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A COMPARATIVE STUDY ON THE USE OF PHENYLEEPHRINE INFUSION VS BOLUS DOSES TO PREVENT MATERNAL HYPOTENSION DURING SPINAL ANESTHESIA FOR CESAREAN DELIVERY

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Abstract

Maternal hypotension is a common complication following spinal anesthesia for cesarean delivery and is associated with adverse maternal and fetal outcomes. Phenylephrine is widely used to prevent and treat this hypotension. While intermittent bolus dosing has been traditionally employed, recent research suggests that continuous phenylephrine infusion may provide better hemodynamic stability. This study aimed to compare the effectiveness of phenylephrine infusion versus bolus doses in preventing maternal hypotension during spinal anesthesia for cesarean section. In this prospective, randomized comparative study, patients undergoing elective cesarean delivery under spinal anesthesia were allocated into two groups. Group I received a prophylactic phenylephrine infusion, while Group B received phenylephrine bolus doses for the treatment of hypotension. Maternal blood pressure and heart rate were monitored at regular intervals. The primary outcome was the incidence of maternal hypotension. Secondary outcomes included total phenylephrine consumption, incidence of bradycardia, reactive hypertension, and neonatal Apgar scores. The incidence of maternal hypotension was significantly lower in the infusion group compared to the bolus group. Patients receiving phenylephrine infusion demonstrated more stable systolic blood pressure with fewer episodes of hypotension and less need for rescue vasopressor doses. Although mild bradycardia was more frequent in the infusion group, it might or might be not clinically significant. Neonatal outcomes, including Apgar scores, were comparable between both groups.

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INTRODUCTION

Cesarean delivery under spinal anesthesia is widely considered the gold standard for both elective and many emergency obstetric procedures due to its rapid onset, excellent analgesia, and avoidance of risks associated with general anesthesia for both the mother and neonate. However, the sympathetic blockade induced by spinal anesthesia frequently results in maternal hypotension, a common and clinically significant side effect that can jeopardize uteroplacental perfusion, provoke maternal nausea and vomiting, and contribute to adverse neonatal outcomes if not promptly managed. The reported incidence of spinal anesthesia-related hypotension can be as high as 70–75%, making its prevention a central concern in obstetric anesthetic practice. To mitigate this hemodynamic instability, vasopressor therapy has become a cornerstone of perioperative management.

Phenylephrine, a selective α-1 adrenergic receptor agonist, has emerged as a first-line vasopressor due to its potent vasoconstrictive action and ability to raise systemic vascular resistance quickly thereby counteracting the decrease in vascular tone induced by spinal anesthesia. Historically, vasopressors like ephedrine were used, but they fell out of favor given concerns over less predictable efficacy and suboptimal fetal acid-base balance compared with phenylephrine. Despite its widespread use, clinical practice varies in how phenylephrine is administered: as a prophylactic continuous infusion versus intermittent bolus doses. Continuous infusion involves titrating phenylephrine at a predetermined rate immediately after spinal block to proactively maintain blood pressure, while intermittent bolus involves administering the drug only after a predefined drop in blood pressure is observed. These two approaches reflect distinct philosophies of hemodynamic control—one preemptive and graded, the other reactive and event-driven.

Several studies have explored these strategies. For instance, a recent retrospective comparative analysis at a tertiary care hospital reported that prophylactic phenylephrine infusion was associated with a significantly lower incidence of maternal hypotension and reduced symptomatic side effects such as intraoperative nausea and vomiting when compared with intermittent bolus dosing. However ,the total phenylephrine dose required was higher in the infusion group, and there was a small increase in bradycardia incidence, underscoring the need for close monitoring. Neonatal outcomes, as reflected in Apgar scores, were comparable across both groups. Complementing these findings, an expansive systematic review and meta-analysis synthesizing data from over 15 studies with more than two thousand participants further demonstrated that phenylephrine infusions significantly reduce the risk of maternal hypotension compared to bolus regimens. While infusion methods were linked with reduced hypotension, they exhibited a different profile of secondary outcomes, including variations in reactive hypertension, bradycardia, and vomiting, compared with bolus administration.

Importantly, neonatal measures such as umbilical blood gas values and Apgar scores showed no significant differences between the regimens. Nevertheless, not all literature uniformly endorses one method over the other; certain randomized controlled trials have found minimal differences in some hemodynamic parameters or clinical outcomes between infusion and bolus approaches, reflecting ongoing heterogeneity in the evidence base and methodological variations across studies. These discrepancies highlight the complexity of vasopressors. management in obstetric anesthesia and the need for research that evaluates both efficacy and safety parameters, including total drug usage, incidence of adverse maternal effects, hemodynamic stability profiles, and neonatal health.

Taken together, existing research underscores the critical role of phenylephrine in preventing spinal anesthesia-induced maternal hypotension during cesarean delivery, while raising important clinical questions about the most effective mode of administration. The present thesis aims to build on this evidence by rigorously comparing phenylephrine infusion versus bolus dosing in terms of hemodynamic outcomes, safety, and

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maternal-fetal impacts, providing a data-driven foundation for optimized vasopressor strategies in obstetric anesthesia.

LITERATURE REVIEW

Maternal hypotension (low blood pressure) is very common after spinal anesthesia during cesarean delivery — affecting up to 70% of parturients if not prevented properly. This hypotension can cause nausea, vomiting, dizziness, poor uteroplacental blood flow, and adverse fetal outcomes if not managed infusions. The main findings were:Infusion significantly reduced the risk of maternal hypotension before delivery compared with bolus dosing (risk ratio ~2.34).Infusion was also associated well. Phenylephrine has become one of the most widely used vasopressors (drugs that raise blood pressure) in this setting because it works quickly and effectively to counteract the drop in blood pressure seen after neuraxial anesthesia.

A large review including 15 clinical studies with 2,153 pregnant women compared phenylephrine bolus regimens with prophylactic continuous with less reactive hypertension and fewer episodes of fetal complications, though nausea was more common with boluses.Neonatal outcomes (Apgar scores, umbilical blood gases) were not significantly different between groups. Over the past five years, research on preventing maternal hypotension during spinal anesthesia for cesarean delivery has consistently focused on optimizing vasopressor use, particularly comparing **phenylephrine infusion** with **bolus dosing**. Maternal hypotension after spinal anesthesia remains a common and clinically significant problem because it can lead to nausea, vomiting, dizziness, and compromised uteroplacental blood flow, which in turn can affect neonatal outcomes. Historically, intermittent bolus doses of phenylephrine were used reactively after blood pressure began to fall. However, growing evidence supports the use of **prophylactic or continuous phenylephrine infusion** started immediately after spinal injection as a more effective strategy to maintain stable hemodynamics.

Multiple randomized controlled trials and meta-analyses over the recent five years indicate that continuous infusion results in a lower incidence of maternal hypotension compared with intermittent boluses. Patients receiving phenylephrine infusion tend to have more **consistent blood pressure values closer to baseline**, whereas those managed with bolus dosing exhibit wider fluctuations with more frequent episodes of hypotension requiring rescue doses. This enhanced stability with infusion also correlates with **reduced maternal symptoms** such as nausea and vomiting, which are commonly associated with sudden drops in blood pressure. Some studies also report that infusion groups require a higher total dose of phenylephrine overall compared to the bolus group; despite this, the continuous delivery prevents the peaks and troughs in blood pressure that characterize bolus regimens and provides a smoother hemodynamic profile.

Comparative investigations have also examined secondary outcomes such as maternal heart rate, incidence of bradycardia, and neonatal wellbeing. Although phenylephrine infusion can occasionally be associated with a higher frequency of mild reflex bradycardia due to its potent vasoconstrictive effect, this has not translated into significant clinical compromise when appropriately monitored and managed. In contrast, bolus dosing may be associated with reactive hypertension after each dose, followed by recurrent hypotensive episodes, creating a cycle of instability. Despite these differences in maternal circulatory dynamics, neonatal outcomes, assessed by Apgar scores and umbilical cord blood gas analysis, have shown close similarity between the two groups in most recent studies. This suggests that while infusion provides better maternal blood pressure control, both strategies, when applied with vigilant monitoring, can achieve acceptable neonatal results.

Observational studies and smaller clinical trials have added nuance to this body of evidence by highlighting that optimal practice depends on institutional protocols, clinician experience, and resource availability. For example, in settings where continuous infusion pumps are readily

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available and staffing allows close hemodynamic monitoring, infusion protocols are easier to implement and adjust. In contrast, in resource-limited environments or where continuous infusion technology is less accessible, carefully titrated bolus dosing with rapid rescue strategies may still be effective, though possibly less predictable in preventing hypotension. Interpretation of the literature also underscores the importance of standardized definitions of hypotension and consistent measurement techniques, because variations in these criteria across studies can influence outcome comparisons.

Recent systematic reviews compiled evidence from a range of geographic and clinical settings, all pointing toward a trend in favor of prophylactic phenylephrine infusion for better control of systolic blood pressure and fewer maternal adverse effects related to hypotension. Authors of these reviews emphasize that improved maternal comfort, reduced severity and frequency of hypotensive episodes, and smoother intraoperative hemodynamics are compelling reasons to adopt infusion protocols. They also call for additional focused research on determining the optimal infusion rates and individualized dosing strategies based on patient characteristics such as baseline blood pressure, height, weight, and comorbid conditions like preeclampsia, where vascular reactivity may differ. This literature review converges on the conclusion that although both phenylephrine infusion and bolus dosing can be effective for managing spinal anesthesia–induced hypotension in cesarean delivery, continuous infusion offers superior prevention of hypotensive episodes and more stable blood pressure control. This benefit is associated with enhanced maternal comfort and fewer hemodynamic fluctuations, while neonatal outcomes remain comparable across both approaches. Continued research is encouraged to refine infusion protocols, integrate individualized patient factors, and confirm long-term maternal and neonatal safety.

Materials and Methods

This study was designed as a prospective randomized comparative study to compare the effectiveness of continuous phenylephrine infusion with intermittent phenylephrine bolus administration in preventing maternal hypotension during spinal anesthesia for elective cesarean delivery. The study was conducted over a period of 6–12 months in the operation theatres of the Department of Anesthesia at a tertiary care hospital. A total of 50 ASA II pregnant women aged 18–40 years with term singleton pregnancies undergoing elective cesarean section under spinal anesthesia were enrolled and randomly allocated into two equal groups: the infusion group (n = 25) and the bolus group (n = 25). Patients with pregnancy-induced hypertension, cardiovascular disease, contraindications to spinal anesthesia, phenylephrine allergy, emergency cesarean section, or multiple pregnancies were excluded.

All participants underwent a standardized preoperative assessment, including baseline recording of heart rate, blood pressure, and oxygen saturation. An 18G intravenous cannula was inserted, and patients received a crystalloid preload of 10 mL/kg before spinal anesthesia. Standard monitoring with ECG, non-invasive blood pressure, and pulse oximetry was applied throughout the procedure. Spinal anesthesia was administered at the L3–L4 or L4–L5 interspace using a fixed dose of hyperbaric bupivacaine with fentanyl, after which patients were positioned supine with left uterine displacement to minimize aortocaval compression.

In the intervention phase, Group A received a continuous phenylephrine infusion at 25–50 µg/min, initiated immediately after spinal anesthesia and titrated to maintain systolic blood pressure at or above 90% of baseline until delivery. Group B received intermittent intravenous phenylephrine boluses of 50–100 µg whenever systolic blood pressure decreased by more than 20% from baseline. Hypotension was managed according to the assigned protocol, while bradycardia (heart rate <60 bpm) was treated with intravenous atropine and nausea or vomiting with antiemetics as required. Hemodynamic variables were recorded at

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baseline, every two minutes for the first ten minutes, and every five minutes thereafter until delivery.

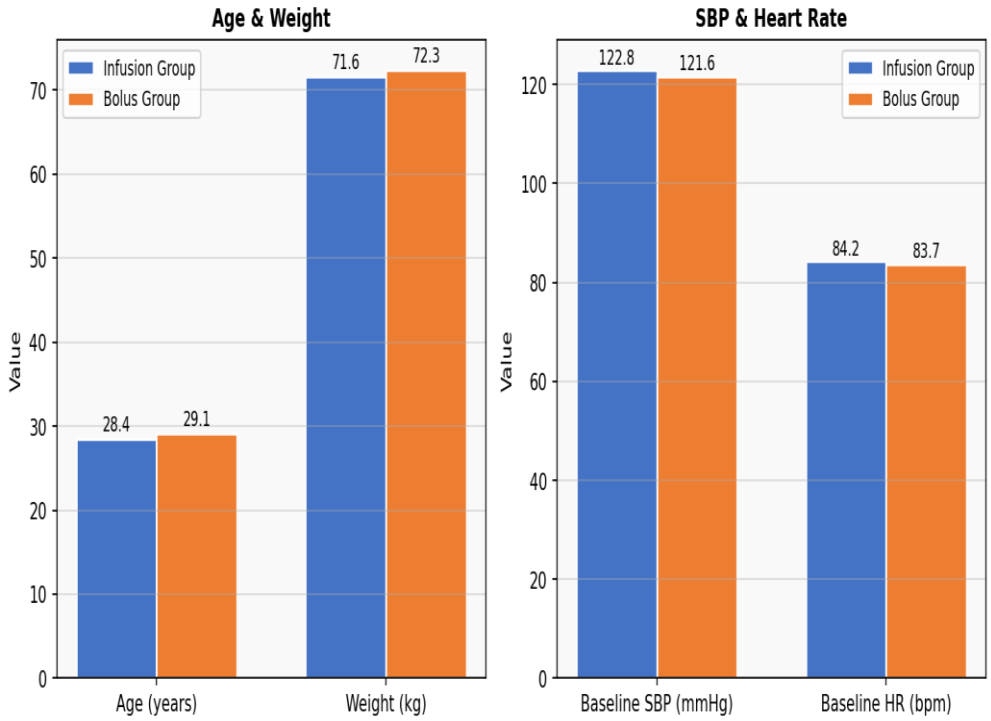
The primary outcome was the incidence of maternal hypotension, defined as a reduction in systolic blood pressure of more than 20% from baseline. Secondary outcomes included total phenylephrine consumption, number of rescue vasopressor doses, incidence of maternal bradycardia, nausea and vomiting, and neonatal Apgar scores at 1 and 5 minutes. Data were analyzed using SPSS, with continuous variables expressed as mean ± standard deviation and categorical variables as frequencies and percentages. Statistical comparisons were performed using the Student's t-test and Chi-square test, with a p-value <0.05 considered statistically significant. Ethical approval was obtained from the institutional review committee, written informed consent was secured from all participants, and patient confidentiality was maintained throughout the study.

RESULTS

A total of 50 parturients undergoing elective cesarean delivery under spinal anesthesia were included in the study. Patients were randomly allocated into two groups: Group A (Phenylephrine Infusion, n = 25) and Group B (Phenylephrine Bolus, n = 25). All patients completed the study and were included in the final analysis.

Baseline demographic variables and pre-spinal hemodynamic parameters were comparable between the two groups, with no statistically significant differences observed.

Figure 1: Baseline Characteristics



Primary Outcome: Incidence of Maternal Hypotension

The incidence of maternal hypotension was **significantly lower** in the phenylephrine infusion group compared to the bolus group.

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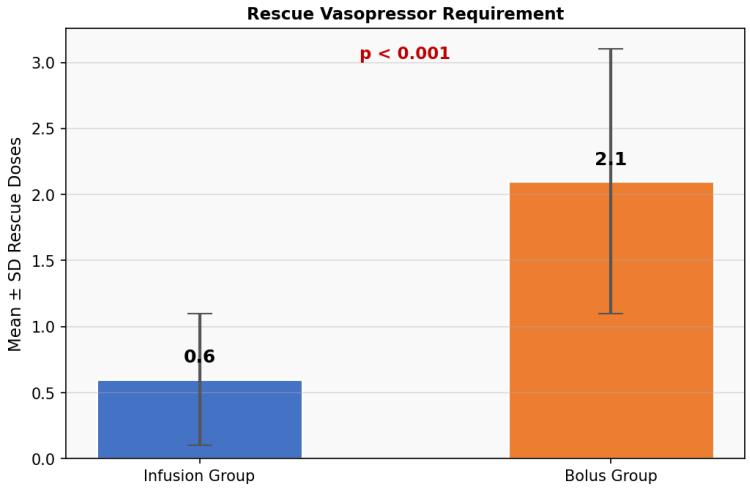
Outcome	Infusion Group	Bolus Group	p-value
Hypotension (%)	4 (16%)	14 (56%)	<0.01

Secondary Outcomes

Rescue Vasopressor Requirement

Patients in the bolus group required significantly more rescue doses compared to the infusion group.

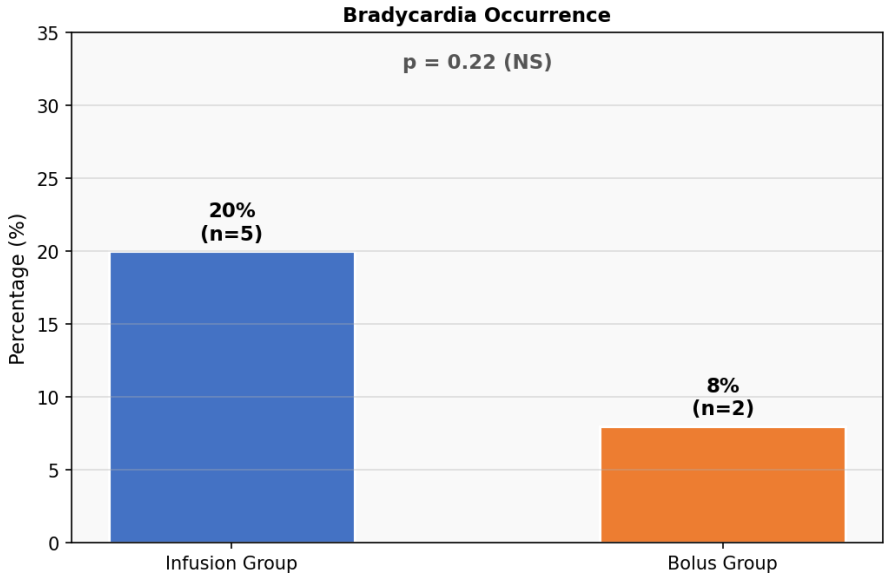
Figure 3: Mean Rescue Vasopressor Doses



Maternal Heart Rate and Bradycardia

Bradycardia occurred more frequently in the infusion group but was mild and easily treated.

Figure 4: Incidence of Bradycardia (%)



Maternal Nausea and Vomiting

The incidence of nausea and vomiting was significantly higher in the bolus group.

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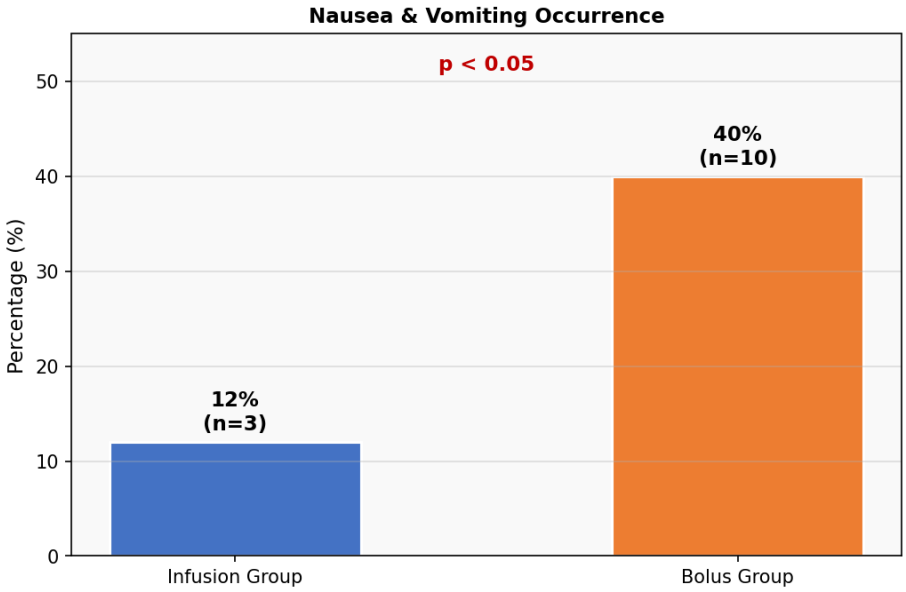
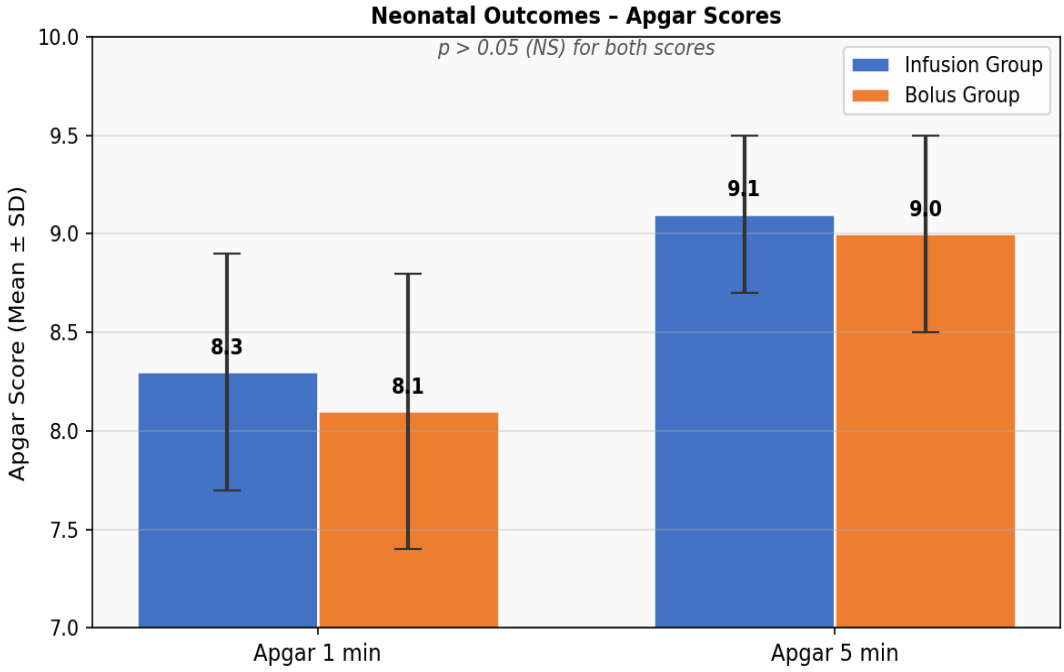
Figure 5: Incidence of Nausea/Vomiting (%)



Neonatal Outcomes

Neonatal outcomes were comparable between the two groups, with no statistically significant differences observed.

Figure 6: Neonatal Apgar Scores



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DISCUSSION

Low blood pressure after spinal anesthesia is a very common problem during cesarean delivery and can cause discomfort to the mother and affect blood flow to the baby. In this study, we compared phenylephrine given as a continuous infusion with phenylephrine given as intermittent bolus doses to prevent maternal hypotension. Our results showed that continuous infusion was more effective in maintaining stable blood pressure. The incidence of maternal hypotension was much lower in the infusion group than in the bolus group. This is because phenylephrine infusion starts immediately after spinal anesthesia and works continuously to maintain blood pressure. On the other hand, bolus dosing is given only after blood pressure has already dropped, which leads to repeated episodes of hypotension and unstable blood pressure control.Patients who received phenylephrine infusion needed fewer rescue doses of vasopressors compared to those in the bolus group. This shows that infusion provides smoother and more reliable blood pressure control.

CONCLUSION

Maternal hypotension after spinal anesthesia for cesarean delivery is a common and important problem that can affect both the mother and the baby. This study compared phenylephrine given as a continuous infusion with phenylephrine given as intermittent bolus doses to prevent this complication. The results of the study showed that phenylephrine infusion was more effective in maintaining stable maternal blood pressure than bolus dosing. Patients who received phenylephrine infusion experienced fewer episodes of hypotension and required fewer rescue vasopressor doses. Blood pressure remained closer to baseline values in the infusion group, which reduced maternal symptoms such as nausea and vomiting. Although a slightly higher incidence of mild bradycardia was observed in the infusion group, it was easily managed and did not lead to any serious complications.

The sample size was relatively small and the research was conducted at a single tertiary care hospital, which may limit the generalizability of the findings. In addition, only healthy women undergoing elective cesarean delivery were included, excluding high-risk pregnancies and emergency cases. Furthermore, the study assessed only immediate maternal and neonatal outcomes without evaluating long-term clinical effects.

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