

The Effect of PIEB vs CEI for Quality of Parturient Care and Neonatal Outcomes: A Comparative Review

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ABSTRACT: Epidurals are the gold standard for pain relief in labor analgesia worldwide. However, reports on the effects of PIEB compared to CEI on rescue bolus, motor block, and adverse effects remain unclear. This research paper aims to review the effect of PIEB and CEI on rescue bolus, motor block, and adverse effects. Existing literature found that there was an overall lower incidence of requirement for rescue bolus, similar levels of motor block, and either lower or no statistically significant difference in PIEB compared to CEI in terms of adverse effects. Additionally, higher maternal satisfaction was reported in PIEB compared to CEI. Overall, more research is needed to determine whether the results from the studies reveal a general trend or if one or two studies are outliers. Further research on the varying effects of PIEB and CEI can help healthcare suppliers improve pain relief for patients as well as long-term neonatal outcomes.

KEYWORDS: Health and Medicine, Labor Analgesia, Epidural, Programmed Intermittent Epidural Bolus (PIEB), Continuous Epidural Infusion (CEI).

■ Introduction

Approximately 135 million births occur annually worldwide.¹ Global epidural rates vary, but are usually lower in developing countries.² For example, China has an epidural rate of 30%,³ whereas for some developed countries like Finland, the rate can be as high as 83.4%.⁴ Continuous epidural infusion (CEI) is the traditional epidural method of use, where anesthesia is continuously dripped through a catheter inserted into the epidural space in the spine.⁵ CEI is associated with increased risk of hypertension, motor block, and numerous other complications, yet it remains the industry's standard.⁵ Perhaps this may contribute to the rapidly declining global fertility rate, with the drastic reduction of 5.31-2.25 live births/woman globally from 1963 to 2023.⁶ Thus, there has recently been a rise in research related to new epidural methods that aim to improve the quality of pain relief and minimize side effects.⁵

Programmed intermittent epidural bolus (PIEB) is a modern epidural method in which a fixed amount of anesthetic is administered to the patient at pre-programmed intervals using a computer-controlled pump.⁷ PIEB has been hypothesized to reduce rescue bolus (amount of analgesia required to reach pain relief), motor block (interruption of motor nerve fibers which allows for pain relief),⁸ and adverse effects (side effects incurred due to the analgesia) more than CEI.⁹ However, the exact effect on rescue bolus, motor block, and adverse effects between PIEB and CEI remains unclear.

Therefore, the primary purpose of this review is to compare the effects of PIEB versus CEI on rescue bolus, motor block, and adverse effects. The secondary aim of this review is to understand the effect of PIEB versus CEI on women of different parities across parities and maternal satisfaction. By thoroughly reviewing the existing literature surrounding modern epidural methods, this further educates providers on the effect of PIEB across parities, subsequently allowing patient anesthesia to be

better tailored to their unique needs and effectively relieving pain during labor and delivery.

■ Methods

Literature Search Strategy:

PubMed and Google Scholar were the databases used to search for existing literature for review. These databases were utilized from the 5th of October to the 11th of December 2025. Search terms used included "labor," "analgesia," "PIEB," "CEI," "rescue bolus," "motor block," "adverse effects," "parity," "compare," "multicenter," "randomized controlled trial," "quasi-experimental," and "maternal satisfaction."

After applying the search terms mentioned above, 38 studies were determined to be sufficient but required further review. Before screening, 3 duplicate research articles were removed. During the screening process, 28 papers were excluded due to the eligibility criteria. After eligibility criteria were met, 7 papers were included in the review (Figure 1).

Eligibility Criteria:

Randomized and quasi-experimental studies that included patients from obstetric populations who requested labor analgesia and agreed to take part in studies that compared continuous epidural infusions (CEI) and programmed intermittent epidural bolus (PIEB) were included in this review.

Additionally, eligible studies included women between 18 and 40 years of age, ≥ 37 weeks' gestation, with singleton pregnancies and cephalic presentation, without contradictions to labor analgesia. Studies included women with fetuses that had a healthy baseline fetal status (normal fetal heart rate, absence of decelerations, normal amniotic fluid, and good fetal movement). Lastly, only studies that directly compared the effect of PIEB and CEI on rescue bolus, motor block, and adverse effects were included.

Non-eligible studies included women with multiple gestation, preterm labor, non-cephalic presentation, unhealthy fetal baseline status, and contradictions to labor analgesia. Additionally, studies that did not directly compare the effect of PIEB and CEI on the effect of rescue bolus, motor block, and adverse effects were excluded.

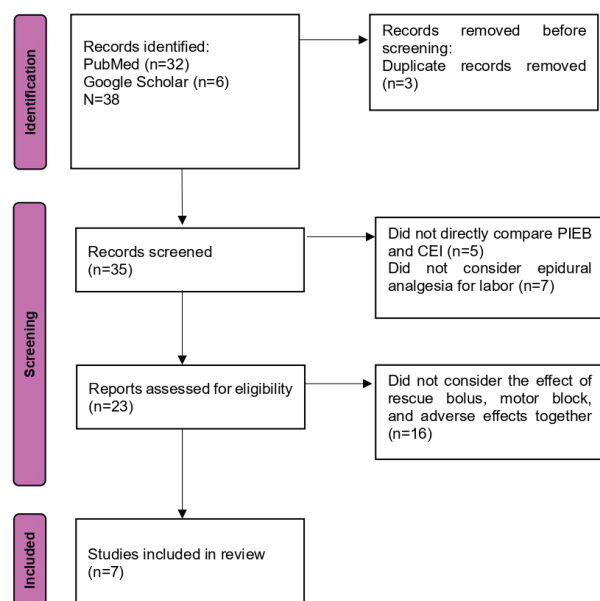


Figure 1: Review inclusion and exclusion criteria PRISMA flowchart. 38 records identified, 35 screened, 23 assessed for eligibility, and 7 studied were included in the review after screening.

■ Discussion

Rescue Bolus:

Dangers of Excessive Rescue Bolus:

Rescue bolus is the additional amount of labor analgesia required for pain relief to occur. Lower rescue bolus requirement is important for labor analgesia as it means pain relief can be achieved with lower analgesic consumption. This is cost-effective and minimizes potential adverse effects from the rescue boluses. For example, if high volumes of epidural analgesia are administered, it can lead to severe consequences such as stroke due to increased epidural pressure (ICP).¹⁰ This increase in ICP may rupture epidural blood vessels and nerve tissue, which could result in ischemia (reduced blood flow) of the cauda equina (nerve roots extending from the lower end of the spinal cord)¹¹ or distal spinal cord (lower spinal cord),¹² resulting in neurological deficits (CNS impairment) in patients.¹³

Requirement for Rescue Bolus:

Of the seven studies included in this review, six reported that PIEB reduced rescue bolus requirement more than CEI; however, whether this was statistically significant varied between studies.^{9,14-18} One study reported that CEI reduced rescue bolus requirement more compared to PIEB.¹⁹ For example, in 2011, Capogna and colleagues compared the effect of PIEB and CEI on labor analgesia in terms of incidence of motor block and labor outcomes.⁹ These researchers found that PIEB had a statistically significantly lower number of patient-controlled epidural analgesia (PCEA) boluses per patient and number

of patients requiring additional PCEA boluses ($p < 0.001$) compared to CEI.⁹ Additionally, in 2024 Ou and Chen investigated the amount of work in obstetrics anesthesia units between PIEB and CEI and found that PIEB had a statistically significantly lower proportion of patients (females about to give birth) that required unscheduled visits from healthcare professionals ((20.8% to 27.7%) ($p = 0.033$) (RR=0.69, 95% CI=(0.48-0.97)) compared to CEI (Table 1).¹⁵ Unscheduled visits are defined as “unplanned visits by healthcare staff to control issues outside routine scheduled checks” e.g., requirement for rescue bolus and side effects.¹⁵ Additionally, Haidl *et al.*, in 2022, investigated the effect of PIEB compared to CEI on labor analgesia using an adrenaline epidural solution and reported that the mean number of PCEA boluses required per patient was statistically significantly lower for PIEB compared to CEI (3.9 (SD 4.1) vs 1.9 (SD 2.0)) ($p < 0.001$).¹⁴ Lin *et al.*, in 2016, also investigated differences in PIEB and CEI as it relates to the safety of techniques for patients and neonates; the authors reported a statistically significantly lower requirement of PCEA rescue bolus in PIEB compared to CEI (1.27 ± 0.26 vs 5.71 ± 1.03) ($p = 0.00$).¹⁷ Lastly, Liu *et al.*, in 2020, determined the efficacy and safety of PIEB and CEI and found there was a statistically significant decrease in total rescue bolus requirement from PIEB compared to CEI ($p = 0.030$) (RR=0.61, 95% CI).²⁰ These studies all suggest a trend that the requirement for rescue bolus was statistically significantly lower in PIEB groups compared to CEI. However, a 2024 study by Kim *et al.* compared PIEB and CEI on the effects of the flow rates for labor analgesia and found that PIEB did not have a statistically significantly lower percentage of patients requiring rescue bolus (65.5% in PIEB vs 78.9% in CEI) ($p = 0.081$) compared to CEI.¹⁶ Furthermore, Wang *et al.*, in 2021, which compared PIEB and CEI for duration of labor, mode of delivery, side effects, and maternal satisfaction score, found a statistically significant difference in the number of patients who required PCEA bolus, with PIEB being higher than CEI (425 in PIEB vs 423 in CEI) (OR = 0.27, 95% CI=(0.14–0.51), $p < 0.0001$, $I^2 = 65\%$, p for heterogeneity = 0.01).¹⁹ This is the converse to the other studies, as in this case, PIEB required more rescue bolus compared to CEI. This key difference in results in the Wang *et al.* study¹⁹ may be because this study includes several variables that are not accounted for in the other studies and thus, evaluates the relationship between the amount of rescue bolus required and pain relief more thoroughly. Therefore, further research is required to understand whether this study was an anomaly of the trend or whether other studies do not have enough variables included in the analysis to detect accurate differences if they do exist. Overall, these findings show a consensus of reduced rescue bolus requirement with the use of PIEB compared to CEI.

Motor Block:

Impact of Motor Block on the Labor Experience:

Motor block occurs when labor analgesia temporarily blocks nerve signals to muscles, causing reduced or temporary immobility in the legs.²¹ This block targets specific spinal levels (e.g., T10-lower sacral nerve roots (S2-4)),²¹ which reduces

the patient's ability to push during labor as contractions of the abdominal and pelvic floor muscles are weakened, which could prolong the secondary stage of labor.²² Such weakened muscle contraction can be harmful to both the patient (more exhaustion and increased chance of instrumental delivery) and fetus (lower Apgar scores or shoulder dystocia).²³ Lower incidence of motor block is extremely important to prioritize due to its ability to improve the quality of the parturient's birth. By reducing motor block, this allows the patient to have more mobility and to find a comfortable birthing position, as well as being able to actively push out the fetus during the second stage of labor.²⁴

Incidence of Motor Block:

Of the seven papers referenced above, two found that PIEB had a statistically significantly lower incidence of motor block compared to CEI,¹⁵ one reported PIEB had a statistically significantly higher incidence of motor block compared to CEI,¹⁹ while four reported no statistically significant difference between the two methods of epidural analgesia for labor.^{14-16,17-20} For example, Capogna *et al.* found that PIEB had a statistically significantly lower incidence of motor block compared to CEI (2.7% vs 37%) (p<0.001) (OR=21.2, 95% CI=(4.9-129.3), HR=7.8, 95% CI=(1.9-30.8)) (Table 1).⁹ Additionally, Ou and Chen found there to be a statistically significantly lower incidence of motor block in PIEB compared to CEI (7.1% vs 2.1%) (p=0.03).¹⁵ Together, these results suggest that PIEB is more favorable compared to CEI in terms of minimizing the incidence of motor block. Conversely, Wang *et al.* found that PIEB was more prone to extensive motor block than CEI.¹⁹ However, Haidl *et al.* found that there was no statistically significant difference in motor block for PIEB compared to CEI at delivery.¹⁴ Similarly, Kim *et al.* reported there was no statistically significant difference in motor blockade between PIEB and CEI after 4 hours of labor analgesia (p=0.224).¹⁶ Furthermore, Lin *et al.* reported no difference in motor block for PIEB compared to CEI.¹⁷ Lastly, Liu *et al.* found that PIEB had a lower risk of motor blockade than CEI; however, these findings were not statistically significant. Thus, there was no statistically significant difference between PIEB and CEI for the risk of motor blockade (p=0.058) (95% CI = (0.19–1.03, RR=0.44) (Table 1).²⁰ Despite not being statistically significant, there was a 56% reduction in motor blockade, which may be due to over-adjustment of covariates, which may have adjusted away a possible true difference. Over-adjustment occurs when mediators are included, which results in biased results, usually towards the null. Therefore, the results of these 4 studies suggest that there is no statistically significant difference between PIEB and CEI usage in terms of the incidence of motor block. Overall, due to the varying reports of these studies, a larger, more in-depth multicenter study is needed to determine whether PIEB is associated with a higher, lower, or no statistically significant difference in motor block incidence than CEI.

Table 1: Characteristics of research articles included in the review.

Author(s)	Year of Publication	Country and Facility	Research Objective(s)	Key Findings
Capogna et al. ⁹	2011	Rome, Italy, Città di Roma Hospital	Compare the incidence of motor block and labor outcome in women who received PIEB or CEI for maintenance of labor analgesia.	Rescue bolus: PIEB had a lower number of PCEA boluses per patient and number of patients requiring additional PCEA boluses than CEI (p<0.001). Motor block: PIEB had lower motor block compared to CEI (2.7% vs 37%) (p<0.001) (OR=21.2, 95% CI=(4.9-129.3), HR=7.8, 95% CI=(1.9-30.8)). Adverse effects: None reported.
Haidl et al. ¹⁴	2022	Norway, Akershus University Hospital	Investigate the effect of programmed intermittent boluses using an epidural solution containing adrenaline.	Rescue bolus: Mean number of PCEA boluses required per patient was lower for PIEB compared to CEI (3.9±4.0 vs 1.9±2.0) (p<0.001). Motor block: No difference in motor block for PIEB compared to CEI at delivery. Adverse effects: No significant difference in need for anesthetic intervention. Maternal satisfaction: No statistically significant difference in maternal satisfaction between PIEB compared to CEI.
Ou and Chen ¹⁵	2024	Taipei, Taiwan, Kung Memorial Wu Ho-Su Hospital	Investigate the validity that PIEB may function as a feasible tool in reducing the amount of work in the obstetrics anesthesia units.	Rescue bolus: PIEB reduced proportion of parturients requiring unscheduled visits* compared to CEI from 27.7% to 20.8% (p=0.033) (OR=0.69, 95% CI=(0.45-0.97)). PIEB had a significant predictive value of maintenance for the probability of requiring unscheduled visits compared to CEI (p<0.01) (OR=0.53, 95% CI=(0.36-0.80)). Motor block: Lower incidence of motor block in PIEB compared to CEI (7.1% vs 12.1%) (p=0.03). Adverse effects: PIEB had a lower rate of episiotomy than CEI regardless of parity, 210 (92.5%) (p<0.01) compared to 159 (83.2%). Degree of perineal laceration lower in PIEB 2(2-3) for nulliparous women compared to CEI 3(2-3) (p<0.01), no difference for parous women. No difference in Apgar score at 1 and 5 mins for both PIEB and CEI for both parous and nulliparous women. Maternal satisfaction: Lmpaternal satisfaction in PIEB compared to CEI (p=0.003) (WMD=0.91).
Wang et al. ¹⁹	2021	Multiple Countries (systematic review and meta-analysis)	Compare the efficacy of PIEB with that of CEI with respect to the maintenance of epidural analgesia during labor, duration of labor, mode of delivery, side effects, and satisfaction score.	Rescue bolus: Different number of patients who require PCEA bolus, 425 in PIEB compared to 423 in CEI (OR=0.27, 95% CI=(0.14-0.51), p<0.0001, I ² =85%, p for heterogeneity=0.01). Motor block: PIEB was more prone to extensive motor block. Adverse effects: No difference in nausea, vomiting, need for norepinephrine therapy, and time to first. Lower Apgar score at 1 and 5 minutes for CEI compared to PIEB (WMD=0.07, 95% CI: 0.02-0.13, p=0.007, I ² =55%, p for heterogeneity=0.04). (WMD=-0.08, 95% CI=(-0.12--0.05, p<0.0001, I ² =21%, p for heterogeneity=0.27). Maternal satisfaction: Higher maternal satisfaction in PIEB compared to CEI (WMD=0.91, 95% CI=(0.42-1.39), p=0.0003, I ² =98%, p for heterogeneity<0.00001).
Kim et al. ¹⁶	2024	South Korea, Samsung Medical Centre	Compare the effects of epidural analgesics infused at different flow rates on labor analgesia	Rescue bolus: No difference in percentage of patients requiring rescue bolus between PIEB and CEI. Motor block: No difference in motor blockade 4h after labor analgesia induction. Adverse effects: Lower instrumental rate in PIEB compared to CEI (0 out of 29 vs 3 out of 28), 3 participants (2 in CEI and 1 in PIEB) complained of numbness in the lower extremities immediately after labor analgesia induction, they recovered within 1hr. No difference in Apgar scores at 1 and 5 mins for PIEB compared to CEI (WMD=0.07, 95% CI: 0.02-0.13, p=0.007, I ² =55%, p for heterogeneity=0.34). (WMD=-0.08, 95% CI=(-0.12--0.05, p<0.00001, I ² =21%, p for heterogeneity=0.27). Maternal satisfaction: No statistically significant difference in maternal satisfaction score between PIEB and CEI (9/8/10) in CEI compared to 9/8/10) in PIEB) (p=0.297).
Lin et al. ¹⁷	2016	China, Guangxi Medical University	Investigate whether there are any differences between CEI and programmed PIEB analgesia for the Chinese parturients undergoing spontaneous delivery and to further investigate the safety of these techniques for parturients and neonates.	Rescue bolus: Lower requirement of PCEA rescue bolus in PIEB compared to CEI (1.27±0.26 vs 5.71±1.03) (p=0.003). Motor block: No difference in motor block for PIEB and CEI. Adverse effects: Longer first and second stage labor in CEI compared to PIEB. No difference in labor instruments usage when compared with normal age. Apgar score at 1 minute in PIEB compared to CEI, and Apgar scores at 5 minutes was lower in PIEB compared to CEI but not statistically significant.
Liu et al. ²⁰	2020	Multiple Countries (meta-analysis)	Determine the efficacy and safety of PIEB and CEI for labor analgesia.	Rescue bolus: Decrease in total rescue bolus requirement from PIEB compared to CEI (p=0.030) (RR=0.61). Motor block: No difference in PIEB compared to CEI. Adverse effects: No difference in pruritus, nausea and vomiting, hypotension, shivering, fetal bradycardia, postpartum hemorrhage, intrapartum fever, perineal tears, and retained placental products between PIEB and CEI. Maternal satisfaction: Higher maternal satisfaction using PIEB compared to CEI.

Adverse Effects:

Risk of Adverse Effects:

Adverse effects are unintended side effects that negatively harm the physical or mental health of the parturient or infant.²⁵ These are important to consider as it allows healthcare professionals to conduct a risk-benefit analysis for the parturient and infant to consider whether the potential complications of using either epidural method outweigh the improved pain relief caused by it.²⁶

Impact on Adverse Effects:

Of the seven studies included, three found statistically significant differences in PIEB compared to CEI for adverse effects,¹⁵⁻¹⁹ while four found no statistically significant difference.^{9,14,17,20} Firstly, in 2024, Ou and Chen discovered that PIEB had a higher rate of episiotomy than CEI, regardless of parity, 210 (92.5%) compared to 159 (83.2%) (p<0.01).¹⁵ This suggests that PIEB is worse compared to CEI in terms of the occurrence of the adverse effect of an episiotomy. Conversely, the degree of perineal laceration was statistically significantly lower in PIEB 2(2-3) compared to CEI 3(2-3) (p<0.01) for nulliparous women but not statistically significantly the same for parous women, 2(2-2) (p=0.67).¹⁵ Together, these results indicate that PIEB results in fewer adverse effects in mothers compared to CEI after labor. However, in 2021, Wang *et al.* showed that there was no statistically significant difference in nausea, vomiting, need for norepinephrine therapy, and time to first passage of flatus or feces (p=0.06) when comparing PIEB to CEI.¹⁹

Additional adverse effects evaluated include numbness, duration of labor, and rate of instrumental delivery. For example, in 2024, Kim *et al.* reported a lower instrumental rate in PIEB compared to CEI (0 out of 29 vs 3 out of 28).¹⁶ Within this same study, of the 85 participants (PIEB=29, CEI=28, and manual=28), 3 participants (1 in PIEB and 2 in CEI) complained of numbness in the lower extremities immediately after labor analgesia induction, but all recovered within 4 hours.¹⁶ In 2011, Capogna *et al.* reported no difference in duration of labor between PIEB and CEI.⁹ Similarly, in 2022, Haidl *et al.* found there was no significant difference in need for anesthetic intervention between PIEB and CEI.¹⁴ Additionally, in 2016, Lin *et al.* found there to be no statistically significant difference in labor instrument usage when compared with normal age between the two epidural groups.¹⁷ Furthermore, there was not a statistically significant shorter first and second stage labor in PIEB compared to CEI (420.35 ± 20.29 vs 431.51 ± 19.09) ($p=0.75$) and (55.31 ± 9.71 vs) ($p=0.68$).¹⁷ Lastly, in 2020, Liu *et al.* discovered no statistically significant difference in pruritus ($p=0.703$, $RR=1.03$), nausea and vomiting ($p=0.435$, $RR=1.44$), hypotension ($p=0.084$, $RR=1.43$), shivering ($p=0.913$, $RR=0.98$), fetal bradycardia ($p=0.944$, $RR=1.04$), postpartum hemorrhage ($p=0.607$, $RR=0.73$), and intrapartum fever, perineal tears, retained placental products between PIEB and CEI.²⁰ Overall, these studies do not support the theory that PIEB is more favorable than CEI in terms of maternal adverse effects.

In addition to maternal adverse effects, epidurals can also result in neonatal complications. For example, in 2021, Wang *et al.* outlined how there were statistically significantly higher Apgar scores at 1 and 5 minutes for PIEB compared to CEI (WMD = 0.07, 95% CI: 0.02-0.13, $p=0.007$, $I^2 = 55\%$, p for heterogeneity = 0.04), (WMD = -0.08, 95% CI: (-0.12-0.05), $p < 0.00001$, $I^2 = 21\%$, p for heterogeneity = 0.27).¹⁹ Additionally, in Ou and Chen, both PIEB and CEI had the same non-statistically significant Apgar score at 1 and 5 minutes for both parous and nulliparous women. At 1 minute, nulliparous women had non-statistically significant Apgar scores of 8(8-9) ($p=0.82$), while multiparous women had average Apgar scores of 9(8-9) ($p=0.36$).¹⁵ Similarly, at 5 minutes, there was a nonstatistically significant average Apgar score of 9(8-9) for both nulliparous ($p=0.30$) and multiparous women ($p=0.49$).¹⁵ Lastly, in 2024, Kim *et al.* found the same non-statistically significant Apgar scores at 1 minute (PIEB=9(9,9), CEI=9(9,9), manual=9(9,9), $p=0.666$) and at 5 minutes (PIEB=10(9,10), CEI=10(10,10), manual=10(9,10), $p=0.798$).¹⁶ Also, there was no statistically significant difference in Apgar score at 1 minute in PIEB compared to CEI (8.62 ± 0.29 vs 8.57 ± 0.16) ($p=0.74$).¹⁷ Moreover, Apgar scores at 5 minutes were lower in PIEB compared to CEI (9.03 ± 0.18 vs 9.13 ± 0.16) ($p=0.06$).¹⁷ Together, these studies generally indicate that neither PIEB nor CEI is more favorable when considering the effect they have on neonatal Apgar scores. However, more research is needed to determine if this is true, given that the study did find there to be a statistically significant difference.

Overall, most of the studies indicated there was not a statistically significant difference in adverse effects in both groups,

suggesting either can be used when considering side effects for patients and the fetus. However, it is important to consider that most studies considered varying adverse effects, meaning it is difficult to directly compare the adverse effects in each study.

Further Explorations of Maternal and Fetal/Neonatal Adverse Effects of PIEB and CEI:

For this paper, the reviewed literature identified a larger number of maternal effects compared to fetal/neonatal (Table 2). However, the adverse effects on the fetus are critical as it can be directly impacted by the adverse effects of the mother.²⁷

An episiotomy is carried out to prevent perineal laceration.²⁸ Ou and Chen found that although there was a higher episiotomy rate using PIEB, there was ultimately lower severity of perineal lacerations amongst nulliparous women (Table 2).¹⁵ This suggests there are mixed effects on perineal trauma overall. Maternal discomfort can include nausea, vomiting, and itching, and can cause discomfort to the parturient and affect their birthing experience. There was no statistically significant difference in maternal discomfort, such as nausea, vomiting, and itching, in PIEB in both Wang *et al.* and Liu *et al.*^{19,20} This indicated similar rates of maternal discomfort in both. Norepinephrine therapy utilizes synthetic norepinephrine to maintain blood pressure in patients suffering from severe hypotension.²⁹ Wang *et al.* and Heidl *et al.* found no statistically significant difference between PIEB and CEI for norepinephrine therapy and anesthetic intervention, suggesting similar rates of clinically significant hypotension requiring intervention.^{14,19} Moreover, heightened duration of labor increases the likelihood of instrumental delivery, infections, and maternal exhaustion.³⁰ Wang *et al.*, Capogna *et al.*, and Lin *et al.* found no statistically significant difference between PIEB and CEI for time to first passage of feces and duration of first and second stage labor.^{9,17,19} Therefore, it can be concluded that there was a similar recovery of gastrointestinal function postpartum in both, and risks associated with longer labor in PIEB and CEI. Instrumental-assisted delivery can cause maternal pelvic injury, postpartum hemorrhage, and infection.³¹ Interestingly, while Kim *et al.* reported lower instrumental delivery rates with PIEB compared to CEI, Lin *et al.* found no statistically significant difference between PIEB and CEI.^{16,17} This may require further research to conclude whether PIEB has statistically significant benefits in relation to assisted delivery compared to CEI. Excessive postpartum hemorrhage increases blood loss, which results in hypotension.³² Liu *et al.* and Wang *et al.* both found that there was a statistically significant difference between PIEB and CEI.^{18,19} Thus, this indicates similar risks of severe maternal blood loss. High intrapartum fever can increase postpartum hemorrhage and, in severe cases, be fatal, even leading to organ failure.³³ Liu *et al.* found no significant difference between PIEB and CEI for intrapartum fever.¹⁸ In conclusion, while PIEB was associated with higher episiotomy but lower severity of perineal laceration and assisted deliveries, other maternal effects had no statistically significant difference between PIEB and CEI.

In terms of neonatal/fetal effects, fetal bradycardia refers to a sustained fetal heart rate below 110 bpm, which can lead

to hypoxic-ischemic injury and even severe acute hypoxia.³⁴ Liu *et al.* found no statistically significant difference between PIEB and CEI for fetal bradycardia, suggesting similar fetal cardiovascular safety profiles.¹⁸ Lastly, Apgar scores are a test performed on a neonate 1 and 5 minutes after birth. The 1-minute score determines how well the baby has tolerated the birthing process, while the 5-minute score exemplifies how the neonate is adapting to living outside the mother's womb.³⁵ Ou and Chen, Kim *et al.*, and Lin *et al.* found no statistically significant difference in Apgar scores at 1 and 5 minutes; however, Wang *et al.* reported slightly higher scores with PIEB compared to CEI.^{15-17,19} Overall, Apgar scores are similar in both PIEB and CEI. Conclusively, there is no large statistically significant difference in the neonatal/fetal effects of PIEB and CEI.

Table 2: Maternal and Fetal/Neonatal Adverse Effects of PIEB vs CEI.

	Adverse Effects	Studies	Definitive Conclusion
Maternal	Episiotomy/perineal laceration	Ou and Chen ¹⁵	PIEB was associated with higher episiotomy rate than CEI, but lower severity of perineal lacerations amongst nulliparous women.
	Nausea/vomiting/itching	Wang <i>et al.</i> , Liu <i>et al.</i> ¹⁹⁻²⁰	No statistically significant difference between PIEB and CEI.
	Norepinephrine therapy	Wang <i>et al.</i> , Haidl <i>et al.</i> ¹⁹⁻¹⁴	No statistically significant difference between PIEB and CEI.
	Anesthetist intervention		
	Time to first passage of faces	Wang <i>et al.</i> , Capogna <i>et al.</i> , Lin <i>et al.</i> ¹⁹⁻⁹⁻¹⁷	No statistically significant difference between PIEB and CEI.
	Duration of labor		
	Instrument assisted delivery	Kim <i>et al.</i> , Lin <i>et al.</i> ¹⁶⁻¹⁷	Kim <i>et al.</i> reported lower instrumental delivery rates with PIEB compared to CEI, Lin <i>et al.</i> found no statistically significant difference between PIEB and CEI.
	Blood pressure Hemorrhage	Liu <i>et al.</i> , Wang <i>et al.</i> ¹⁸⁻¹⁹	No statistically significant difference between PIEB and CEI.
Fetal/Neonatal	Intrapartum fever	Liu <i>et al.</i> ¹⁸	No statistically significant difference between PIEB and CEI.
	Fetal bradycardia	Liu <i>et al.</i> ¹⁸	No statistically significant difference between PIEB and CEI.
	Apgar scores	Wang <i>et al.</i> , Ou and Chen, Kim <i>et al.</i> , Lin <i>et al.</i> ¹⁵⁻¹⁶⁻¹⁷⁻¹⁹	Ou and Chen, Kim <i>et al.</i> and Lin <i>et al.</i> found no statistically significant difference in Apgar scores at 1 and 5 minutes, however Wang <i>et al.</i> reported slightly higher scores with PIEB compared to CEI.

Comparative Effect of PIEB and CEI on Maternal Factors and Outcomes:

Importance of Parity Stratification and Maternal Satisfaction:
Maternal satisfaction scores are a crucial indication of the quality of the labor experience for patients. These scores also allow the parturient to feel more included and that their opinion is valued. Furthermore, having a positive birth experience boosts self-esteem.³⁶ Conversely, low satisfaction may lead to increased risk of postpartum depression, anxiety, post-traumatic stress disorder (PTSD), and weakened mother-infant bonding.³⁷ Maternal satisfaction scores are usually collected through questionnaires, for example, the “Childbirth Experience Questionnaire (CEQ)” which contains 22 questions combining a 4-point Likert scale with a visual analog scale

(VAS) measured from 0-100 to determine the patient’s satisfaction with the labor and delivery process.³⁸

Parity refers to the number of pregnancies that reached 20 weeks’ gestation regardless of the outcome that a parturient has experienced.³⁹ Being able to separate maternal and labor outcomes based on parity (parity stratification) is important, as nulliparous women tend to have longer, more challenging labors as their cervix and pelvic tissues are undergoing the labor process, specifically stretching and opening, for the first time.⁴⁰ Furthermore, there is a lower risk of obstetric and sphincter injuries (OASIS) in multiparous compared to nulliparous women.⁴¹ Additionally, parous women usually have shorter lengths of labor, so having a mixed parity group and not stratifying by parity may skew conclusions and lead to an underestimation of the length of labor.⁴¹ Lastly, stratifying by parity allows the results of the study to be applied more specifically to all women, which makes the findings applicable to a larger demographic.

Effect on Maternal Outcomes and Parity Consideration:
Of the seven papers included, five papers reported maternal satisfaction,¹⁵⁻²⁰ while the remaining two did not.⁹⁻¹⁷ Firstly, in 2024, Ou and Chen discovered there was a statistically significantly higher maternal satisfaction in PIEB compared to CEI (p = 0.0003) (WMD = 0.91).¹⁵ Also, this is the only study that stratified adverse effects by parity.¹⁵ It was found that the degree of perineal laceration was lower in PIEB compared to CEI for nulliparous women but the same for parous women; however, these results were not statistically significant.¹⁵ Furthermore, both PIEB and CEI had the same Apgar score at 1 and 5 minutes for both parous and nulliparous women; however, these results were also not statistically significant.¹⁵ Moreover, in 2021, Wang *et al.* found a statistically significantly higher maternal satisfaction in PIEB compared to CEI (WMD = 0.91, 95% CI = (0.42–1.39), p = 0.0003, I² = 98%, p for heterogeneity < 0.00001).¹⁹ Lastly, in 2020, Liu *et al.* discovered that using CEI had lower maternal satisfaction compared to PIEB.²⁰ Together, these three studies indicate that PIEB is more favorable compared to CEI in terms of parturient satisfaction. However, in 2024, Kim *et al.* reported no statistically significant difference in maternal satisfaction score (9(8,10) in CEI compared to 9(9,10) in PIEB) (p=0.287).¹⁶ Additionally, in 2022, Haidl *et al.* found there was no statistically significant difference in maternal satisfaction between PIEB and CEI.¹⁴ Overall, the method to measure maternal satisfaction for each study must be considered, as well as the different preferences of patients regarding their labor experience, as this may explain the varying maternal satisfaction. Similarly, maternal satisfaction is subjective and cannot be quantitatively measured and accurately compared across studies, especially across studies conducted in different facilities and regions that have access to varying qualities of equipment and training.

Strengths and Limitations

This review offers a balanced and unbiased consideration of the compared effects of PIEB and CEI on the incidence of motor block, requirement for rescue bolus, and adverse effects.

This literature review addresses a key gap in labor analgesia literature. This is because no known literature reviews simultaneously offer information on the requirement for rescue bolus, incidence of motor block, adverse effects, and maternal satisfaction, as well as consider parity stratification. Furthermore, this review included two multicenter studies to improve reliability, as well as studies from multiple countries. This increases the generalizability of the findings to a larger geographical population. Additionally, this review included papers that stratified by parity to allow results to be applied to both parous and nulliparous women.

One of the limitations of this review is the limited number of studies included, this being largely because many studies failed to meet the eligibility criteria. This limits the scope of information that the review can consider, so a strong conclusion cannot be formed based on the limited evidence. Similarly, only one study stratified by parity, a secondary aim of this study, meaning researchers and providers may be wary of trusting the findings based on parity. Lastly, studies included were very heterogeneous and varied in the type of analgesia used, dosage, and point of labor at which it was administered, which makes the results difficult to compare.

Several methods were used to minimize the limitations. Firstly, the eligibility criteria were broadened to allow more research papers to be included. Additionally, to minimize heterogeneity, this review clearly stated the type of analgesia used, dosage, and point of labor at which it was administered. This helps emphasize that the results cannot be directly compared and only suggest a general trend.

■ Conclusion

Overall, labor analgesia is important to relieve pain during labor and delivery. Two common epidural methods are PIEB and CEI. Of the studies reviewed, 86% reported a rescue bolus, and 67% of the findings were statistically significant in terms of whether PIEB led to a higher or lower requirement for rescue bolus compared to CEI.^{9,14,19} There was an overall reduction in rescue bolus in PIEB compared to CEI, apart from one anomaly,¹⁹ which could be due to adjusting covariates. All papers reported the incidence of motor block (43% statistically significant) and adverse effects (43% statistically significant).¹⁵⁻¹⁹ Additionally, 71% reported secondary outcomes (maternal satisfaction or parity stratification), 60% of which were statistically significant.¹⁵⁻¹⁹ Furthermore, motor block was found to be lower in PIEB groups than CEI; however, the statistical significance of these findings varied. Similarly, adverse effects varied between statistically significantly higher in PIEB compared to CEI, as well as no statistically significant difference. Lastly, maternal satisfaction was either statistically significantly higher in PIEB compared to CEI, or there was no statistically significant difference between the two groups. Future studies should stratify by parity and be conducted over multiple facilities, and also choose only a few of the same adverse effects instead of a large range. Furthermore, future studies should avoid including indiscriminate variables by using a theory-driven approach instead to only identify the necessary confounders and minimize

overadjustment. Further education on PIEB compared to CEI can improve the quality of parturient care and neonatal outcomes.

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