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Original Research Article

A Comparative Study of Intravenous Patient-Controlled Analgesia Using Morphine versus Fentanyl, with and without Background Infusion, in Patients Undergoing Major Spine Surgery

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Abstract

Background: Postoperative pain following major spine surgery is often severe and requires effective analgesic strategies to facilitate early recovery and improve patient outcomes. Intravenous patient-controlled analgesia (IV-PCA) is widely used for postoperative pain management, and many regimens include a continuous background infusion to maintain stable analgesia. However, the routine use of background infusion remains controversial due to concerns regarding increased opioid consumption and opioid-related adverse effects, with limited evidence specific to spine surgery patients. Objective- To compare postoperative opioid consumption, pain intensity, rescue analgesic requirement, opioid-related adverse effects, and IV-PCA discontinuation rates between IV-PCA with and without background infusion in patients undergoing major spine surgery.

Materials and Methods: This hospital-based prospective observational comparative study included 240 adult patients undergoing elective major spine surgery under general anesthesia. Patients were allocated into two groups: IV-PCA with background infusion (basal group, n = 120) and IV-PCA without background infusion (no-basal group, n = 120). IV-PCA was administered using morphine or fentanyl according to institutional protocol. Postoperative pain was assessed using the Numeric Rating Scale at rest and for maximum pain during the first 24 hours and 24–48 hours. Total opioid consumption via IV-PCA, requirement for rescue analgesics, opioid-related adverse effects, and IV-PCA discontinuation were recorded over the first 48 postoperative hours.

Results: Baseline demographic and perioperative characteristics were comparable between the two groups. Total opioid consumption during the first 24 hours, 24–48 hours, and overall 0–48 hours postoperatively was significantly higher in the basal group compared to the no-basal group ($p < 0.05$). Postoperative pain scores and rescue analgesic requirements were similar between the groups ($p > 0.05$). Opioid-related adverse effects, particularly nausea, vomiting, and sedation, as well as IV-PCA discontinuation due to side effects, were significantly more frequent in the basal group ($p < 0.05$).

Conclusion: IV-PCA without background infusion provides comparable postoperative analgesia with lower opioid consumption and fewer opioid-related adverse effects compared to IV-PCA with background infusion in patients undergoing major spine surgery. Demand-only IV-PCA may represent a safer and equally effective analgesic strategy in this population.

Keywords: Background Infusion, Intravenous Patient-Controlled Analgesia, Major Spine Surgery, Opioid Consumption, Postoperative Pain.

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Introduction

Postoperative pain following major spine surgery is often severe due to extensive soft tissue dissection, muscle retraction, bony manipulation, and instrumentation. Inadequate pain control in these patients can result in delayed mobilization, impaired pulmonary function, prolonged hospital stay, and reduced patient satisfaction [1,2]. Effective postoperative analgesia is therefore a critical component of perioperative care in spine surgery. Intravenous patient-controlled analgesia (IV-PCA) is a widely used modality for managing moderate to severe postoperative pain. IV-PCA

allows patients to self-administer opioids within predefined limits, providing individualized analgesia and improving patient satisfaction compared with conventional, nurse-administered opioid regimens [3,4]. Morphine and fentanyl are the most commonly used opioids for IV-PCA because of their proven efficacy and predictable pharmacokinetics.

Traditionally, IV-PCA regimens have often included a continuous background (basal) infusion in addition to patient-controlled bolus doses, with the intent of maintaining stable plasma opioid concentrations and preventing breakthrough pain. However, the routine use of basal infusion has been increasingly questioned. Several studies and systematic reviews have demonstrated that the addition of a basal infusion does not consistently improve analgesic efficacy when compared with demand-only PCA, while it may significantly increase total opioid consumption and the incidence of opioid-related adverse effects such as postoperative nausea and vomiting, sedation, and respiratory depression [5–7].

Macintyre and colleagues emphasized that basal infusion may increase the risk of opioid-induced respiratory depression, particularly in opioid-naïve adult patients, without providing clear additional analgesic benefit [6]. Similarly, a Cochrane systematic review comparing patient-controlled opioid analgesia with conventional opioid administration reported that although PCA improves patient satisfaction, background infusion does not confer additional advantages and may increase adverse effects [4]. Meta-analyses have further shown that basal infusion is associated with a higher risk of respiratory events in adults receiving IV-PCA [7,8].

Despite this evidence, clinical practice regarding basal infusion remains variable, and many institutions continue to use background infusion based on traditional protocols rather than robust evidence. Importantly, data specifically evaluating IV-PCA with and without background infusion in patients undergoing major spine surgery are limited. Spine surgery patients represent a distinct subgroup with unique analgesic requirements and potential vulnerability to opioid-related respiratory complications due to prolonged anesthesia, prone positioning, and postoperative immobility [9,10].

Given the lack of consensus and the limited spine-specific evidence, further prospective evaluation of IV-PCA regimens with and without background infusion in major spine surgery is necessary. Therefore, this study was conducted to compare postoperative opioid consumption, pain intensity, rescue analgesic requirement, opioid-related adverse effects, and IV-PCA discontinuation rates between intravenous patient-controlled analgesia with and without background infusion in adult patients undergoing major spine surgery.

Materials and Methods

This hospital-based prospective observational comparative study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. The study was carried out in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and adhered to the principles of the Declaration of Helsinki.

Total of 240 adult patients undergoing elective major spine surgery under general anesthesia at tertiary care facility, Rajasthan during for study period of 18 months were prospectively enrolled. Major spine surgeries included cervical, thoracic, and lumbar spinal procedures such as decompression, instrumentation, fusion, and deformity correction surgeries. Patients aged 18 years and above who received intravenous patient-controlled analgesia (IV-PCA) for postoperative pain management were included. Patients requiring postoperative intensive care unit admission, those receiving epidural or regional analgesia, patients with known opioid allergy or intolerance, chronic opioid dependence, cognitive impairment preventing PCA use, or incomplete records were excluded from the study.

Postoperative pain management was supervised by the Acute Pain Service (APS) team, which assessed patients at regular intervals until postoperative day 2. Demographic variables, including age, sex, and body mass index, along with surgical details such as type and duration of surgery, were prospectively recorded. Pain intensity at rest and the maximum pain experienced during the preceding 24 hours were assessed using an 11-point Numeric Rating Scale, where 0 indicated no pain and 10 indicated the worst imaginable pain. Total opioid consumption through IV-PCA, requirement for rescue analgesics, and the occurrence of opioid-related adverse effects such as postoperative nausea and vomiting, sedation, dizziness, pruritus, and respiratory depression were documented. Discontinuation of IV-PCA and the reasons for discontinuation were also recorded. Temporary interruption of PCA due to adverse effects followed by resumption was not considered permanent cessation.

240 patients were allocated into two groups (120 in each group) based on the IV-PCA regimen used for postoperative analgesia. The basal group received IV-PCA with a continuous background infusion, while the no-basal group received IV-PCA without background infusion and relied solely on patient-controlled bolus doses. IV-PCA was prepared using

either morphine or fentanyl in accordance with institutional protocols and at the discretion of the attending anesthesiologist, taking into account patient age, body weight, and comorbid conditions. Bolus dose and lockout intervals were standardized for both groups, and PCA settings were not altered by the APS team based on pain scores during follow-up. A programmable electronic infusion pump was used for IV-PCA delivery in all patients.

General anesthesia was administered using standard institutional protocols with inhalational anesthetic agents or total intravenous anesthesia with propofol. Intraoperative analgesia was provided using remifentanil infusion, titrated to maintain hemodynamic parameters within acceptable limits. Neuromuscular blockade was achieved with rocuronium. Prophylaxis for postoperative nausea and vomiting was administered according to institutional practice. There were no changes in anesthetic or perioperative management protocols during the study period.

Additional data collected included American Society of Anesthesiologists physical status, preoperative opioid use, estimated blood loss, postoperative oxygen supplementation, and episodes of hypoxemia, defined as oxygen saturation below 90% within the first 48 postoperative hours. The administration and frequency of rescue analgesics during the first 24 hours and between 24 and 48 hours postoperatively were also recorded.

The primary outcome measure of the study was total opioid consumption via IV-PCA during the first 24 hours and between 24 and 48 hours after surgery. Secondary outcome measures included postoperative pain scores, requirement and frequency of rescue analgesic administration, incidence of opioid-related adverse effects, and the rate and reasons for IV-PCA discontinuation.

Statistical Analysis

Statistical analysis was performed using Microsoft Office 365. The normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous data were expressed as mean and standard deviation or median with interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages.

Comparisons between the basal and no-basal groups were made using the independent t-test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. Multivariable regression analysis was performed to adjust for potential confounding factors such as age, body mass index, and duration of surgery, ASA physical status, and type of opioid used in IV-PCA. A two-sided p-value of less than 0.05 was considered statistically significant.

Results

[Table-1] In the present study, the baseline demographic and perioperative characteristics were comparable between the basal infusion group and the no-basal infusion group. There was no statistically significant difference between the two groups with respect to age, sex distribution, body mass index, ASA physical status, type of spine surgery, or duration of surgery ($p > 0.05$ for all parameters), indicating that both groups were well matched at baseline.

[Table- 2] In this study, patients in the basal infusion group consumed a significantly higher amount of opioids via IV-PCA compared to the no-basal infusion group during the first 24 hours, 24–48 hours, and the overall 0–48 hour postoperative period. The differences in opioid consumption between the two groups were statistically significant at all time intervals ($p < 0.05$).

[Table- 3] Postoperative pain scores assessed using the Numeric Rating Scale at rest and maximum pain intensity during both the 0–24 hour and 24–48 hour postoperative periods were comparable between the basal infusion and no-basal infusion groups. No statistically significant difference in pain scores was observed between the two groups at any assessed time point ($p > 0.05$).

[Table- 4] The proportion of patients requiring rescue analgesia and the number of rescue analgesic doses administered during the first 24 hours and between 24–48 hours postoperatively were similar in both groups. The differences in rescue analgesic requirement between the basal infusion and no-basal infusion groups were not statistically significant ($p > 0.05$).

[Table- 5] In this study, the incidence of opioid-related adverse effects such as nausea, vomiting, and sedation was significantly higher in the basal infusion group compared to the no-basal infusion group ($p < 0.05$). Although dizziness and pruritus were more frequent in the basal infusion group, these differences were not statistically significant. The overall occurrence of any opioid-related adverse effect was significantly higher in the basal infusion group than in the no-basal infusion group ($p = 0.004$).

[Table- 6] The rate of IV-PCA discontinuation was significantly higher in the basal infusion group compared to the no-basal infusion group. Discontinuation due to opioid-related side effects was also significantly more frequent in the basal infusion group ($p < 0.05$). However, discontinuation due to adequate pain relief was comparable between the two groups and did not

show a statistically significant difference (p > 0.05).

Table 1: Baseline Demographic and Perioperative Characteristics

Parameter	Basal infusion (n=120)	No-basal infusion (n=120)	p-value
Age (years)	52.6 ± 11.8	51.9 ± 12.1	0.68
Sex (M/F)	74/46	72/48	0.79
BMI (kg/m²)	24.8 ± 3.2	25.1 ± 3.5	0.45
ASA I/II/III	34/62/24	36/60/24	0.93
Cervical/Thoracic/Lumbar	28/22/70	30/20/70	0.88
Duration of surgery (min)	198 ± 46	202 ± 48	0.54

Table 2: IV-PCA Opioid Consumption

Parameter	Basal infusion	No-basal infusion	p-value
0–24 hours	42.5 ± 11.6	34.8 ± 10.4	<0.001
24–48 hours	31.2 ± 9.8	25.6 ± 8.9	0.002
Total (0–48 h)	73.7 ± 17.2	60.4 ± 15.6	<0.001

Table 3: Postoperative Pain Scores (NRS)

Time point	Basal infusion	No-basal infusion	p-value
NRS at rest (0–24 h)	3.2 ± 1.1	3.3 ± 1.2	0.61
Maximum NRS (0–24 h)	5.8 ± 1.4	5.9 ± 1.5	0.73
NRS at rest (24–48 h)	2.6 ± 1.0	2.7 ± 1.1	0.55
Maximum NRS (24–48 h)	4.7 ± 1.3	4.8 ± 1.4	0.67

Table 4: Rescue Analgesic Requirement

Parameter	Basal infusion	No-basal infusion	p-value
Rescue analgesia (0–24 h)	46 (38.3%)	50 (41.7%)	0.59
Rescue doses (0–24 h)	1 (0–2)	1 (0–2)	0.84
Rescue analgesia (24–48 h)	32 (26.7%)	35 (29.2%)	0.67
Rescue doses (24–48 h)	0 (0–1)	0 (0–1)	0.91

Table 5: Opioid-Related Adverse Effects

Adverse effect	Basal infusion	No-basal infusion	p-value
Nausea	34 (28.3%)	22 (18.3%)	0.048
Vomiting	21 (17.5%)	12 (10.0%)	0.047
Sedation	26 (21.7%)	14 (11.7%)	0.032
Dizziness	19 (15.8%)	11 (9.2%)	0.11
Pruritus	14 (11.7%)	8 (6.7%)	0.18
Any adverse effect	58 (48.3%)	36 (30.0%)	0.004

Table 6: IV-PCA Discontinuation

Parameter	Basal infusion	No-basal infusion	p-value
IV-PCA discontinued	24 (20.0%)	11 (9.2%)	0.018
Due to side effects	18 (15.0%)	7 (5.8%)	0.021
Due to adequate pain relief	6 (5.0%)	4 (3.3%)	0.52

Discussion

In the present study, we prospectively evaluated the impact of background infusion in intravenous patient-controlled analgesia on postoperative analgesic efficacy, opioid consumption, and opioid-related adverse effects in patients undergoing major spine surgery.

The principal findings of this study were that IV-PCA with background infusion was associated with significantly higher postoperative opioid consumption and a greater incidence of opioid-related adverse effects, without providing superior pain control or reducing the need for rescue analgesics, when compared with IV-PCA without background infusion. These findings are clinically relevant, as effective postoperative pain management in spine surgery requires a balance between adequate analgesia and minimization of opioid-related complications. The results of this study support a demand-only IV-PCA approach as an effective and potentially safer strategy for postoperative analgesia in this patient population.

Baseline demographic and perioperative characteristics: In the present study, both study

groups were comparable with respect to age, sex distribution, BMI, ASA physical status, surgery level distribution (cervical/thoracic/lumbar), and duration of surgery ($p>0.05$). This baseline comparability strengthens the interpretation that differences observed in opioid consumption and adverse effects are more likely related to PCA settings rather than major preoperative or operative imbalances. Similar methodology—ensuring comparability when interpreting opioid consumption and adverse outcomes after spine procedures—has been emphasized in postoperative spine analgesia outcome studies such as Patel et al [11] (2020), where differences in opioid exposure were interpreted in relation to analgesic delivery strategy.

IV-PCA opioid consumption: In the present study, opioid consumption was significantly higher in the basal infusion group across 0–24 hours, 24–48 hours, and 0–48 hours ($p<0.05$). This pattern is consistent with early controlled trials demonstrating that adding a continuous background infusion tends to increase total opioid delivery. McCoy et al [12] (1993) reported improved early pain relief with background infusion but also noted higher nausea and increased opioid exposure when a background infusion was used. Similarly, Dawson et al13 (1995) evaluated morphine PCA with and without a continuous infusion and showed that adding a background infusion alters total opioid delivery during the early postoperative period, supporting the concept that basal infusion increases cumulative dose.

In contrast, Dal et al [14] (2003) found that background infusion did not enhance analgesia after cardiac surgery, underscoring that increased opioid delivery does not necessarily translate into better clinical benefit.

Postoperative pain scores (NRS): In the present study, NRS pain scores at rest and maximum pain intensity were comparable between groups at all time points ($p>0.05$), despite higher opioid consumption in the basal infusion group. This aligns with the broader observation that additional continuous infusion may not improve patient-reported pain when demand dosing is already available. Dal et al [14] (2003) similarly reported no meaningful analgesic advantage from adding background infusion (despite opioid delivery differences), reinforcing that analgesic efficacy may plateau even as opioid dose increases. More recent randomized evidence in fentanyl-based IV-PCA settings also supports this concept: Jun et al [15] (2024) showed that adding basal infusion did not provide advantages in acute pain control compared with no basal infusion in their randomized pilot study.

Rescue analgesic requirement: In the present study, the proportion of patients requiring rescue analgesia and the number of rescue doses were comparable between the two groups ($p>0.05$). This supports the inference that omission of basal infusion did not increase breakthrough pain requiring additional interventions. This is consistent with the idea shown in controlled PCA infusion comparisons that, when bolus demand dosing is appropriately set, patients can self-titrate to similar pain outcomes without requiring additional rescue medications. Evidence from morphine PCA infusion trials, such as McCoy et al [12] (1993), supports that differences in background infusion may not reliably reduce supplemental analgesic needs beyond early postoperative hours.

Opioid-related adverse effects: In the present study, opioid-related adverse effects (nausea, vomiting, sedation, and overall adverse events) were significantly higher in the basal infusion group ($p<0.05$). This is clinically expected because background infusion increases continuous opioid exposure, which can increase nausea and sedation even if pain scores remain similar. McCoy et al [12] (1993) observed higher nausea with background infusion regimens.

Importantly, randomized controlled evidence also supports a specific increase in PONV with basal infusion: Kim et al [16] (2025) reported that fentanyl-based IV-PCA without basal infusion resulted in less postoperative nausea and vomiting while maintaining adequate analgesia.

Additionally, Russell et al [17] (1993) evaluated background infusion effects on oxygen saturation and pain after gynecological surgery, reflecting long-standing concern that basal infusion can worsen safety profiles even when analgesia is similar.

IV-PCA discontinuation: In the present study, IV-PCA discontinuation and discontinuation due to side effects were significantly higher in the basal infusion group ($p<0.05$). This is consistent with the higher adverse event burden seen with basal infusion, which often necessitates stopping PCA for patient safety and comfort. Kim et al [16] (2023), in a Scientific Reports cohort study on discontinuation of IV-PCA, identified background infusion as being associated with a tendency to discontinue PCA and discussed how higher infused opioid dose and side effects contribute to cessation.

Conclusion

The findings of our study demonstrated that the use of a continuous background infusion in IV-PCA does not provide additional analgesic benefit when compared with demand-only IV-PCA. Postoperative pain scores at rest and maximum

pain intensity during the first 48 hours after surgery were comparable between patients receiving IV-PCA with background infusion and those receiving IV-PCA without background infusion, indicating similar analgesic efficacy in both groups.

Despite comparable pain control, patients receiving IV-PCA with background infusion had significantly higher total opioid consumption during the postoperative period. This increased opioid exposure was accompanied by a higher incidence of opioid-related adverse effects, particularly postoperative nausea, vomiting, and sedation. Additionally, discontinuation of IV-PCA due to adverse effects was more frequent in the basal infusion group, highlighting potential safety concerns associated with routine background infusion in this patient population. The requirement for rescue analgesics and the number of rescue doses administered during the postoperative period were similar between the two groups, further supporting the finding that omission of background infusion does not compromise pain relief. These results suggest that demand-only IV-PCA is sufficient to achieve effective postoperative analgesia following major spine surgery while minimizing unnecessary opioid exposure.

Overall, the findings of this study indicate that routine use of background infusion in IV-PCA after major spine surgery may not be justified. IV-PCA without background infusion offers comparable pain control with a lower risk of opioid-related adverse effects and reduced likelihood of PCA discontinuation.

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