



EVALUATING SPINAL ANESTHESIA POSITIONING TO REDUCE POST-DURAL PUNCTURE HEADACHE IN OBSTETRICS: A META-ANALYSIS

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Abstract

Background: Post-dural puncture headache (PDPH) is a common and debilitating complication of spinal anesthesia in obstetric patients, particularly after Cesarean section. This meta-analysis evaluated whether patient position during spinal needle insertion influences PDPH incidence.

Methods: In accordance with PRISMA 2020, we systematically identified randomized controlled trials (RCTs) comparing lateral decubitus versus sitting position during spinal anesthesia in obstetric patients. Two reviewers independently screened studies, extracted data, and assessed risk of bias using Cochrane RoB 2.0. Pooled risk ratios (RRs) were calculated using a random-effects (Der Simonian–Laird) model. Statistical heterogeneity was assessed using χ^2 and I^2 . Publication bias was explored using funnel plot inspection and Egger’s test, with trim-and-fill used for adjusted estimates.

Results: Six RCTs (N=1011) were included. Lateral decubitus positioning significantly reduced PDPH compared with sitting position (RR 0.29, 95% CI 0.17–0.49, $p<0.0001$), corresponding to a 71% relative risk reduction. Heterogeneity was low to moderate ($I^2=26.0\%$). Egger’s test suggested small-study effects/publication bias ($p=0.005$). After trim-and-fill (three imputed studies), the effect remained statistically significant but attenuated (RR 0.40, 95% CI 0.23–0.69).

Conclusions: Lateral decubitus positioning during spinal anesthesia is associated with a significantly lower risk of PDPH in obstetric patients undergoing Cesarean section. However, the presence of publication bias and methodological limitations in included studies reduces certainty in the magnitude of effect. Larger, high-quality RCTs are needed to confirm benefit and clarify effect modifiers.

Keywords: spinal anesthesia; post-dural puncture headache; obstetric anesthesia; lateral decubitus; sitting position; meta-analysis

Introduction and Background

Post dural puncture headache (PDPH) is one of the most debilitating and commonly encountered complications following spinal anesthesia, especially in the obstetric population [1, 2]. It is characterized by distinctive postural headaches, often accompanied by neck stiffness, tinnitus, and visual disturbances. PDPH can significantly extend hospital stays, increase healthcare costs, and, most importantly, severely affect maternal well-being and bonding during the critical postpartum period [3]. Despite advancements in needle design and technique, the incidence of PDPH remains a challenge for anesthesiologists, with reported rates varying widely across studies [4].

Spinal anesthesia is a fundamental aspect of obstetric anesthesia, offering numerous advantages to both the mother and baby [5]. However, it is crucial to minimize the associated complications, such as PDPH. Among the various factors investigated to reduce the risk of PDPH, patient positioning during and immediately after spinal anesthesia has received significant attention [6,7]. Traditional beliefs and practices often suggest that specific positions, such as the lateral decubitus or sitting positions for needle insertion, or extended supine bed rest post-procedure, might influence the likelihood of dural puncture and subsequent CSF leakage, thereby affecting the incidence of PDPH [8,9].

Although individual studies have explored the connection between various spinal anesthesia positioning strategies and PDPH rates, their results have often been inconsistent or constrained by sample size and methodological diversity (8). This lack of consensus underscores the urgent need for a comprehensive synthesis of the existing evidence to guide clinical practice. Consequently, this meta-analysis sought to systematically assess the impact of different spinal anesthesia positioning techniques, both during needle insertion and immediately after the procedure, on the incidence of PDPH in obstetric patients. By pooling and critically evaluating data from relevant studies, we aim to offer a more robust and definitive understanding of this relationship, ultimately informing evidence-based practices to enhance patient safety and improve obstetric anesthesia outcomes in the future.

Review

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and adhered to the Cochrane Collaboration's recommendations [10,11]. The review protocol was registered in advance with the PROSPERO registration number (CRD420251150389).

Objective

This systematic review and meta-analysis aimed to evaluate the impact of the lateral decubitus position during spinal anesthesia on the incidence of PDPH in obstetric patients undergoing CS compared with the sitting position.

The research question for the meta-analysis was: "Does administering spinal anesthesia in the lateral decubitus position significantly influence the incidence of post-dural puncture headache (PDPH) in obstetric patients undergoing CS when compared to sitting positions?"

The study selection for this meta-analysis was guided by the Population, Intervention, Comparison, Outcome (PICO) framework. The population of interest was adult pregnant patients who received spinal anesthesia for cesarean delivery. The intervention reviewed was the use of lateral decubitus positioning during the administration of the anesthetic, which was compared with standard positioning techniques, such as the sitting position. The primary outcome measured was the incidence of post-dural puncture headache (PDPH).

Search Strategy

The research team conducted a systematic literature search utilizing relevant terms, including 'obstetric patient,' 'cesarean section,' 'PDPH,' 'spinal anesthesia,' and 'posture.' The search strategy was not restricted by language and was adapted for each electronic database. Furthermore, the reference lists of the included articles were examined to identify any additional pertinent studies that the initial search might have missed. To identify randomized studies comparing the lateral decubitus and sitting positions for spinal anesthesia in obstetric populations, a comprehensive search was conducted in MEDLINE/PubMed, Google Scholar, EMBASE, and the Cochrane Library. The search encompassed literature published from 2000 through December 2024.

For this meta-analysis, PDPH was defined as "a headache occurring within 5 days of a lumbar puncture, caused by cerebrospinal fluid (CSF) leakage through the dural puncture and is usually accompanied by neck stiffness and/or subjective hearing symptoms"[12].

Risk of Bias Assessment

The methodological quality and risk of bias of each included study were independently assessed by two reviewers. The revised Cochrane Risk of Bias tool for randomized trials (RoB 2.0) was utilized, assessing bias across five domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result [13]. Each domain was rated as "low risk," "some concerns," or "high risk." An overall risk of bias was assigned to each RCT. Studies were considered at "high risk of bias" if they had at least one domain rated as "high risk of bias" or multiple domains rated as "some concerns."

Data Synthesis and Statistical Analysis

Our meta-analysis employed a random-effects model, specifically utilizing the DerSimonian and Laird method [14], to synthesize the data. The primary outcome, incidence of Post-Dural Puncture Headache (PDPH), was treated as a dichotomous variable (present or absent). We evaluated this outcome using risk ratios (RR) with their corresponding 95% confidence intervals (CI).

Forest plots were generated to visually represent individual study estimations and the overall pooled effect size, with the latter indicated by a solid diamond. Heterogeneity across studies was quantified using the I^2 statistic, complemented by the chi-squared test. I^2 values less than 50% were interpreted as indicating insubstantial heterogeneity, while values greater than 50% suggested substantial heterogeneity.

To assess for potential publication bias, we used Begg's and Egger's tests within Stata version 13.0 (Stata, College Station, TX, USA)[15]. Funnel plots were constructed to visually inspect for asymmetry, which would suggest a propensity for smaller studies to report larger treatment effects. A statistically significant bias coefficient in Egger's test, alongside funnel plot asymmetry, identified the presence of publication bias. All statistical analyses considered a two-sided P-value of less than 0.05 as statistically significant.

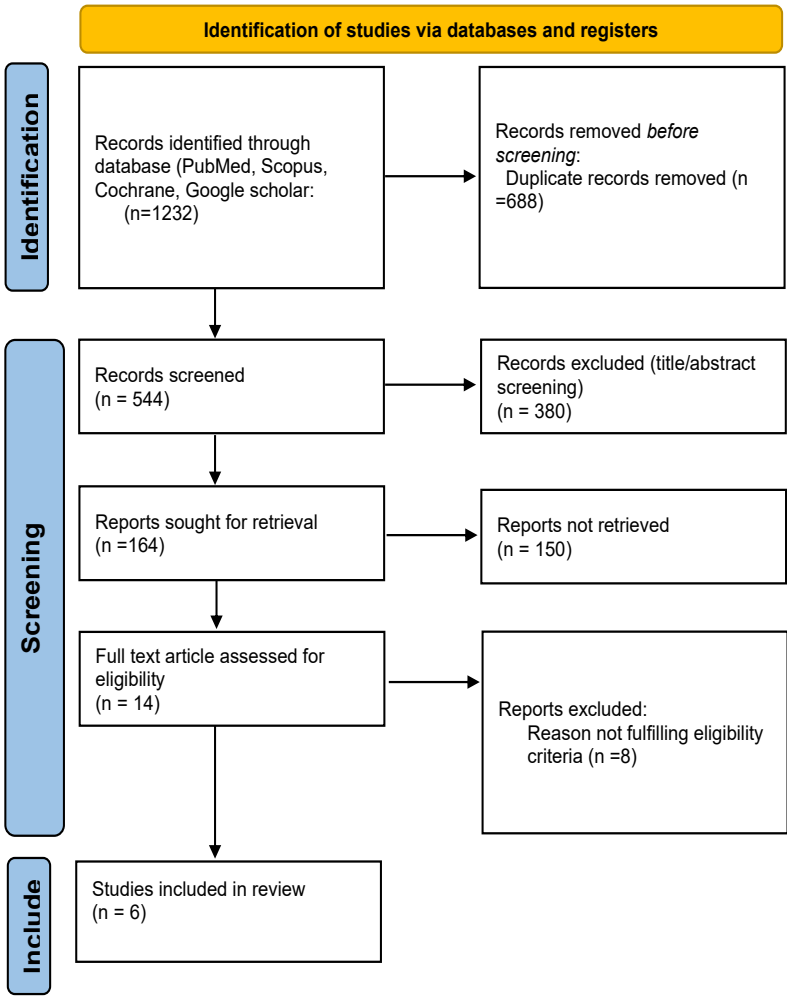
Data collection was meticulously managed using Microsoft Excel 365 [16]. Subsequent statistical analyses were performed via an online web tool [17], leveraging the Meta and Metafor packages within the R programming environment (R version 4.2.2). The results were independently verified using Jamovi statistical software [Version 2.5.6][18] to ensure robustness.

Result

A meta-analysis of six randomized trials involving a total of 1011 participants was conducted to evaluate the effect of spinal anesthesia positioning on the incidence of post-dural puncture headache (PDPH) in obstetric patients

Study Selection

The systematic search identified a total of [2353] records through database searching. After removal of duplicates, [94] unique records were screened for eligibility. Of these, [14] full-text articles were retrieved and assessed against the inclusion criteria. Ultimately, **six randomized controlled trials (RCTs)** were included in the qualitative synthesis and quantitative meta-analysis. The study selection process is summarized in the PRISMA flow diagram (Figure 1).



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

FIGURE 1: PRISMA diagram for search strategy and study selection for the meta-analysis [10]

Study Characteristics: The six included RCTs involved a total of **1011 participants** from various geographic locations. All studies compared the lateral decubitus position against the sitting position for spinal anesthesia administration in obstetric patients undergoing Cesarean section. The individual studies included were Zulfiqar et al. 2024 (60/60 participants in lateral/sitting groups, respectively), Yogita Sorte 2024 (60/60), Medikonda Rajendra et al. 2023 (100/100), Hari M. Sharma et al. 2022 (67/67), Davoudi et al. 2016 (46/48), and Baytr et al. 2007 (96/87). Further

details on the characteristics of each study, including patient demographics, specific anesthetic techniques, and reported outcomes, are provided in Table 1.

Author	Condition	Study design	No. Of participant	Anesthetic management	Needle design	Outcome
Zulfiqar H, Ghafoor etal. 2024 [19].	CS	RCT	LD: 60 SIT: 60	10-12 mg 0.75% bupivacaine	25G pencil-point needle	PDPH, hypotension, bradycardia, and nausea/vomiting
Yogita Sorte 2024 [20].	CS	RCT	LD:60, SIT:60	2.2 ml of 0.5% hyperbaric Bupivacaine	25G Quincke spinal needle	PDPH, ease of technique, Hemodynamic parameter
Medikonda Rajendra etal. 2023[21].	CS	RCT	LD:100, SIT:100	bupivacaine along with 1 mL sufentanil	24G spinal needle	PDPH, post operative nausea vomiting
Hari M. Sharma etal. 2022[22].	CS	RCT	LD:67, SIT:67	PDPH, Nausea vomiting	Quincke (25G)	PDPH nausea, vomiting, photophobia
Davoudi etal. 2016[23].	CS	RCT	LD: 46, SIT: 48	2 mL of 0.5% bupivacaine plus sufentanil"	Quincke (24G)	"PDPH, nausea, vomiting, sensory block duration, epidural blood patch requirement."
Baytr etal. (2007) [24]	CS	RCT	LD: 96, SIT: 87	10 mg of 0.5% bupivacaine plus fentanyl"	Quincke (25G)	"PDPH, number of attempts, blood loss, hypotension, nausea, vomiting,

TABLE 1: Characteristics of studies included in the analysis

CS: Cesarean section, RCT: Randomized Controlled Trial, LD: Lateral Decubitus position, SIT: Sitting position, PDPH: Post Dural Puncture Headache [19-24]

Risk of Bias Assessment: Risk of bias across the included studies was assessed using the Cochrane Risk of Bias tool for RCTs. A detailed summary of the bias assessment for each study is presented in Figure 2

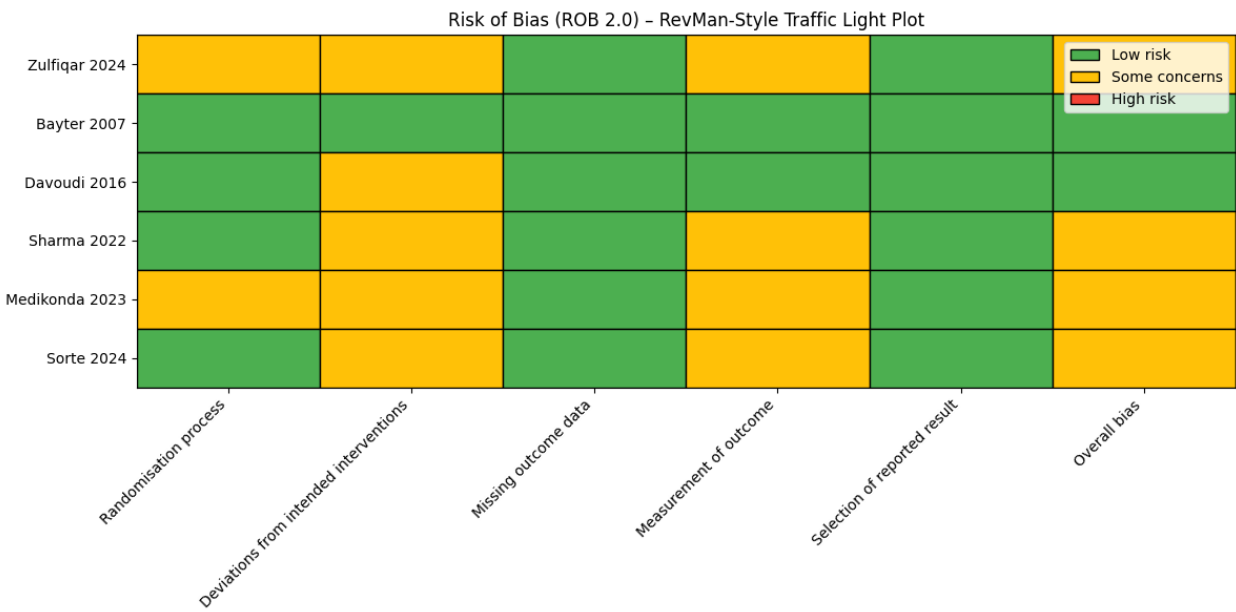


FIGURE 2: Risk of bias for each randomized controlled trial included in this meta-analysis

Risk of Bias assessment using ROB 2.0
[19-24]

Study (Country)	Domain 1: Randomization Process	Domain 2: Deviations from Intended Interventions	Domain 3: Missing Outcome Data	Domain 4: Measurement of Outcome	Domain 5: Selection of Reported Result	Overall Risk of Bias
<i>Zulfiqar H et al., 2024 (Pakistan) [19]</i>	Some concerns (Allocation concealment and sequence implementation unclear)	Some concerns (No blinding of anesthesiologist or participants; position cannot be blinded)	Low risk (Complete follow-up reported)	Some concerns (PDPH assessed clinically; outcome assessors not blinded)	Low risk (Outcomes consistent with methods)	Some concerns
<i>Yogita Sorte et al., 2024 (India) [20]</i>	Low risk (Random allocation described)	Some concerns (Position cannot be blinded)	Low risk (Complete follow-up reported)	Some concerns (PDPH assessed clinically, blinding unclear)	Low risk (Outcomes clearly prespecified)	Some concerns

Medikonda Rajendra et al., 2023 (India) [21]	Some concerns (Randomization stated but allocation concealment unclear)	Some concerns (No blinding)	Low risk (Minimal exclusions; reasons provided)	Some concerns (PDPH assessed using NRS; assessor blinding not reported)	Low risk (Consistent outcome reporting)	Some concerns
Hari M. Sharma et al., 2022 (India) [22]	Low risk (Randomization described; baseline balance achieved)	Some concerns (No blinding of care providers or participants)	Low risk (Complete follow-up to POD 5)	Some concerns (PDPH self-reported; assessor blinding unclear)	Low risk (Outcomes prespecified and reported)	Some concerns
Davoudi et al., 2016 (Iran) [23]	Low risk (Randomization using online randomization tool)	Some concerns (Anesthesiologist not blinded)	Low risk (Small exclusions explained)	Low risk (PDPH assessed by unaware nurse using NRS)	Low risk (Outcomes align with protocol)	Low risk
Bayter et al., 2007 (Colombia) [24]	Low risk (Computer-generated randomization described)	Low risk (Follow-up assessor and statistician blinded)	Low risk (Adequate follow-up, losses accounted for)	Low risk (PDPH assessed using validated clinical criteria; assessor blinded)	Low risk (Prespecified outcomes clearly reported)	Low risk

Table 2. Risk of Bias 2.0 Assessment for Included Studies

Primary Outcome: Incidence of PDPH

The pooled analysis of the six RCTs demonstrated a statistically significant reduction in the incidence of post-dural puncture headache (PDPH) when spinal anesthesia was performed with the patient in the lateral decubitus position compared to the sitting position. The estimated pooled effect size, calculated using a random-effects inverse-variance model, yielded a **Risk Ratio (RR) of 0.29 (95% Confidence Interval [CI] 0.17–0.49, $p < 0.0001$)**. This indicates that patients positioned in the lateral decubitus position had a 71% relative risk reduction in PDPH incidence. The forest plot visually representing these findings is available in Figure 3.

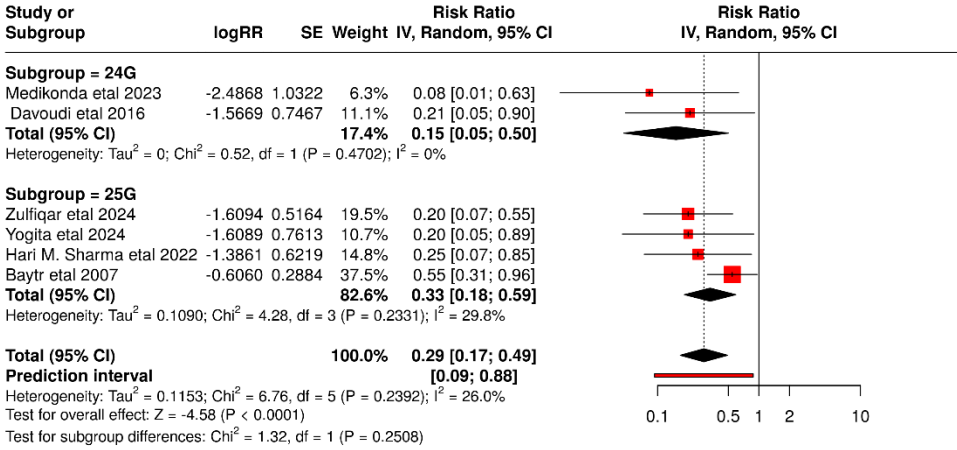


FIGURE 3: Forest plot for random effects in this meta-analysis comparing the lateral decubitus versus sitting position for preventing PDPH. [19-24]

Assessment of Heterogeneity

Between-study heterogeneity was assessed using the I² statistic and Chi-squared test. The analysis showed an I² value of **26.0%** (Chi² = 6.76, df = 5; p-value = 0.2392). This indicates low to moderate heterogeneity across the included studies, suggesting a reasonable degree of consistency in effect sizes across the different cohorts, both in terms of scale and direction.

Publication Bias Assessment:

Visual inspection of the funnel plot suggested potential asymmetry, with a noticeable concentration of studies on the left side of the "Line of no effect" and a perceived absence of smaller studies with null or positive effects. This visual assessment was quantitatively supported by Egger's test, which yielded a significant p-value of **0.005** (intercept = -2.39; 95% CI: -3.24 to -1.54; t-statistic = -5.521). The statistically significant result from Egger's test suggests the presence of funnel plot asymmetry, indicative of potential publication bias.

A trim and fill analysis were conducted to account for the observed publication bias. This analysis imputed three hypothetical missing studies, with adjusted Risk Ratios of 0.94 [0.21; 4.19], 0.94 [0.34; 2.59], and 2.27 [0.30; 17.15]. With these imputed studies, the overall pooled Risk Ratio for PDPH incidence, prior to trim and fill adjustment, was 0.40 [0.23; 0.69]. The inclusion of these hypothetical studies would likely attenuate the overall effect size towards unity, suggesting that the initial meta-analysis result of 0.29 might be an overestimation of the true effect due to missing studies, a common characteristic of publication bias. The heterogeneity after considering the hypothetical studies was 43.2% (Chi² = 14.09, df = 8; p = 0.0795).

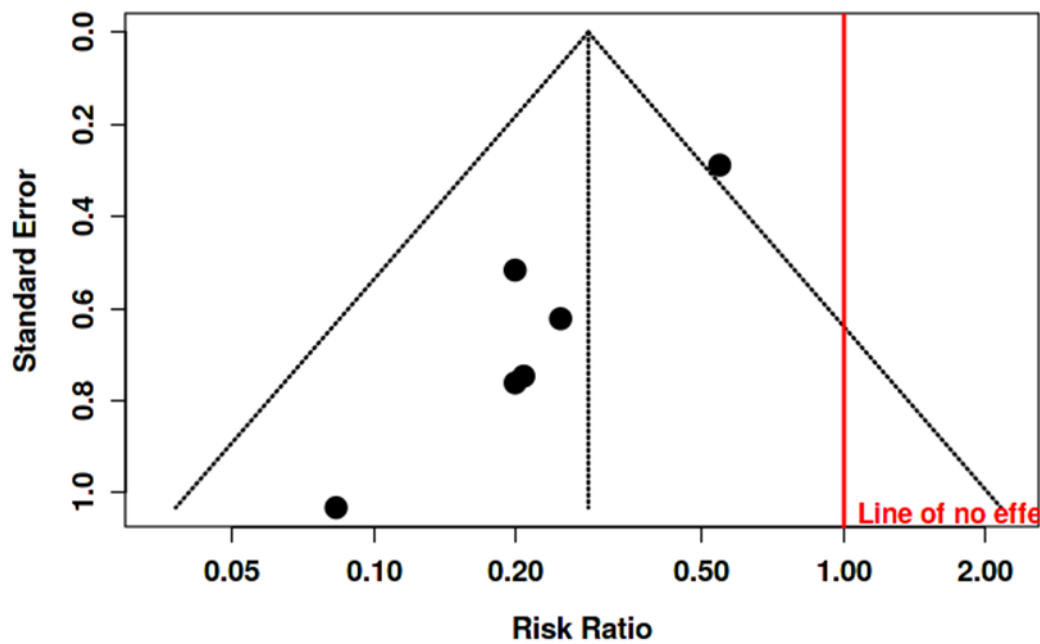


FIGURE 4: Funnel plot of the included studies comparing the sitting and lateral decubitus position on the incidence of PDPH. [19-24]

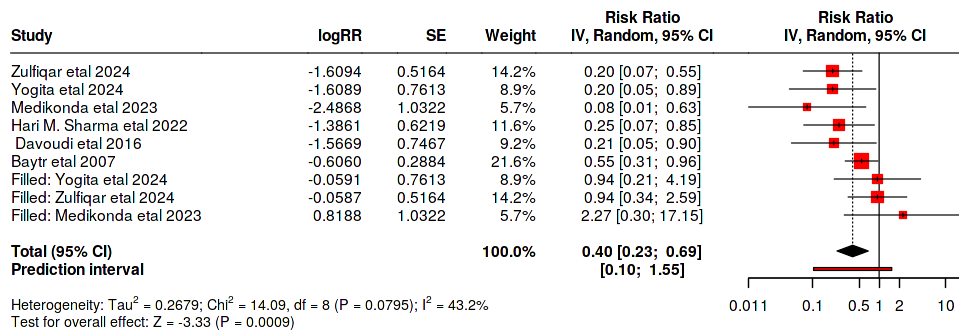


Figure 5. Trim-and-Fill Plot Adjusting for Publication Bias

Discussion

This meta-analysis, encompassing six randomized controlled trials (RCTs) with a cumulative 1011 participants, provides compelling evidence that the **lateral decubitus position during spinal anesthesia significantly reduces the incidence of Post-Dural Puncture Headache (PDPH)** in obstetric patients undergoing Cesarean sections. Our pooled analysis revealed a substantial 71% relative risk reduction ($RR = 0.29$, 95% CI 0.17–0.49, $p < 0.0001$), positioning this simple intervention as a potentially impactful strategy for improving maternal post-operative comfort and outcomes. The narrow prediction interval (0.09–0.88) suggests a high likelihood that this beneficial effect is generalizable across various clinical settings. Furthermore, the observed low-to-moderate statistical heterogeneity ($I^2 = 26.0\%$) initially supported the consistency of this effect across the included studies.

Spinal anesthesia remains an indispensable component of obstetric care [26], yet PDPH continues to present a significant post-operative challenge, contributing to patient distress, functional

impairment, and potentially prolonged hospitalization [3]. While established risk factors such as younger age, female sex, and specific needle characteristics are recognized [27], our findings highlight the critical, yet often overlooked, role of patient positioning during the procedure itself. Previous research has extensively covered the management of established PDPH, but a comprehensive meta-analytic exploration of optimal positioning during the initial lumbar puncture has been lacking. Our study addresses this evidence gap, offering practitioners an evidence-based perspective to inform their choice of position, moving beyond perceived ease of performing blocks in sitting versus lateral positions [28].

The physiological advantages underlying the lateral decubitus position's protective effect against PDPH are likely rooted in cerebrospinal fluid (CSF) pressure dynamics. The sitting position is associated with significantly higher CSF pressure (approximately 40 cm H₂O) compared to the lateral decubitus position (5-20 cm H₂O) [29]. This elevated pressure in the sitting position could exacerbate CSF leakage through the dural puncture site, potentially enlarging the defect. Moreover, the caudal displacement of brain matter and meninges, a well-recognized contributor to PDPH symptomatology, is hypothesized to be more pronounced in the sitting position, an effect that the lateral position appears to mitigate [30].

Despite these physiological advantages, the sitting position often remains preferred by anesthesiologists due to perceived patient comfort, higher perceived success rates in obese patients, and simpler anatomical landmark identification. In the obstetric population, concerns regarding aortocaval compression in the lateral decubitus position, which could compromise maternal cardiac output, have also historically favored the sitting position [31]. However, several trials have demonstrated comparable rates of hypotension between the two positions, challenging a key disadvantage often associated with sitting [32]. Conversely, the lateral decubitus position may offer benefits such as faster and enhanced sensory block spread [33], though it carries a theoretical risk of axillary and neurovascular compression.

Limitations and Certainty of Evidence

While the findings are robust in direction and initial magnitude, several important limitations necessitate a cautious interpretation and influenced our GRADE-based assessment of the evidence certainty, which we downgraded to low.

- **Publication Bias:** A significant concern for this meta-analysis was the presence of potential publication bias. Both the visual asymmetry in the funnel plot and a statistically significant Egger's test ($p = 0.005$) suggested an over-representation of studies with larger effect sizes, indicative of missing smaller studies with less favorable outcomes.
- **Attenuated Effect after Adjustment:** To address this, a trim-and-fill analysis was performed, which yielded an adjusted RR of 0.40 (95% CI 0.23–0.69). While still demonstrating a statistically significant reduction in PDPH, this attenuated effect size, coupled with an increased heterogeneity ($I^2 = 43.2\%$), underscores that the true magnitude of benefit might be more modest than initially suggested by the primary pooled estimate.
- **Methodological Limitations in Included Studies:** The certainty of evidence was further downgraded due to methodological shortcomings identified in several included studies through the Cochrane Risk of Bias 2.0 tool. Specific concerns included unclear allocation concealment, which could introduce selection bias, and the inherent lack of blinding for participants and personnel in studies involving positioning, which raised "some concerns" for performance bias. Subjective outcome assessment of PDPH by unblinded assessors also led to "some concerns" for detection bias. These factors collectively reduce our confidence in the precision of the effect estimate.
- **Scope of Outcomes and Unmeasured Heterogeneity:** Our meta-analysis focused solely on PDPH incidence, and did not evaluate other clinically relevant factors such as headache duration or the need for an epidural blood patch. Additionally, variations in post-puncture positioning protocols across studies were not fully accounted for, representing a source of unmeasured heterogeneity that could influence results.

- **Clinical Applicability vs. Preference:** Despite the evidence, the broad clinical applicability of the lateral decubitus position requires careful consideration given the widespread and often ingrained preference for the sitting position among anesthesiologists.

Future Research Directions

Acknowledging the limitations of small-study effects, potential publication bias, and methodological concerns, further high-quality, adequately powered RCTs are crucial. Future research should prioritize transparent reporting, standardized outcome definitions beyond PDPH incidence, and rigorous trial conduct to minimize bias. Investigations into additional influencing factors, such as needle type, operator experience, and precise post-puncture positioning protocols, are also recommended. Such trials are essential to confirm the true magnitude of the lateral decubitus position's effect and to inform definitive, evidence-based clinical recommendations for optimizing spinal anesthesia in obstetric patients.

Conclusion

This meta-analysis suggests that administering spinal anesthesia in the lateral decubitus position may reduce the incidence of post-dural puncture headache (PDPH) compared with the sitting position in obstetric patients undergoing Cesarean section. The direction of effect was consistent across all included randomized trials, and statistical heterogeneity was low to moderate.

However, the **certainty of the evidence is low**, primarily due to methodological limitations in several studies, including unclear allocation concealment, lack of blinding, and subjective outcome assessment (as per RoB 2.0 judgments). Furthermore, evidence of small-study effects and potential publication bias (Egger's test $p=0.005$) suggests an overestimation of the treatment effect. Adjustment for this bias attenuated the estimated relative risk from 0.29 to 0.40, indicating that while the benefit persists, its magnitude may be smaller than initially suggested.

Given these limitations, the findings should be interpreted cautiously. Nevertheless, the lateral decubitus position represents a simple and low-risk intervention that may be considered as part of a multifactorial approach to PDPH prevention. Future high-quality, adequately powered randomized controlled trials with rigorous methodology, including improved allocation concealment and standardized, objective outcome assessment, are required to confirm the true magnitude of this effect and inform definitive clinical recommendations.

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