligns with findings from some classic meta-research studies. For example, in the study by Zhang et al., VAS scores were significantly lower in the ropivacaine + dexmedetomidine group than in the control group (ropivacaine + sufentanil, ropivacaine + Nalbuphine, or ropivacaine alone) at 15 min, 30 min, 60 min, and 90 min, and pruritus incidence was also significantly lower than in the control group [5]. Qian et al. also found that dexmedetomidine assisted ropivacaine epidural anesthesia effect was better than fentanyl assisted ropivacaine, and had fewer adverse reactions.

Dexmedetomidine is a frequently employed perioperative analgesic intervention, but the mechanism of epidural analgesia with dexmedetomidine remains unclear. Dexmedetomidine has the ability to permeate the cerebrospinal fluid by diffusing through the dura mater. It acts on both presynaptic and postsynaptic membranes of spinal cord neurons, inducing hyperpolarization of neuronal membrane potential through G protein-mediated activation of potassium ions (K+). This process results in a reduction in sympathetic outflow, inhibition of norepinephrine release, and the blockade of pain signal transmission [71]. Additionally, in peripheral nerve block, dexmedetomidine hinders activity-dependent cation channels, exhibiting a more pronounced impact on unmyelinated C fibers and small myelinated fibers, and a lesser effect on myelinated motor fibers [72].

Additionally, regarding the concentrations of dexmedetomidine used, Liu et al. found that the EC50 of ropivacaine of 0.4·μg/ml, 0.5·μg/ml, and 0.6·μg/ml dexmedetomidine was significantly lower than that of 0·μg/ml and 0.3 μg/ml dexmedetomidine [73]. However, there was no difference in the EC50 of ropivacaine between 0.4·μg/ml, 0.5·μg/ml, and 0.6·μg/ml, suggesting that the optimal clinical effect of ropivacaine is achieved at the lowest concentration of dexmedetomidine, specifically 0.4 μg/ml. Furthermore, there was no additional analgesic benefit observed even at concentrations higher than

this threshold. Among the studies we included, a study utilized dexmedetomidine at a concentration of 0.4 μg/ml [67], while others employed a concentration of 0.5 μg/ml. Consequently, it is reasonable to assume that the concentration and dose of dexmedetomidine had little impact on the results of the meta-analysis.

In terms of side effects, this review identified that Bpv_Mor had a higher incidence of pruritus than most combination measures, and Ropivacaine_Dexmedetomidine(Rop_Dex) exhibited a significantly lower nausea rate than Rop_Suf. However, the other pairwise comparisons did not reveal differences in any other safety outcomes. Considering the low ranking of Bpv_Mor in analgesia, in future clinical anesthesia guidance, priority should be given to interventions that perform better in analgesia-related outcomes. Although these intervention measures exhibit superior rankings in analgesic outcomes and are significantly better than some measures, their incidence of side effects is comparable to other measures. Common side effects of epidural analgesia, such as motor block and intrapartum fever, were not analyzed due to the limited number of articles on these aspects. However, there was no difference in the incidence of motor block between dexmedetomidine + ropivacaine and the control groups in the study by Fan et al. [68], and Li's research found that the incidence of intrapartum fever of dexmedetomidine combined with ropivacaine was significantly lower than that of ropivacaine alone [65]. These findings collectively demonstrate the safety of the combined dexmedetomidine regimen.

Strengths and limitations

Our study possesses several strengths. Firstly, we conducted a thorough and meticulous retrieval in databases and tracked back the references of relevant reviews to ensure the comprehensiveness of the included documents. Secondly, we comprehensively compared all analgesic drugs. Thirdly, to minimize heterogeneity among the participants, we rigorously restricted the inclusion criteria to encompass only those who underwent natural childbirth, excluding those who received epidural analgesia during cesarean sections.

This study has several limitations. Firstly, although we included all RCTs, some studies did not adequately explain the randomization method. Secondly, our focus was solely on differences between various drugs, and we did not subdivide into various doses and concentrations of different anesthetics. Thirdly, the number of studies on some intervention measures was small, potentially impacting the reliability of the conclusions to some extent. Finally, despite our comprehensive literature retrieval, we omitted certain documents due to the presence of only images, some of which lacked data explanation. Among the included studies, there were also articles with data from many years ago. The substantial differences in the years of publication, medical technology, environment, and other factors across different years may also influence our conclusions.

Conclusion

Overall, this meta-analysis offers valuable insights for clinicians in selecting appropriate analgesic drugs. Regimens combined with dexmedetomidine was superior to most analgesic regimens. Specially, Bupivacaine_Dexmedetomidine(Bpv_Dex), Ropivacaine_Dexmedetomidine(Rop_Dex), and Ropivacaine_Dexmedetomidine_Sufentanil (Rop_Dex_Suf) regimens showcased excellent analgesic efficacy and safety. Nevertheless, given the limited number of studies on certain protocols, further high-quality, large-scale RCTs are anticipated to substantiate our conclusion in the future.

Abbreviations

Rop_Dex_Suf	Ropivacaine_Dexmedetomidine_Sufentanil
Rop_Dex	Ropivacaine_Dexmedetomidine
Bpv_Pet	Bupivacaine_Pethidine
Bpv_Dex	Bupivacaine_Dexmedetomidine
Fen	Fentanyl
Bpv_DiaMor	Bupivacaine_Diamorphine
Bpv_Fen	Bupivacaine_Fentanyl
Bpv_Lido	Bupivacaine_Lidocaine
Bpv_Mor	Bupivacaine_Morphine
Chlo	Chloroprocaine
LevoBpv_Fen	Levobupivacaine_Fentanyl
Lido	Lidocaine
Lido_Buto	Lidocaine_Butorphanol
Rop_Fen	Ropivacaine_Fentanyl
VAS	Visual Analog Scale
RCTs	Randomized controlled trials
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
CI	Confidence interval
MD	Mean differences
MCMC	Markov chain Monte Carlo
SUCRA	Surface under the cumulative ranking probabilities

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03014-0.

Supplementary Material 1 Table S1 Baseline characteristics of the included studies. Table S2 League table for VAS. Table S3 League table for time to take effect. Table S4 League table for duration of analgesia. Table S5 League table for hypoglycemia. Table S6 League table for pruritus. Table S7 League table for nausea. Table S8 League table for vomiting. Table S9 Sucra.

Supplementary Material 2: Figure S1 Node splitting method plot for VAS (A), duration of analgesia (B), hypotension (C), pruritus (D), nausea (E), vomiting (F) Figure S2 Probability rankogram for VAS (A), time to take effect (B), duration of analgesia (C), hypotension (D), pruritus(E), nausea (F), vomiting (G).

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Author contributions

All authors contributed to the study conception and design. Writing - original draft preparation: Pan Li; Writing - review and editing: Xiaoting Ma;

Conceptualization: Meng Zhang; Methodology: Pan Li; Formal analysis and investigation: Longlu Cao; Resources: Jianli Li and Ran Duan; Supervision: Jianli Li, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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