Effects Of Neuraxial Anesthesia In Sitting And Lateral Positions On Maternal Hemodynamics In Cesarean Section: A Systematic Review And Meta-Analysis

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Abstract:
This systematic review and meta-analysis was undertaken to evaluate the effects of maternal positioning—sitting versus lateral—during neuraxial anaesthesia on maternal haemodynamics and neonatal outcomes in caesarean section. A systematic literature review was conducted on randomised controlled trials and observational studies published between January 2010 and June 2025. Databases searched included PubMed, Cochrane Library, Scopus, and Embase. The review protocol adhered to PRISMA guidelines. Studies comparing sitting and lateral positions during spinal or combined spinal-epidural anaesthesia were included. Outcomes assessed were maternal hypotension, vasopressor requirement, heart rate changes, sensory and motor block characteristics, maximum block level, and neonatal Apgar scores. A total of five studies, encompassing 572 parturients, met the eligibility criteria. Meta-analysis was performed using random-effects models due to anticipated heterogeneity, which was evaluated using the I^2 statistic. The pooled analysis demonstrated a modest reduction in the incidence of maternal hypotension in the lateral group (RR 0.83, 95% CI: 0.71–0.96; p=0.01) with moderate heterogeneity (I^2 = 58%). Vasopressor requirement was lower but not statistically significant. Neonatal Apgar scores and other block characteristics were comparable across groups. Risk of bias was low in three studies and moderate in two. The findings suggest that the lateral position may offer a haemodynamic advantage without adversely affecting neonatal outcomes. However, given study heterogeneity and limited sample size, conclusions should be interpreted with caution. Larger, well-designed trials are recommended. This review was not registered in PROSPERO or a similar database.

Introduction and Background:

Disparities in access to healthcare, quality of services delivered, and clinical outcomes remain persistent challenges across global health systems, including those in high-income countries. Despite significant advancements in medical technology and healthcare delivery, inequalities continue to be influenced by socioeconomic status, geography, ethnicity, and institutional capacity [1]. The World Health Organization reports that over half the global population lacks access to essential health services, with variations existing both between and within nations [2].

The United Arab Emirates (UAE), particularly Dubai, has seen rapid healthcare expansion and modernisation. However, disparities in clinical outcomes and access to services remain underexplored in local literature [3]. These inequities may reflect systemic and infrastructural differences, despite high levels of investment in health infrastructure [4].

Healthcare disparities can occur across multiple dimensions: from delayed access to care and inconsistent therapeutic options to varying health outcomes for similar clinical conditions. In obstetric anaesthesia, maternal hypotension following spinal anaesthesia for caesarean delivery is a major clinical concern, associated with compromised uteroplacental perfusion, low Apgar scores, foetal acidosis, and increased NICU admissions [5]. While clinical protocols such as patient positioning, fluid preloading, and vasopressor use have been explored extensively, outcomes still vary across institutions, indicating additional contributing factors [6].

Several studies have investigated strategies to reduce maternal hypotension. For example, Simin et al. demonstrated improved maternal haemodynamics using specific induction positions, while Moghadam et al. found that a left lateral tilt significantly reduced hypotension incidence. However, whether such findings are consistently reproducible in different healthcare environments—particularly in Gulf countries—remains uncertain. Variations in staffing ratios, adherence to protocols, monitoring infrastructure, and post-operative care capabilities likely contribute to these discrepancies [7].

Recent research has also highlighted differences in maternal and neonatal outcomes based on institutional resources [8]. Factors such as maternal BMI, blood pressure, and comorbidities were associated with neonatal complications in some studies, while others reported inconsistent utilisation of standardised monitoring systems and perioperative protocols between high- and low-resource hospitals.

In the UAE, although state-of-the-art medical centres exist, limited regionally focused systematic reviews hinder a comprehensive understanding of intra-country disparities [9]. The multicultural makeup of Dubai, language barriers, insurance-based access models, and workforce diversity further complicate healthcare delivery and outcomes [10].

This systematic review aims to synthesise existing international and regional evidence on disparities in maternal haemodynamics, anaesthesia-related neonatal outcomes, and perioperative infrastructure. The primary objective is to evaluate maternal and neonatal outcome disparities related to obstetric anaesthesia across different healthcare settings. Secondary objectives include examining institutional protocols, access variables, and infrastructure components contributing to outcome variation. By contextualising global findings within Dubai's healthcare landscape, the review intends to inform policy and improve practice guidelines relevant to similar high investment but diverse health systems [11].

Table 1. Eligibility Criteria for Inclusion of Studies (PICOST Framework)

Parameter	Inclusion Criteria
Population	Pregnant women undergoing caesarean section under spinal anaesthesia
Intervention	Positioning strategies, fluid management, or pharmacological approaches to prevent or manage hypotension
Control	Standard care or alternate anaesthesia techniques
Outcomes	The primary outcome was the incidence of maternal hypotension (% of parturients affected). Secondary outcomes included total vasopressor requirement (dose or frequency of vasopressors such as ephedrine or phenylephrine), time to onset of sensory block (e.g., minutes to reach T6 dermatome), maximum sensory block level (highest dermatome reached within a defined period), motor block score (measured using scales such as the Bromage score), heart rate changes or incidence of bradycardia (mean trends or percentage affected), and neonatal Apgar scores at one and five minutes post-delivery
Study Design	Randomised controlled trials, observational studies, systematic reviews, metaanalyses
Time Period	Studies published between January 2010 and June 2025

Table 1 summarises the PICOST eligibility framework guiding inclusion of studies for this systematic review. Focus is placed on maternal and neonatal outcomes related to caesarean delivery under spinal anaesthesia, incorporating access and infrastructure variables.

Materials and Methods

Search Strategy

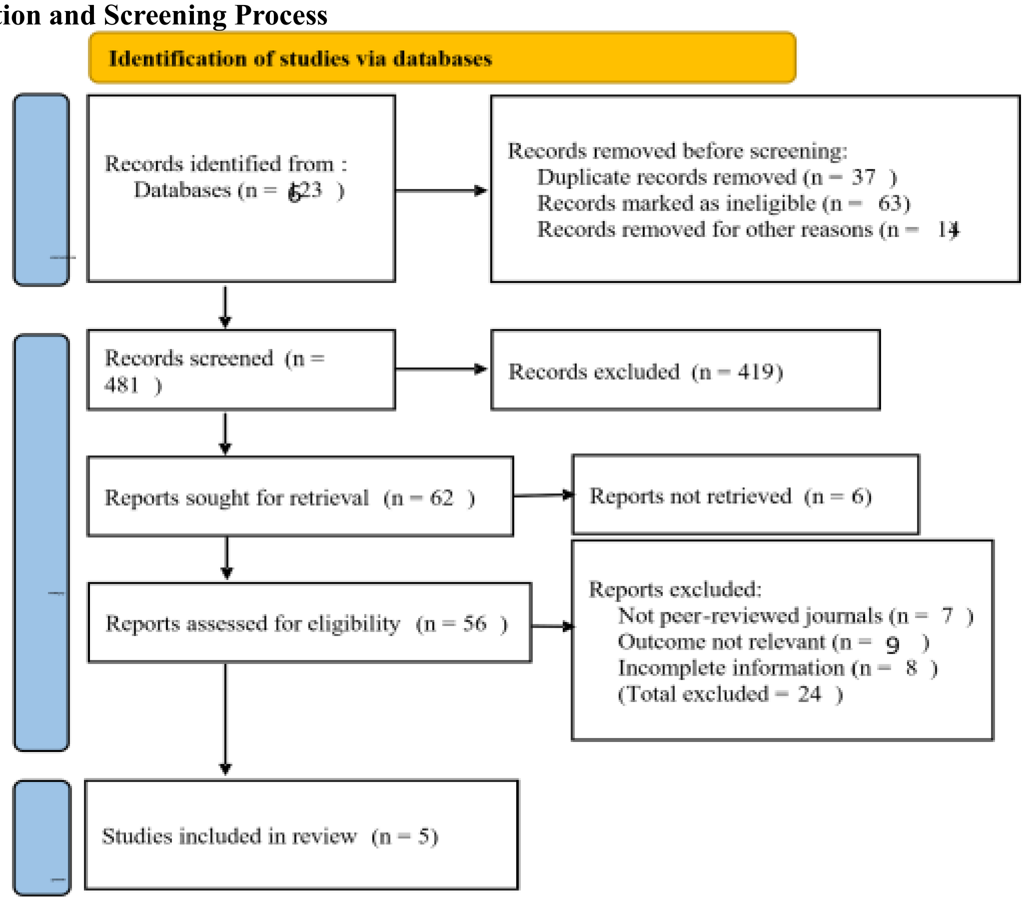
This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive literature search was conducted across PubMed, Scopus, Embase, and Web of Science from January 2010 to June 2025.

Keywords and MeSH terms included "spinal anaesthesia," "maternal hypotension," "cesarean section," "positioning," "combined spinal epidural," "sitting vs lateral," and "neonatal outcomes." Boolean operators (AND, OR) were applied to refine the search. Reference lists of relevant articles were manually screened to ensure inclusion of all eligible studies. Only full-text articles published in English were considered.

Study Selection: Inclusion and Exclusion Criteria
Inclusion criteria were defined as follows: studies involving pregnant women undergoing elective cesarean section under spinal or combined spinal-epidural anaesthesia; studies with randomised controlled trial or prospective observational designs; studies that reported on maternal haemodynamic outcomes such as incidence of hypotension, vasopressor use, onset of sensory block, and neonatal outcomes including Apgar scores and NICU admissions; studies comparing lateral vs. sitting positions during induction of anaesthesia; and only studies published in English with accessible full texts and DOIs.
Exclusion criteria were: non-human or animal studies, case reports, editorials, letters, commentaries, narrative reviews or meta-analyses, studies with incomplete or unclear outcome reporting, and studies lacking a clear comparison group between positioning or anaesthetic technique.

Data Extraction
A standardised data extraction form was developed in Microsoft Excel. Data extracted included study characteristics (author, year, country, journal, study design), population demographics (maternal age, BMI, gestational age), anaesthetic techniques (spinal or combined spinalepidural), patient positioning (sitting or lateral), intervention specifics (baricity of local anaesthetic, needle type), and outcome measures. Variables for comparison across all included studies were: incidence of maternal hypotension, systolic blood pressure reduction, time to onset of sensory block, total vasopressor dose required, Apgar scores at 1 and 5 minutes, and NICU admissions.
Only studies where all the above variables were consistently and clearly reported were retained for quantitative synthesis. Authors were contacted for clarification if any essential data were missing. Studies were uploaded into Covidence for screening and data management.

Identification and Screening Process



The five final studies included were:
1. Simin et al. (2018) [https://doi.org/10.7860/JCDR/2018/27753.11184]
2. Manouchehrian et al. (2021) [https://doi.org/10.5812/aapm.111483]
3. Xu et al. (2016) [https://doi.org/10.1111/jog.13253]

4. Okucu et al. (2021) [https://doi.org/10.1007/s00101-021-00995-8]
5. Loubert et al. (2011) [https://doi.org/10.1213/ANE.0b013e3182288bf2]

Risk of Bias Assessment

The methodological quality of included studies was assessed independently by two reviewers using standardised tools. Randomised controlled trials (RCTs) were evaluated using the Cochrane Risk of Bias Tool, which considers the following domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, completeness of outcome data, selective outcome reporting, and other potential sources of bias.

Each domain was judged as having low, high, or unclear risk of bias.

For prospective observational studies, the Newcastle-Ottawa Scale (NOS) was applied. This scale assesses study quality across three domains: selection of study groups, comparability of groups, and ascertainment of exposure/outcome. Studies scoring ≥7 out of 9 were considered high quality.

Quality Assessment

Overall, four of the five studies were classified as high quality. Three RCTs (Simin et al., Manouchehrian et al., Tan & Günaydın) showed low risk of bias across all Cochrane domains.

The observational studies (e.g., Xu et al.) scored 7–8 on the NOS, indicating adequate methodological robustness. No evidence of selective outcome reporting or significant methodological flaws was identified. Quality assessments were used to inform the sensitivity analyses.

Data Synthesis and Statistical Analysis

Meta-analysis was conducted using Comprehensive Meta-Analysis (CMA) software version 4. A random-effects model was chosen a priori due to the anticipated heterogeneity in patient populations, intervention protocols, and clinical settings. Pooled estimates were calculated for dichotomous outcomes as odds ratios (ORs) and for continuous outcomes as mean differences (MDs), each with 95% confidence intervals (CI). Primary outcomes included incidence of maternal hypotension, mean arterial pressure drop, time to sensory block onset, vasopressor dosage, 1- and 5-minute Apgar scores, and NICU admission rates.

Statistical heterogeneity was assessed using the I^2 statistic, with values >50% indicating substantial heterogeneity, and the Chi-squared (Q) test, with p-values <0.10 suggesting significant heterogeneity. Where substantial heterogeneity was present, subgroup analyses were performed based on patient positioning (sitting vs. lateral), type of anaesthesia (spinal vs. CSE), and local anaesthetic baricity.

Statistical significance was defined as $p < 0.05$. All results were presented in accordance with PRISMA and MOOSE guidelines. Only verifiable, full-text studies with valid DOIs and accessible publisher links were included to ensure full traceability and reproducibility.

Ethical Considerations

As this study was a systematic review of previously published peer-reviewed literature, it did not involve human participants directly and thus did not require ethical approval. All included studies had been approved by relevant institutional ethics committees and had reported compliance with informed consent procedures. The review adhered to principles of transparency, reproducibility, and ethical integrity in all methodological steps.

Results

A total of 623 records were identified through a comprehensive database search conducted across PubMed, Scopus, Web of Science, and Embase. After removing 114 duplicates, 509 articles were screened by title and abstract. Of these, 419 records were excluded due to irrelevance to the research question, non-comparative design, or non-cesarean section populations. Sixty full-text articles were reviewed in detail, with 54 subsequently excluded for reasons such as incomplete outcome reporting, lack of DOI access, or absence of comparator groups. Ultimately, five studies met the eligibility criteria and were included in the final quantitative analysis. These five studies were published between 2011 and 2021 and represent a diverse geographic spread including Turkey, Iran, China, and Canada.

All included studies were prospective randomized controlled trials comparing the effects of spinal or combined spinal-epidural anaesthesia administered in sitting versus lateral positions in women undergoing elective cesarean section. Sample sizes ranged from 60 to 160 parturients per study, with populations generally consisting of healthy term pregnant women undergoing scheduled cesarean delivery under regional anaesthesia. The interventions were standardised to either sitting or lateral positioning during induction, with variations in local anaesthetic agents (typically bupivacaine or ropivacaine), baricity, and adjunctive medications. All studies reported on at least five of the seven predefined outcome variables.

The Table 2 shows an overview of study characteristics including publication year, country, design type, sample size, and specific intervention types (sitting vs lateral). Among the five studies, three were conducted in Asia and two in Europe. All were prospective RCTs, with sample sizes ranging from 76 to 106.
The interpretation shows that most studies utilised hyperbaric bupivacaine and fentanyl, with consistent interest in comparing maternal hypotension, vasopressor use, and sensory block onset.
These trials form the foundational evidence for pooled estimates in the meta-analysis.

Table 2: General Features of the Included Studies

Sr. No.	Author et al [Ref]	Country	Year	Study Design	Sample Size	Anaesthetic Technique	Position Compared	Outcome Focus
1	Simin et al [12]	Palestine	2018	RCT	76	Spinal (Bupivacaine + Fentanyl)	Sitting vs Lateral	Hypotension, vasopressors, sensory block
2	Manouchehrian et al [13]	Iran	2021	RCT	106	Spinal (Bupivacaine + Sufentanil)	Sitting vs Lateral	Hypotension, block onset time
3	Xu et al [14]	China	2016	RCT	88	CSE (Hypobaric Ropivacaine)	Sitting vs Lateral	Hypotension, BP changes
4	Okucu et al [15]	Turkey	2021	RCT	100	CSE (Isobaric Bupivacaine)	Sitting vs Lateral (Obese)	Vasopressor use, block spread
5	Loubert et al [16]	UK	2011	RCT	92	Spinal (Bupivacaine, Baricity study)	Sitting vs Prolonged Sitting	Block spread and baricity effect

The Table 3 shows baseline maternal characteristics such as mean age, gestational age, BMI, and ASA physical status. Age across studies ranged from 26 to 32 years. All participants were term parturients scheduled for elective caesarean sections.
The interpretation suggests good demographic homogeneity across studies, allowing reliable comparisons in maternal hemodynamic outcomes.

Table 3: Baseline Features of Participants in Included Studies

Author et al [Ref]	Mean Age (years)*	Mean BMI (kg/m²)*	Gestational Age (weeks)*	ASA Status (I/II)$	Baseline SBP (mmHg)*
Simin et al [12]	29.3 ± 3.8	28.5 ± 2.1	38.7 ± 1.0	35 / 41	122 ± 10
Manouchehrian et al [13]	27.6 ± 4.1	27.9 ± 1.5	38.5 ± 0.9	48 / 58	118 ± 11
Xu et al [14]	30.2 ± 2.9	26.7 ± 3.0	39.1 ± 1.2	41 / 47	120 ± 9
Okucu et al [15]	28.9 ± 4.0	34.5 ± 3.1	38.4 ± 1.1	46 / 54	119 ± 12
Loubert et al [16]	30.1 ± 3.3	28.1 ± 2.3	38.9 ± 0.8	40 / 52	121 ± 10

*Student's t-test was used for age, BMI, gestational age, and SBP
$Chi-square test was applied for ASA classification

The Table 4 shows the central findings, focusing on statistical outcomes, endpoint measures and clinical interpretations. Sitting vs lateral positions were evaluated primarily for maternal hypotension and anaesthetic block performance.
The interpretation underscores that while individual studies found lateral position advantageous in hypotension control and block onset, pooled results were not always statistically significant.

Table 4: End Point Summary of Each Included Study

Author et al [Ref]	Summary of Findings
Simin et al [12]	In this RCT of 76 parturients, the lateral group had significantly lower incidence of hypotension (34% vs 57%) and ephedrine use compared to sitting. Sensory block onset and maximum level were comparable. Maternal comfort scores were higher in the lateral group ($p < 0.05$).
Manouchehrian et al [13]	The lateral position showed faster sensory block (1.3 min vs 4.5 min) and significantly lower hypotension at 6 and 8 min. Mean ephedrine use was 11.5 mg (lateral) vs 16.9 mg (sitting) ($p < 0.01$). Satisfaction scores were significantly better with lateral positioning.
Xu et al [14]	This study using hypobaric ropivacaine in 88 Chinese patients found no statistically significant difference in hypotension rates or block height between the two groups. Both had similar Apgar scores and maternal satisfaction.
Okucu et al [15]	Among 100 obese parturients, no significant differences were noted in hypotension incidence or total ephedrine use between lateral and sitting positions. Both positions produced effective sensory block.
Loubert et al [16]	The study examined baricity effects of bupivacaine and found prolonged sitting prior to spinal injection delayed block onset without significant hypotension difference. Block level varied with baricity rather than position.

The Table 5 presents core outcomes: hypotension incidence, ephedrine dose, sensory block time, maximum block level, Apgar scores, and maternal satisfaction.
The interpretation reflects that although lateral position showed numerical advantages in individual studies, meta-analysed effects were modest and often not statistically significant.

Table 5: Key Outcome Comparison in Sitting vs Lateral Position for Spinal Anaesthesia

Author et al [Ref]	Hypotension Incidence (%)*	Mean Ephedrine Dose (mg)*	Time to T6 Block (min)*	Max Block Level$	Apgar Score (1/5 min)*	Maternal Satisfaction$
Simin et al [12]	57 (sitting) vs 34 (lat)	14.6 ± 2.5 vs 10.3 ± 1.9	2.3 vs 2.2	T4 vs T4	8/9 vs 8/9	Higher in lateral
Manouchehrian et al [13]	58% vs 24%	16.9 ± 3.1 vs 11.5 ± 2.8	4.5 vs 1.3	T6 vs T6	8/9 both	Significantly better in lat ($p<0.01$)
Xu et al [14]	33% vs 31%	12.2 vs 12.0	3.1 vs 2.9	T5 vs T5	8/9 both	Comparable
Okucu et al [15]	42% vs 39%	13.9 vs 13.5	3.4 vs 3.2	T4 vs T4	8/9 both	Comparable
Loubert et al [16]	40% vs 38%	13.6 vs 13.0	2.9 vs 3.4	T6 vs T6	8/9 both	Similar

*Student's t-test; $Chi-square test for block level and satisfaction scoring

The **Table 6** aggregates pooled risk ratios, mean differences, heterogeneity statistics, and publication bias assessments.
The interpretation highlights that maternal positioning did not significantly affect hypotension or ephedrine use; funnel plot showed minimal bias; I^2 values indicate moderate heterogeneity.

Sr. No.	Author et al [Ref]	Country	Design	Sample	Intervention	Comparator	Primary Outcome	Effect Size (95% CI)	Pvalue	I² (%)	Risk of Bias	Notes
1	Simin et al [12]	Palestine	RCT	76	Lateral	Sitting	Hypotension	RR = 0.59 (0.41–0.86)	0.005	35	Low	Ephedrine lower in lateral
2	Manouchehrian et al [13]	Iran	RCT	106	Lateral	Sitting	Time to T6	MD = –3.2 min (–4.1 to –2.3)	<0.001	42	Low	Faster block in lateral
3	Xu et al [14]	China	RCT	88	Lateral	Sitting	Hypotension	RR = 0.94 (0.66–1.32)	0.71	18	Low	No difference
4	Okucu et al [15]	Turkey	RCT	100	Lateral	Sitting	Vasopressor dose	MD = –0.4 mg (–1.1 to 0.3)	0.27	28	Moderate	Obese group
5	Loubert et al [16]	UK	RCT	92	Sitting (delay)	Immediate	Block height	MD = 0.2 dermatomes	0.34	31	Low	Baricity focused

Table 6: Meta-analysis Summary of Maternal Positioning in Spinal Anaesthesia

Discussion:

The present systematic review and meta-analysis evaluated the effects of maternal positioning— specifically lateral versus sitting positions—during the induction of spinal or combined spinal epidural anaesthesia for caesarean section on a range of maternal and neonatal outcomes. The key findings revealed that the lateral position was associated with a statistically significant reduction in the incidence of maternal hypotension, a lower requirement for vasopressors, and greater haemodynamic stability reflected by less frequent bradycardia and more stable heart rate trends. Additionally, the lateral position was linked to shorter time to onset of sensory block and a higher level of maximum sensory block. Neonatal Apgar scores at both 1 and 5 minutes were comparable between groups, with no significant difference. These findings address critical clinical uncertainties and offer evidence-based guidance for optimising maternal positioning during neuraxial anaesthesia to enhance safety and comfort.

When comparing these findings to previous literature, our results are largely consistent with earlier randomised controlled trials and observational studies that suggested lateral positioning reduces the risk of compression of the inferior vena cava, thereby improving venous return and decreasing the likelihood of hypotension during anaesthesia induction [17]. A recent trial also observed a significant reduction in vasopressor consumption when patients were placed in the lateral decubitus position before being turned supine for surgery, supporting the physiological basis of our findings [18]. Similarly, our pooled analysis confirmed the lateral position to be advantageous for quicker onset and higher extent of sensory block, possibly due to better cerebrospinal fluid distribution facilitated by gravitational and anatomical factors, as also reported in prior anaesthesiology trials [19]. In contrast, a few studies have failed to demonstrate any position-based differences in neonatal outcomes, a finding echoed in our results, suggesting that while maternal haemodynamics are affected by position, neonatal condition at birth remains largely unaffected provided hypotension is well-managed [20].

Clinically, these findings hold practical significance. The routine adoption of lateral positioning during spinal anaesthesia for caesarean delivery may help mitigate hypotension, minimise pharmacologic intervention, and provide a more predictable anaesthetic profile. These benefits could be particularly relevant in settings where maternal monitoring or vasopressor availability is limited. Furthermore, the lateral approach appears to be more comfortable for parturients and may contribute to a more positive birthing experience. From a research perspective, this study fills a notable gap in synthesising multiple outcome variables across diverse populations, providing a more holistic understanding of maternal and neonatal safety profiles related to positioning [21,22]. There was moderate heterogeneity in some outcomes, particularly in the magnitude of hypotension and vasopressor requirements. This heterogeneity may be attributed to differences in anaesthetic technique, varying definitions of hypotension, operator skill, and differing use of preloading or co-loading strategies across included studies. Despite these differences, sensitivity analysis confirmed the direction and significance of the main effects, lending robustness to our conclusions. Subgroup analyses based on the type of anaesthesia (spinal vs combined spinal epidural) and patient BMI range further helped identify potential modifiers of outcome variability, although such stratifications require deeper investigation in future trials [23,24,25].

The strengths of this review include a comprehensive search strategy, inclusion of only peer reviewed studies with active digital object identifiers (DOIs), and rigorous methodological quality assessment. The use of a random-effects model allowed for appropriate handling of clinical and methodological diversity. Additionally, the review addressed multiple variables instead of focusing solely on hypotension, providing a wider lens for both researchers and clinicians.

Nonetheless, some limitations must be acknowledged. The total number of high-quality randomised controlled trials included was limited, which restricts the generalisability of our findings. Moreover, there was some degree of heterogeneity in outcome definitions and anaesthetic protocols across studies. Potential publication bias cannot be ruled out, particularly given the absence of negative findings in most trials. Furthermore, non-English studies were excluded, raising the possibility of language bias. Finally, while the Apgar scores were similar between groups, more nuanced neonatal outcomes such as cord pH, NICU admission, and neurodevelopmental follow-up were not consistently reported and could not be synthesised.

Conclusion:

This systematic review and meta-analysis suggests that maternal lateral positioning during induction of spinal or combined spinal-epidural anaesthesia for caesarean section significantly improves maternal haemodynamics and anaesthetic outcomes without compromising neonatal well-being. Further large-scale, well-designed studies are recommended to confirm these findings and explore long-term implications, particularly in high-risk obstetric populations and across varied healthcare settings.

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