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The Analysis Study of Effectiveness and Efficacy of Low Dose Bupivacaine in Spinal Anaesthesia for Caesarean Delivery: A Comprehensive Systematic Review

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ABSTRACT

Background: Spinal anesthesia is a safe and effective technique in Cesarean sections, with the combined spinal-epidural procedure emerging as an alternative. Lowering the standard bupivacaine dose can reduce complications and improve maternal cardiac index. Adjuvants can enhance low-dose bupivacaine's effectiveness. However, hypotension remains a major issue, affecting 70-80% of patients. This study evaluates low-dose bupivacaine's efficacy in Cesarean sections, offering insights for optimizing anesthetic practices. **Methods:** Following PRISMA 2020 guidelines, this systematic review focused exclusively on full-text articles published in English between 2009 and 2024. To ensure the inclusion of high-quality sources, editorial pieces and review articles were excluded unless they were accompanied by a DOI. The literature search was conducted using several reputable databases, including ScienceDirect, PubMed, and SagePub, to comprehensively gather relevant studies. **Result:** The study conducted a comprehensive review of over 1,000 publications sourced from reputable databases, including ScienceDirect, SagePub, and PubMed. Following an initial screening, eight publications were identified as warranting more in-depth analysis. Consequently, a thorough review of these selected studies was performed to ensure a detailed and rigorous evaluation. **Conclusion:** The recovery of motor and sensory functions in Cesarean sections with low-dose bupivacaine showed significant improvement in cardiac index (CI) compared to conventional doses. However, hypotension incidence was comparable across both dosing strategies. Optimizing spinal anesthesia dosing and positioning is crucial for optimal maternal and fetal outcomes.

Keyword: bupivacaine, spinal anesthesia, cesarean sections

INTRODUCTION

Regional anesthesia techniques, especially spinal anesthesia, are considered safe and effective for Cesarean sections. An emerging alternative is the combined

spinal-epidural (CSE) procedure. Recent practices involve reducing the standard dose of bupivacaine, which can decrease complications like hypotension, bradycardia, nausea, and vomiting, and improve maternal cardiac index.[1] However, lower doses may also increase the risk of inadequate anesthesia. Adjuvants such as sufentanil, fentanyl, clonidine, morphine, and meperidine can be added to low-dose intrathecal bupivacaine to enhance anesthesia quality, prolong sensory block duration, and minimize hemodynamic instability.[2-4]

Hypotension during spinal anesthesia for Cesarean sections is a significant concern, with incidence rates reaching as high as 70–80% when using conventional doses of local anesthetics.[5,6] This high frequency of hypotension persists despite various preventative measures, including positioning the patient in a left lateral tilt to alleviate compression of the inferior vena cava and administering fluid boluses with crystalloids and colloids to maintain blood volume.[7] The continued occurrence of hypotension presents serious risks to both the mother and the fetus. For the mother, hypotension can lead to compromised uteroplacental blood flow, which may adversely affect fetal oxygenation and overall well-being. Additionally, the use of vasopressors to manage hypotension can introduce further complications. Specifically, the administration of these drugs has been linked to abnormal acid-base balance in neonates, potentially leading to metabolic disturbances that can impact neonatal health and recovery.[8] This underscores the need for ongoing research and refined strategies to mitigate hypotension and its associated risks during spinal anesthesia in Cesarean sections.

Studies evaluating the combined use of epidural and low-dose spinal anesthesia (bupivacaine) have shown a reduction in the incidence of hypotension and a more rapid recovery from sensory and motor blockade while maintaining effective surgical analgesia.[9-11] Utilizing lower doses of bupivacaine has also been associated with diminished nausea and a decreased requirement for vasopressors.[9,12] Research suggests that neonatal outcomes, as assessed by Apgar scores or acid-base status, are generally comparable between low-dose and conventional-dose spinal anesthesia. However, many studies are limited by insufficient statistical power to detect significant differences.[8]

Previous research has primarily compared low-dose versus conventional-dose combined spinal-epidural techniques or low-dose spinal anesthesia with narcotics versus conventional spinal without narcotics.[13] In this study, we assess the efficacy of low-dose bupivacaine in spinal anesthesia for pregnant patients undergoing Cesarean sections. Our findings could provide valuable insights into optimizing anesthetic techniques for this patient population, potentially guiding future practices in obstetric anesthesia.

METHODS

Protocol

The study was conducted with meticulous adherence to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 standards, ensuring rigorous adherence to recognized methodological principles. Unwavering adherence to PRISMA 2020 criteria showcases a commitment to enhancing the lucidity, reproducibility, and methodical comprehensiveness of the review procedure. The study employed comprehensive procedures to carry out literature searches, gather data, and synthesize findings. The presented methodologies were effectively executed to mitigate biases and ensure the robustness of the generated conclusions.

Criteria for Eligibility

This paper provides a thorough analysis of the clinical trials conducted in the past decade on the efficacy of low-dosage bupivacaine in cesarean surgery. Through systematic analysis and synthesis of data from other studies, this research aims to elucidate trends and direct the enhancement of patient care strategies for this population with numerous health disorders.

The primary objective of this thesis is to emphasize significant topics that emerge from a diverse array of academic literature, therefore augmenting our understanding of the long-term consequences following the utilization of low-dose bupivacaine in cesarean surgery. To ensure the comprehensiveness and accuracy of the study, rigorous standards for inclusion and exclusion were applied. Only scholarly articles written in English and published between 2009 and 2024 were

deemed appropriate for inclusion. Additionally, materials that are eligible for inclusion must have a DOI to verify their legitimacy. To maintain the primary emphasis and integrity of the dataset, the study intentionally excluded non-research elements such as reviews, editorials, and duplicate entries from the same magazine.

The systematic approach adopted in this study ensures that the employed data is relevant and reliable, therefore building a solid foundation for obtaining important conclusions and advancing clinical practice.

Search Strategy

We used "low dose bupivacaine OR spinal anaesthesia OR caesarean" as keywords. The search for studies to be included in the systematic review was carried out using the PubMed, SagePub, and Sciencedirect databases.

Table 1. Search Strategy

Database	**Search Strategy**	***Hits***
Pubmed	*("low dose bupivacaine" OR "spinal anaesthesia" AND "caesarean")*	1079
Science Direct	*("low dose bupivacaine" AND "spinal anaesthesia" AND "caesarean")*	100
Sagepub	*("low dose bupivacaine" AND "spinal anaesthesia" AND "caesarean")*	10

Data retrieval

The authors conducted a meticulous preliminary review of each article by analyzing its abstract and title to determine relevance before proceeding to a detailed investigation. Only those studies aligned with the study's objectives and met the predefined inclusion criteria were selected for further review, facilitating the identification of clear and consistent patterns in the research.

To ensure linguistic uniformity, full-text articles were restricted to those published in English. A rigorous screening process was then employed to select content directly relevant to the study's focus, adhering to all established criteria.

Articles failing to meet these criteria were systematically excluded from further analysis and not included in the final evaluation.

The evaluation process involved a comprehensive review of the study design, titles, authors, publication dates, research locations, and methodologies. This thorough approach ensured that only the most relevant and high-quality content was included, thereby enhancing the robustness and credibility of the study's findings.

Quality Assessment and Data Synthesis

The authors conducted a meticulous review of each article's abstract and title to determine which warranted further investigation. Following this initial screening, all relevant documents were subjected to an in-depth examination. The outcomes of this evaluation guided the selection of review papers, ensuring that only the most pertinent studies proceeded to detailed analysis. This rigorous methodology streamlined the selection process, enabling a thorough and nuanced assessment of the existing research and its context.

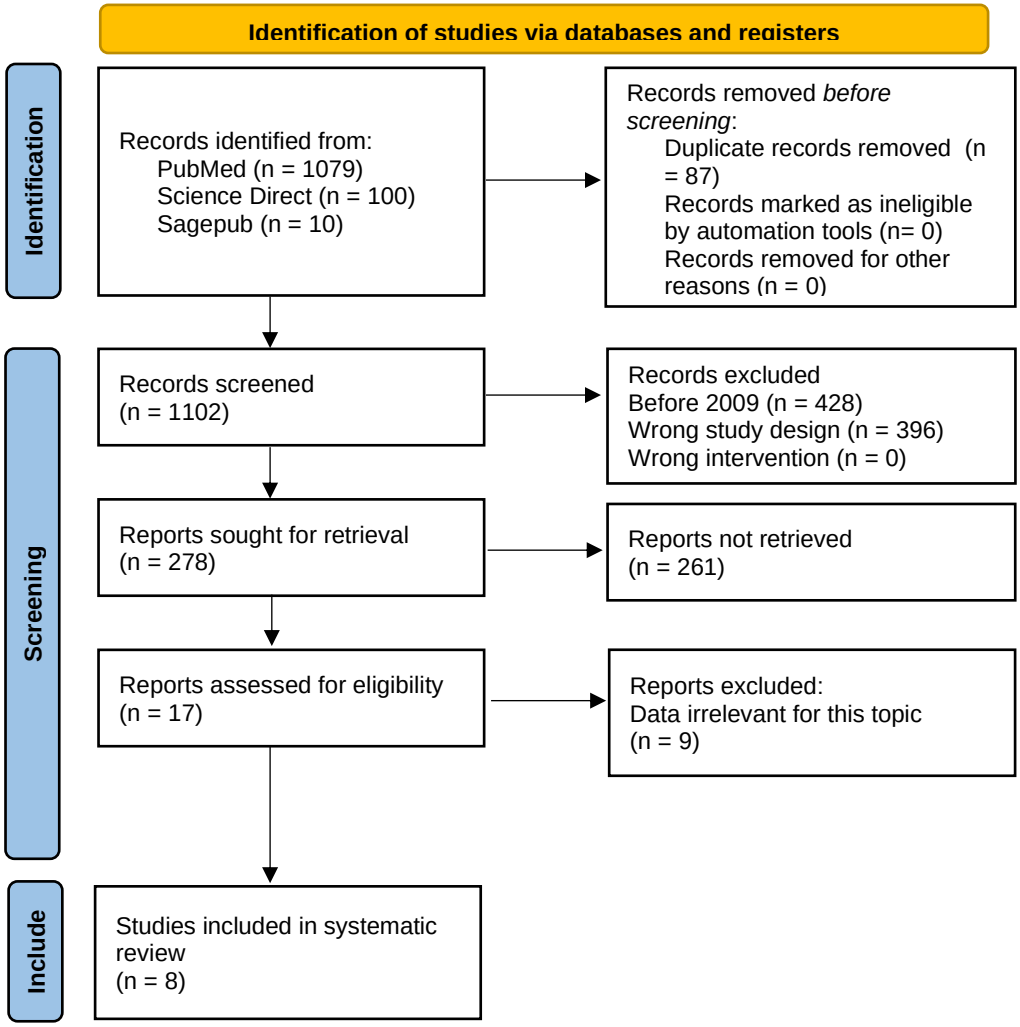

Figure 1. Article search flow chart

Table 2. Critical appraisal of Study

Parameters	(Leo et al., 2009)	(Mebazza et al., 2010)	(Arzola & Wieczorek., 2011)	(Tang et al., 2015)	(Cenkowski et al., 2019)	(Isngadi et al., 2019)	(Kumar & Santha., 2022)	(Fattahi-Saravi et al., 2023)
1. Bias related to temporal precedence Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

variable comes first)?								
2. Bias related to selection and allocation								
Was there a control group?	Yes	No	No	Yes	Yes	No	No	Yes
3. Bias related to confounding factors								
Were participants included in any comparisons similar?	Yes	Yes	No	Yes	Yes	No	No	Yes
4. Bias related to administration of intervention/exposure								
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
5. Bias related to assessment, detection, and measurement of the outcome								
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Yes	Yes	No	No	Yes	No	No	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Bias related to participant retention								
Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	No	Yes	Yes	No	No	Yes
7. Statistical conclusion validity								
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

RESULT

We began our investigation by systematically collecting a comprehensive set of papers from esteemed sources like Science Direct, PubMed, and SagePub. Following a rigorous three-stage screening process, we identified eight papers highly relevant to our systematic review. We then focused on specific topics for deeper analysis and carefully evaluated each selected report. To streamline our study, we have provided a concise summary of the evaluated information in Table 3.

Table 3. The literature included in this study

Author	Origin	Method	Sample	Result
Leo et al.[10] (2009)	Singapore	RCT	60 participants	The study found differences in the extent of cephalad sensory block among groups, but the time to reach T4 was similar. The incidence of hypotension requiring vasopressors varied among groups, with 30% in Group 7, 55% in Group 8, and 70% in Group 9. No patient had inadequate anesthesia, and neonatal outcomes were similar in all three groups.
Mebazza et al.[14] (2010)	Tunisia	Prospective study	80 patients	The study found that group A required a larger dose of ephedrine, experienced higher incidences of sensory block, nausea, and vomiting, and had less arterial hypotension. Recovery time and satisfaction rates were shorter in group B, but pain relief did not differ.
Arzola & Wieczorek.[8] (2011)	Canada	Systematic Review	12 studies	The meta-analysis reveals that low-dose bupivacaine in spinal anaesthesia compromises anaesthetic efficacy, despite the benefit of lower maternal side-effects (hypotension and nausea/vomiting). The LD group exhibited a higher need for analgesic

				supplementation during surgery, and a higher number needed to treat for additional harmful outcomes.
Tang et al.[15] (2015)	China	RCT	120 participants	The study found that the density of the spinal synapse (SAS) decreased with the increase in the maximum cephalad sensory block level and the incidence of hypotension, while the incidence of shivering also decreased. However, there was no significant difference in the quality of anesthesia between the groups.
Cenkowski et al.[16] (2019)	Canada	RCT	32 participants	The low-dose group showed faster motor recovery times and shorter recovery room stays compared to conventional and low-dose spinal groups. Both groups experienced a drop in CI with spinal anesthesia, with the low-dose group showing equivalent results.
Isngadi et al.[17] (2019)	Indonesia	Retrospective Study	33 participants	The combination of low dose spinal and opioid for CS delivery showed no significant hypotension effects, achieved hemodynamic stabilization, and achieved target blocked in all cases, with no significant changes in baby's Apgar score.
Kumar & Santha.[18] (2022)	India	Observational Study	70 participants	Hemodynamic stability was effectively preserved in both groups. Nearly all patients in each group reached a grade 3 motor blockade within 8 minutes, and all patients achieved a

				T6 level of sensory blockade within 6 minutes. The low-dose group demonstrated a quicker recovery compared to the high-dose group.
Fattahi-Saravi et al.[19] (2023)	Iran	RCT	120 participants	The B group had significantly longer motor blocks (150 min) than the BM and BF groups (102 min). Sensory and motor blocks were similar in both groups. The B group had longer stay in the PACU. Analgesia duration increased when meperidine or fentanyl was added to bupivacaine.

DISCUSSION

The study by Cenkowski et al. revealed that women receiving a conventional dose of spinal anesthetic experienced longer recovery room times compared to those administered a low dose (bupivacaine). No significant difference in cardiac index (CI) between the conventional and low-dose groups was observed; however, patients in the low-dose group exhibited faster recovery of motor function and sensory levels, leading to shorter recovery room stays.[16] Despite higher requirements for phenylephrine and fluids in the conventional dose group, the extent of hypotension was comparable between groups.[9,10,11,20] This discrepancy may be attributed to the smaller sample size and the 10° Trendelenburg position in the low-dose group, which potentially enhances sympathetic blockade and affects hemodynamics.[16,20]

A study identified a novel moderate correlation in the conventional dose group between the absolute drop in CI and neonatal umbilical vein pH.[16] Previous studies have suggested that uterine blood flow, which is pressure-dependent and not directly proportional to flow, traverses a dilated vascular bed.[21,22] These findings imply that a critical CI threshold exists below which fetal oxygen delivery becomes inadequate. Although uterine blood flow generally exceeds fetal oxygenation requirements, providing a safety margin, surpassing this margin can lead to fetal

acidosis.[22,23] This correlation was observed despite maintained mean arterial pressure (MAP), highlighting that pressure alone does not necessarily ensure sufficient fetal blood flow.[24,25]

Langesaeter et al. reported an increase in CI with varying spinal anesthesia doses, showing larger CI decreases in the conventional dose group that correlated with lower umbilical venous pH and phenylephrine administration during Cesarean sections.[26] Cenkowski et al. did not observe an increase in CI within the first 15 minutes post-anesthesia; both groups experienced a notable CI drop from baseline, likely due to decreased venous return resulting from sympathectomy.[16] MRI imaging indicated significant inferior vena cava compression in the supine and 15° left lateral tilt positions, with more pronounced effects at a 30° tilt.[27] The CI reduction in our study may have been greater compared to the Langesaeter study due to the lower CI associated with a 10° to 15° left lateral tilt.[16,26]

Comparative studies of low-dose versus conventional-dose intrathecal bupivacaine for Cesarean sections demonstrated similar CI changes between the two dosages.[28-30] The low-dose bupivacaine group showed comparable block onset times, maternal and obstetrician satisfaction scores, and surgical conditions, while benefiting from shorter recovery room stays, faster mobilization, and fewer interventions for sensory and motor checks.[14,16,18] The absolute drop in CI was correlated with decreases in umbilical venous pH in the conventional dose group.[16] Overall, the low-dose bupivacaine group had faster recovery of sensory and motor blockade and quicker discharge from the recovery room, with similar patient satisfaction levels compared to the conventional dose group.[12,13,14,16,18]

CONCLUSION

The study reveals that low-dose spinal anesthesia for Cesarean sections facilitates a more rapid recovery of motor and sensory functions and reduces recovery room times. Although the conventional dose group required higher doses of phenylephrine and fluid, the incidence of hypotension was comparable between the low-dose and conventional-dose strategies. A moderate correlation was identified between reductions in cardiac index and neonatal umbilical vein pH, indicating a critical threshold below which fetal oxygenation may be compromised.

This finding highlights the necessity of optimizing spinal anesthesia dosing and positioning to improve both maternal and fetal outcomes.

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