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Original Research Article

Evaluating the Role of Intrathecal Fentanyl in Reducing Post-Dural Puncture Headache Among Parturient Undergoing Cesarean

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Abstract:

Background: Post-dural puncture headache (PDPH) is a frequent and distressing complication of spinal anesthesia in parturient patients undergoing cesarean section, causing discomfort and delaying recovery. Intrathecal fentanyl has been proposed as an adjunct to alleviate the incidence of PDPH.

Aim: To evaluate the role of intrathecal fentanyl in alleviating the incidence of PDPH among parturient patients undergoing cesarean section under spinal anesthesia.

Methodology: We conducted a prospective, randomized, double-blind trial in 100 ASA II parturient patients, randomized into two groups: Group F (n = 50) received 0.5% hyperbaric bupivacaine with 25 µg fentanyl; Group C (n = 50) received bupivacaine with saline. Subarachnoid block (SAB) was induced using a 25G Quincke needle. The patients were monitored for 72 hours post-operatively, then followed up every day until day 14, when we evaluated PDPH using the Visual Analogue Scale (VAS). Data was analyzed using Chi square and Student's T-test.

Results: Group F demonstrated a lower incidence of both mild (2% vs 6%) and moderate (0% vs 4%) PDPH than Group C. While the distribution, quality, and associated symptoms of headaches (nausea and vertigo, backache) was lower in Group F, these values did not reach statistical significance ($p > 0.05$).

Conclusion: There is potential that intrathecal fentanyl may reduce the severity and incidence of PDPH and suggest a potential protective effect as an adjunct to spinal anesthesia in parturient patients undergoing cesarean section.

Keywords: Post-Dural Puncture Headache, Spinal Anesthesia, Cesarean Section, Intrathecal Fentanyl, Bupivacaine.

Introduction

Subarachnoid block or spinal anesthesia is the most favored method of anesthesia during lower segment cesarean section (LSCS) since it results in rapid onset, intense motor and sensory blockades, minimum drug exposure to the fetus, and a high success rate. The technique continues to be both absolutely safe and exceedingly effective, and yet never without a complication. Some of the most common complications are hypotension, unilateral block, transient neurological symptoms, and post-dural puncture headache (PDPH). Some infrequent, yet clinically significant, untoward effects are backache, nausea, vomiting, vertigo, tinnitus, and blurring of vision [1]. Amongst the complications, post-dural puncture headache is one which causes the most frustration since it results in a lot of distress, a prolonged hospital stays, and interference in post-partum bonding between the infant and mother.

PDPH typically presents as a postural headache, which is intense frontal or occipital in character and worsens on sitting or standing and is relieved on recumbency. Neck stiffness, photophobia, nausea, tinnitus, and visual disturbances are associated symptoms and significantly deter parturients' quality of life. The prevalence among obstetric patients was significantly higher than in the general public, and was 0.3% to 20% in various reports, depending on the size and type of needles, and the patient groups and technical skill. The greater predisposition among obstetric patients is thought to be due to physiological changes during pregnancy, which include heightened intra-abdominal pressures, and

cerebrospinal fluid dynamics and pressures are altered.

The etiology of PDPH is multifactorial and incompletely understood. The most well accepted theory continues to be that involving leakage of CSF along the dural puncture tract, leading to intracranial hypotension. This in turn leads to compensatory vasodilation within the brain and traction on pain-sensitive meningeal structures, and headache results. In obstetric patients, additional intervening factors in the form of labour associated dehydration, acute postpartum changes in blood volume following delivery, and accidental dural puncture during epidural or spinal anaesthesia can predispose towards the development of PDPH [2]. Also, the size and type of the spinal needle, the multiple puncture efforts, and patient position during the procedure all come into play in fixing the incidence and severity of the complication.

Several techniques have been attempted in the prevention or treatment of PDPH, from non-pharmacological ones like adequate hydration, bed rest, and administration of caffeine to pharmacological ones like epidural blood patch, vasoconstrictors, and some drugs as theophylline or gabapentin. Amongst all, the use of opioids added to local anesthetics in SAB has been considered, besides in the enhancement of analgesia, also in the overall reduction in the incidence of PDPH. The administration of spinal opioids synergistically with local anesthetics enhances the quality of anesthesia and postoperative pain control without significantly enhancing motor block.

Fentanyl, a lipophilic opioid, has been popular as an adjuvant to local anesthetics in spinal anesthesia due to its quick onset of action, low cephalad spread in CSF, and positive side effect profile. Used in low doses, fentanyl augments sensory blockade, adds superior intraoperative analgesia, and extends the duration of effective anesthesia without significantly increasing the severity of adverse effects like respiratory depression or pruritus. Notably, there is evidence that the addition of intrathecal fentanyl results in a diminished incidence of PDPH, potentially by altering CSF dynamics, minimizing requirements for larger volumes of local anesthetics, and lessening dural tension [3]. This presents a double blessing in obstetric anesthesia: adding maternal comfort during surgery and potentially preventing one of the most feared postoperative complications.

In the scenarios involving cesarean sections, optimal pain management is essential, as suboptimal pain relief will distract the processes of maternal-infant bonding, breastfeeding, and psychiatric well-being in the mother. Even though bupivacaine on its own has been a staple in SAB in LSCS, added adjuvants like fentanyl could potentially achieve a better outcome, yet there is no consensus on the use of intrathecal fentanyl in the prevention of PDPH, solely in obstetric patients. The majority of the existing evidence thus far has been tilted towards its analgesic benefit rather than its use in the prevention of PDPH.

As a consequence of the high morbidity associated with PDPH, especially in parturient who are themselves physiologically compromised, it is critical that we establish effective and safe prevention methods. Towards this end, our investigation was designed as a basis upon which we could explore the role of intrathecal fentanyl as an adjuvant in SAB performed for cesarean section, and in particular whether it could be utilized in a specific role protecting against the development of PDPH. Through a comparative outcome measurement in a control arm receiving bupivacaine and in an experimental arm receiving bupivacaine and fentanyl, we aim to establish whether there exists a measurable degree of protection in the inclusion of intrathecal fentanyl against what is otherwise a debilitating outcome. Through the study, we intend, in particular, contribute towards optimizing in obstetric care anesthetic practice, and thereby increase the safety, comfort, and postpartum recovery in the parturient woman.

Methodology

Study Design: This study was designed as a prospective, randomized, double-blind, interventional clinical trial aimed at evaluating the role of intrathecal fentanyl in reducing the incidence of post-dural puncture headache (PDPH) among parturient undergoing cesarean section under spinal anesthesia.

Study Area: The study was conducted in the Department of Anesthesiology, Radha Devi Jageshwari Memorial Medical College and Hospital, Dr. Kalam Nagar, Manariya Chhajan, Turki, Muzaffarpur, Bihar, India.

Study Duration: The study was carried out over a period of one year.

Study Population: The study population consisted of parturient aged 18–45 years, classified as American Society of Anesthesiologists (ASA) grade II, who were scheduled for either elective or emergency cesarean section under spinal anesthesia.

Sample Size: A total of 100 parturient meetings the inclusion criteria were enrolled and randomly allocated into two groups of 50 each using a computer-generated random number table.

- Group F (Fentanyl group): Received 2.0 mL of 0.5% hyperbaric bupivacaine + 0.5 mL (25 µg) fentanyl intrathecally.
- Group C (Control group): Received 2.0 mL of 0.5% hyperbaric bupivacaine + 0.5 mL normal saline intrathecally.

Inclusion Criteria

Participants were included if they met the following criteria:

- Age between 18 and 45 years.
- ASA grade II physical status.
- Scheduled for elective or emergency cesarean section.
- Provided written informed consent for participation.

Exclusion Criteria

Parturient with any of the following conditions were excluded from the study:

- Pregnancy-induced hypertension or eclampsia.
- Neurological disorders or history of chronic headaches such as migraine.
- Anatomical deformities of the spine (e.g., scoliosis, lordosis).
- Body Mass Index (BMI) > 35 kg/m².
- Patients taking analgesic medications prior to surgery.
- Cases require more than one attempt for subarachnoid block (SAB).
- Known allergy to fentanyl or local anesthetics.

Procedure: Prior to the procedure, all parturient were pre-anesthetically checked. On the day of surgery, an 18G intravenous (IV) cannula was inserted for IV access, and all patients received Ringer Lactate solution pre-loading at 10 mL/kg. Metoclopramide 10 mg IV was given in premedication. All parameters were monitored (ECG, NIBP, HR and SpO_2) and recorded throughout using a multiparameter monitor (Mindray iPM10).

Spinal anesthesia was performed under strict aseptic precautions in the sitting position of the patient. The L3-L4 interspace was identified, and a midline approach was utilized, with a 25-gauge Quincke spinal needle with the bevel in the lateral position inserted. Free flow of cerebrospinal fluid (CSF) was confirmed, and the study drug was injected intrathecally according to allocation to the group. The spinal needle was then withdrawn with the stylet in situ to reduce the risk of PDPH.

All parturient were monitored in the hospital for 72 hours and was followed up via telephone until the fourteenth postoperative day. If a patient reported that they had developed a headache, further information about the headache was collected, including the time of onset, duration, character, factors aggravating and relieving the headache, as well as any associated symptoms including backache, vertigo, nausea, vomiting, or pruritic sensation. The intensity of headache was assessed via the Visual Analogue Scale (VAS). For subjects that developed PDPH, treatment included conservative management consisting of adequate hydration, caffeinated beverages, and oral paracetamol (500 mg) as needed.

Data Collection and Management: Data were methodically collected with a structured proforma developed for the study. Included were demographic information, intraoperative notation, postoperative follow-up, headache incidence and characterizations, VAS, and complications. All patient data were de-identified with a coding system before using it to maintain confidentiality. All data were stored securely, and only the members of the research team had access to the stored data. The research team members carried out regular checks to complete, and accurate patient data were compiled before commencement of statistical analysis.

Statistical Analysis: Data collected were entered into Microsoft Excel and analyzed with SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables and IV numbers are summarized as mean ± standard deviation (SD), and categorical variables are summarized as frequencies and percentages. The Chi-square test was utilized with categorical data to compare PDPH incidence and the student's T-test was used for continuous variables such as VAS scores. In all analyses, p-value < 0.05 was considered statistically significant. Statistical interpretations as to the efficacy of the intrathecal fentanyl in preventing PDPH in parturient undergoing cesarean section was performed."

Result

Table 1 shows the demographic profile of the study participants in both groups. The mean age of patients in Group F was 25.16 ± 3.82 years, which was comparable to Group C with a mean age of 25.10 ± 4.14 years. The mean body weight was slightly lower in Group F (57.01 ± 6.45 kg) compared to Group C (57.91 ± 6.04 kg). Similarly, the mean height was 155.07 ± 2.91 cm in Group F and 155.79 ± 5.60 cm in Group C. These findings indicate that both groups were demographically comparable, minimizing the risk of confounding variables.

Table 1: Demographic Profile

	Group F (Mean ± SD)	Group C (Mean ± SD)
Age (yr)	25.16 ± 3.82	25.10 ± 4.14
Weight (kg)	57.01 ± 6.45	57.91 ± 6.04
Height (cm)	155.07 ± 2.91	155.79 ± 5.60

Table 2 summarizes the characteristics of post-dural puncture headache (PDPH) among the study participants. In terms of severity, moderate PDPH (VAS 4–7) was reported in 2 patients (4%) in Group C, while no cases were observed in Group F. Mild PDPH (VAS ≤ 3) occurred in 3 patients (6%) in Group C compared to 1 patient (2%) in Group F, while no severe cases (VAS > 7) were reported in either group. Regarding the site of headache, frontal headaches were seen in 3 patients (6%) in Group C and 1 patient (2%) in Group F, whereas generalized headaches were reported in 2 patients (4%) in Group C and none in Group F. For headache quality, dull aching headaches were more frequent, affecting 5 patients (10%) in Group C and 1 patient (2%) in Group F, with no throbbing headaches reported in either group. Among associated symptoms, nausea/vomiting occurred in 3 patients (6%) and backache in 3 patients (6%) in Group C, while vertigo was noted in 1 patient (2%); none of these symptoms were observed in Group F. Overall, the incidence of PDPH and its related symptoms was higher in Group C compared to Group F, though the differences were not statistically significant (p > 0.05).

Table 2: Post Dural Puncture Headache

Characteristics of PDPH	Group C No. of Patients (%)	Group F No. of Patients (%)	p value
Severity			
Severe (VAS > 7)	0 (0%)	0 (0%)	-
Moderate (VAS 4 - 7)	2 (4%)	0 (0%)	0.15
Mild (VAS ≤ 3)	3 (6%)	1 (2%)	0.31
Site			
Generalized	2 (4%)	0 (0%)	0.31
Frontal	3 (6%)	1 (2%)	0.31
Quality			
Throbbing	0 (0%)	0 (0%)	-
Dull aching	5 (10%)	1 (2%)	0.098
Associated Symptoms			
Pruritus	0 (0%)	0 (0%)	-
Nausea/Vomiting	3 (6%)	0 (0%)	0.3
Vertigo	1 (2%)	0 (0%)	0.3
Backache	3 (6%)	0 (0%)	0.31

Discussion

The findings in our research indicated a tendency towards less post-dural puncture headache (PDPH) and associated symptoms in the intrathecal fentanyl group (Group F) than the control group (Group C), but without statistical significance. The mean demographic profile, age, weight, and height were similar between groups and thus indicate low confounding by the parameters. Specifically, the mean age in Group F was 25.16 ± 3.82 and in Group C 25.10 ± 4.14, respectively, the mean weight was 57.01 ± 6.45 compared with 57.91 ± 6.04, and the mean height was 155.07 ± 2.91 compared with 155.79 ± 5.60, respectively. Similarity in baseline characteristics in our research is in line with others in matching participant demography well in an effort to eliminate bias in outcome (Ali et al., 2020; Irzafeldi & Choy, 2013) [4, 5].

In relation to the occurrence of PDPH, we did not find any patient in Group F developed moderate or severe headache, 4% in Group C developed moderate PDPH (VAS 4–7), and 6% developed mild PDPH (VAS ≤ 3) in comparison with 2% in Group F. These results are in line with Ali et al. (2020) [4], which noted that intrathecal fentanyl reduced the severity of PDPH but did not significantly differ in overall incidence. Accordingly, Irzafeldi and Choy (2013) [5] observed a reduction in headache intensity with the addition of opioids in local anesthetics, in line with the proposal that intrathecal opioids could potentially alleviate symptoms without completely preventing the development of PDPH. The tendency toward lower headache frequencies and lower intensity within the present investigation points toward the potential analgesic benefit in the administration of fentanyl, ostensibly a reflection on its central action on presynaptic and postsynaptic opioid receptors, as noted previously by Brinser et al. (2019) and Cohen et al. (1994) [6,7].

The frequency and severity of headaches in our study were predominantly dull, aching and frontal, and no throbbing was noted in the patients. Fewer cases of generalized and frontal headaches were noted in Group F compared with the control group, a comparable finding by Oberoi et al. (2009) and Martlew (2009) [1,8], that opioid inclusion in the spinally administered anesthetics does not only increase analgesia but also diminishes headache pain. The statistical significance was, however, not achieved in our study, in spite of a trend in the results, which indicate a clinical advantage in the application of fentanyl with local anesthetics, in particular a diminution in the severity of PDPH.

Our investigation also assessed associated symptoms, including nausea, vomiting, vertigo, pruritus, and backache. Group F exhibited all lower incidences in all symptoms: nausea and vomiting occurred in 6% in Group C compared with none in Group F, vertigo in 2% compared with none, and backache in 6% compared with none, although all associated p-values remained greater than 0.05. These findings are in accord with previous work establish that intrathecal opioids, and in particular fentanyl, suppress visceral pain and attenuate postoperative nausea and vomiting (Barash et al., 2013; Acar et al., 2010) [2,9]. However, morphine, effective in analgesia, is more characteristically associated with pruritis and nausea and would therefore account for lower side effect profile in our fentanyl group (Yetkin & Demirkiran, 2021) [10].

There are certain mechanistic rationales in support of our results. Intrathecal fentanyl enhances local anesthetic activity by combining with opioid receptors in the spinal cord, leading to hyperpolarization and inhibition in nociceptive transmission (Brinser et al., 2019; Ali et al., 2020) [6,4]. Furthermore, systemic opioid absorption, although a minor contributor, would be responsible for modest reductions in headache severity, as suggested by a previous post comparing various doses of intrathecal opioids (Peralta et al., 2020) [11]. Our findings of severity reduction in PDPH and associated symptoms, despite a lack of statistical significance, establish clinical relevance in opioid adjuncts in neuraxial anesthesia.

In comparison with other work, similarities and contrasts are observed. Ali et al. (2020) and Irzafeldi and Choy, 2013, [4, 5] observed similar reductions in severity of PDPH, but without clinically significant changes in incidence, validating trends in our study. Some, however, as in Yetkin and Demirkiran, 2021, have observed a dose-dependent reduction in frequency of PDPH with larger doses of intrathecal opioids, something we did not test, and thus possibly responsible for a lack of statistically significant results. Variability in gauge of needle, regimen of patient hydrations, and BMI in different studies also could be responsible for different incidences in PDPH as observed in the literature, with different results observed by Oberoi et al., 2009, and Martlew, 2009, respectively, [1, 8].

The study shows that the administration of intrathecal fentanyl as part of local anesthetics in elective cesarean deliveries could lower the incidence of severe PDPH and symptoms, but the overall incidence was statistically nonsignificant. Trends in the study are in agreement with prior literature in confirming the symptom-modifying and analgesic role of spinal opioids. The results present a point requiring larger samples and stratification by potential confounders, including opioid dose, needle size, and patience, in order to refine the contribution of intrathecal fentanyl administration in preventing PDPH.

Conclusion

The study showed that the use of intrathecal fentanyl in an intrathecal needle (spinal) approach for cesarean section may have a protective effect on the incidence and severity of post-dural puncture headache (PDPH). Everyone in both groups were demographically similar, which suggests that the differences in outcomes are likely because of the intrathecal fentanyl intervention and likely not patient demographics/characteristics. Patients experiencing PDPH reflected fewer instances of mild headache and moderate headache in those who received intrathecal fentanyl. More importantly, the distribution and quality of headaches, as well as the symptoms of nausea, vertigo and backache were all generally lower in those who received intra-thecal fentanyl. No severe headache was seen in either group; however, the involvement of intrathecal fentanyl was associated with fewer instances of mild and moderate PDPH. These results encourage the consideration of using intrathecal fentanyl as an adjunct to spinal anesthesia for a cesarean section to improve immediate postoperative comfort and effectively reduce the overall burden of PDPH amongst parturient.

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