Section: General Surgery

Original Research Article

EFFECTIVENESS OF CONTINUOUS INFUSION VERSUS INTERMITTENT BOLUS OF TRAMADOL IN PATIENTS HAVING UP TO 3 RIB FRACTRES

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ABSTRACT

Background: Rib fractures are a common consequence of traumatic injuries, often resulting from incidents such as motor vehicle accidents, falls, or physical assaults. Effective pain management is crucial in this patient population to enhance recovery, promote pulmonary function, and improve overall outcomes.
Objective: The analgesic outcomes of continuous infusion and intermittent bolus administration of tramadol in surgical patients having up to 3 rib fractures by evaluating their effectiveness in terms of pain relief, opioid consumption, patient satisfaction, and other relevant patient-centered outcomes
Materials and Methods: A total of 184 patients with up to 3 rib fractures were divided into two groups (92 each). Group 1 had continuous infusion of tramadol (12mg per hour),while Group 2 had intermittent bolus of tramadol(100mg intravenous 8th hourly). Key parameter assessed pain relief and is assessed by visual analogue scale for pain.
Results: Continuous infusion of tramadol is significantly more effective for pain management compared to intermittent bolus administration at Q8H. This conclusion is supported by consistently lower Visual Analog Scale (VAS) pain scores across all time points (24, 48, and 72 hours) for continuous infusion. Furthermore, the statistical significance of these results, highlighted by P values of 0.0001 at each interval, provides strong evidence that the observed differences are not due to random variation.
Conclusion: Continuous infusion of tramadol in management of pain in patients having upto 3 rib fractures have better outcome compared to intermittent bolts dose in terms of analgesia.
Keywords: Rib fractures, tramadol, visual analogue scale, continuous infusion, intermittent bolus.

INTRODUCTION

Rib fractures are among the most common injuries resulting from blunt thoracic trauma, often caused by motor vehicle accidents, falls, or physical assaults. These fractures are associated with significant morbidity due to severe pain, which can lead to impaired respiratory mechanics, reduced lung expansion, and an increased risk of complications such as pneumonia, atelectasis, and respiratory failure. Effective pain management in patients with rib fractures is therefore crucial not only for comfort but also for preventing secondary pulmonary complications and improving overall recovery outcomes.[1,2]

The Challenge of Rib Fracture Pain Management
Pain from rib fractures is typically intense and exacerbated by respiratory movements, coughing, and physical activity.[3] Inadequate analgesia can lead to shallow breathing, retained secretions, and hypoventilation, increasing the risk of pulmonary infections. Traditional pain management strategies include systemic opioids, nonsteroidal anti-inflammatory drugs (NSAIDs), regional anesthesia techniques (such as epidural analgesia or paravertebral blocks), and multimodal approaches. However, each method has limitations. - Opioids

(e.g., morphine, fentanyl) provide potent analgesia but carry risks of respiratory depression, sedation, and dependence. NSAIDs offer anti-inflammatory benefits but may cause gastrointestinal bleeding or renal dysfunction. -Regional techniques, while effective, require specialized skills and are not always feasible in all clinical settings. Given these challenges, there is a need for alternative analgesic strategies that balance efficacy, safety, and practicality Tramadol.[4]

A Dual-Mechanism Analgesic Tramadol,[5] a centrally acting synthetic opioid, has emerged as a valuable option for moderate to severe pain. Its unique dual mechanism of action—weak μ-opioid receptor agonism and inhibition of norepinephrine/serotonin reuptake—provides analgesia with a lower risk of respiratory depression compared to conventional opioids. Tramadol is metabolized to an active metabolite (O-desmethyltramadol) with higher opioid affinity, contributing to its prolonged effect. Despite its advantages, tramadol's optimal administration method remains debated. The two primary approaches are.[6]

1. Intermittent Bolus Dosing: Provides peak analgesic effects but may lead to fluctuating plasma levels, resulting in periods of inadequate pain control.
2. Continuous Infusion: Maintains steady drug concentrations, potentially offering more consistent analgesia and reducing breakthrough pain.

Rationale for the Study While tramadol has been extensively studied in postoperative settings (e.g., abdominal, orthopedic, and gynecological surgeries), limited research focuses on its role in rib fracture management. Existing studies suggest that continuous infusion may reduce opioid consumption and improve pain stability compared to intermittent dosing. However, no conclusive evidence exists for rib fracture patients, who represent a distinct population with unique pain dynamics and respiratory concerns. This study aims to compare the effectiveness of continuous infusion versus intermittent bolus administration of tramadol in patients with up to three rib fractures, evaluating: - Pain relief (measured by Visual Analog Scale [VAS] scores at 24, 48, and 72 hours). - Opioid consumption (total rescue doses required).

MATERIALS AND METHODS

It was a Prospectice Comparative study conducted for a period of 12 months after IRB clearance in Department of General Surgery ,Govt .medical college Kottayam, Kerala, India. Patients admitted with traumatic chest injury having up to 3rib fractures Government Medical College Kottayam

Sample

From previous study conducted by Rud et al,[2] group 1 was 69.2%, requested only one or no repetitive bolus of compound to 40.3% where two or more bolus were demanded p = p_1+ rp_2/1+r.

r =1 (ratio of group 1)

Ratio of group 2 n≥[z_1-α/2√(r+1)p(1 p)+z_1-β√rp_1(1-p_1)+p-2(1-p_2)]^2/r(p_2-p_1)^2

α – 0.05

β – 0.2

p_2 - 0.403

p_1 −0.652

γ – 1

Minimum sample size in each group is 92

Inclusion Criteria

- Patients with isolated chest injury (up to 3 rib fractures)
- Age above 18 years

Exclusion Criteria

Patients with, multiple rib fractures, flail chest, poly trauma. Patients allergic to tramadol.

For this comparative study on the Effectiveness of continuous infusion versus intermittent bolus administration of tramadol in surgical patients having up to 3 rib fractures, a combination of convenience sampling and consecutive sampling techniques will be employed. Convenience sampling will be used to select patients who meet the inclusion criteria and are readily available for recruitment within the specified study period. This sampling technique is chosen for its practicality and efficiency, allowing for the inclusion of patients who are accessible and willing to participate in the study. Consecutive sampling will then be applied within the convenience sample to ensure a continuous recruitment of eligible participants. All patients who meet the inclusion criteria and provide informed consent during the study period will be consecutively included in the study until the desired sample size is achieved. This technique helps to minimize selection bias and increase the generalizability of the findings to the target population of surgical patients having upto 3 rib fractures. Pain is assesed at 24hour,48hour and 72 hour after admission in groups receiving continuous infusion of tramadol and intermittent bolus of tramadol and is by using visual analogue scale for pain.

Consecutive sampling till sample size reached. All eligible participants fulfilling the study criteria will be enrolled consecutively._For this comparative on the analgesic outcome of continuous infusion and intermittent bolus administration of tramadol in surgical patients with 2 to 3 rib fractures, a combination of convenience sampling and consecutive sampling techniques will be employed. Convenience sampling will be used to select patients who meet the inclusion criteria and are readily available for recruitment within the specified study period. This sampling technique is chosen for its practicality and efficiency, allowing for the inclusion of patients who are accessible and wiling to participate. Consecutive sampling will then be applied within the convenience sample to ensure a continuous recruitment of eligible participants. All

patients who meet the inclusion criteria and provide informed consent during the study period will be consecutively included in the study until the desired sample size is achieved. This technique helps to minimize selection bias and increase the generalizability of the findings to the target population of surgical patients with 2 to 3 rib fractures. Pain assesed by visual analogue scale.

Data management and Statistical analysis

Data will be entered in MS Excel and analysed using SPSS software 18. All quantitative variables will be expressed as mean +/- of standard deviation and all qualitative variables will be expressed as proportion. A statistical analysis software package (SPSS version 26) was used to analyse the data. Results were expressed in either percentage or proportion. Normality of data was checked using Kolmogorov Smirnov test and appropriate parametric or non-parametric test was applied. For qualitative data chi-square test or Fisher exact test was used to find out the significant difference in groups. Independent sample t test was used to compare mean difference between continuous infusion of tramadol vs intermittent bolus administration of tramadol at Q8H.

RESULTS

Table 1: Shows the age distribution of study participants in both the group

Age category	Continuous infusion of tramadol	Percent age	Intermittent bolus of tramadol at Q8H	Percentage
Age between 20 to 25	36	39.1	36	39.1
Age between 26 to 30 years	33	35.9	35	38
Age between 31 to 35 years	12	13	11	12
Age between 36 to 40 years	11	12	10	10.9
Total	92	100	92	100

For continuous infusion, the age group of 20–25 years dominates, contributing 39.1 percent of the total, closely followed by the 26–30 age group at 35.9 percent. The older age groups, 31–35 years and 36–40 years, have much smaller proportions, making up 13 percent and 12 percent, respectively. Similarly, for intermittent bolus at Q8H, the youngest age group, 20–25 years, also leads with 39.1 percent, while the 26–30 group shows a slightly higher share of 38 percent compared to continuous infusion. The trend of reduced representation continues in the 31–35 and 36–40 groups, contributing 12 percent and 10.9 percent, respectively. The data highlights gender-based differences in the administration of tramadol via continuous infusion and intermittent bolus. For continuous infusion, males represent the majority, accounting for 70.65 percent of the total, whereas females make up 29.35 percent. Similarly, for intermittent bolus, males still dominate at 65.22 percent, but females account for a slightly higher share of 34.78 percent compared to the continuous infusion method.

Table 2: Shows distribution of number of fractured ribs

No rib fractured	ontinuous infusion of tramadol	Percen tage	Intermittent bolus of tramadol at Q8H	Percentage
1	62	67.39	57	61.96
2	21	22.83	25	27.17
3	9	9.78	10	10.87
Total	92	100	92	100

The data outlines the distribution of tramadol administration based on the number of ribs fractured across both continuous infusion and intermittent bolus methods. For patients with a single rib fractured, 67.39 percent received continuous infusion, while 61.96 percent were administered intermittent bolus. Among those with two ribs fractured, the percentage for continuous infusion decreases to 22.83 percent, whereas intermittent bolus shows a higher percentage at 27.17 percent. In the case of three ribs fractured, the percentages are similar but slightly higher for intermittent bolus at 10.87 percent compared to 9.78 percent for continuous infusion.

Table 3: Shows effectiveness of VAS scores at different time intervals

Parameters	Continuous infusion of tramadol	Intermittent bolus of tramadol at Q8H	P Value
VAS score at 24 Hours	7.54 ±1.14	8.22 ±0.93	0.0001
VAS score at 48 Hours	3.48 ±1.11	5.21 ±1.32	0.0001
VAS score at 72 Hours	2.92 ±1.01	4.34 ±1.22	0.0001

The results highlight the effectiveness of pain management using continuous infusion and intermittent bolus of tramadol at different time intervals. The mean Visual Analog Scale (VAS)

score for continuous infusion is 7.54 ± 1.14, compared to 8.22 ± 0.93 for intermittent bolus. This indicates that patients receiving continuous infusion experienced slightly less pain at 24 hours compared to those receiving intermittent bolus. The P value of 0.0001 demonstrates that this difference is statistically significant, meaning the observed difference in pain scores is unlikely due to chance. Continuous infusion shows more effective pain management at this early stage. At 48 hours, the continuous infusion method shows a further reduction in pain levels, with a mean VAS score of 3.48 ± 1.11, while the intermittent bolus method reports a higher mean score of 5.21 ± 1.32. The greater pain relief observed with continuous infusion becomes even more apparent at this time point. The P value of 0.0001 again confirms that this difference is statistically significant, reinforcing the superior effectiveness of continuous infusion for pain management. By 72 hours, the continuous infusion method continues to show better pain relief, with a mean VAS score of 2.92 ± 1.01 compared to 4.34 ± 1.22 for intermittent bolus. This indicates sustained effectiveness of continuous infusion in reducing pain over a longer duration. The P value of 0.0001 confirms the statistical significance of this difference, indicating that continuous infusion consistently provides better pain management compared to intermittent bolus over the study period.

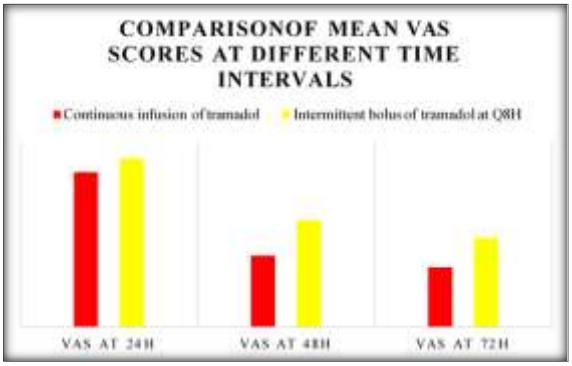

Figure 1: Showing the comparison of mean VAS scores at different time intervals

The data clearly demonstrates that continuous infusion of tramadol is significantly more effective for pain management compared to intermittent bolus administration at Q8H. This conclusion is supported by consistently lower Visual Analog Scale (VAS) pain scores across all time points (24, 48, and 72 hours) for continuous infusion. Furthermore, the statistical significance of these results, highlighted by P values of 0.0001 at each interval, provides strong evidence that the observed differences are not due to random variation.

DISCUSSION

Our study's finding of superior pain relief with continuous tramadol infusion compared to intermittent bolus administration aligns with the conclusions of Rud et al,[7] who reported that 76.5% in their infusion group (Group I) experienced excellent or good pain relief compared to 65.6% in the bolus group (Group B). Similarly, our study demonstrated significantly lower VAS scores at 24, 48, and 72 hours with continuous infusion. Rud et al,[7] also noted that 69.2% in Group I required only one or no repetitive bolus compared to 40.3% in Group B, suggesting better-sustained analgesia with infusion, a trend mirrored in our study's sustained lower pain scores in the continuous infusion group. While Rud et al,[7] observed comparable analgesic consumption in the first 6 hours but increased consumption in the infusion group thereafter, our study focused on pain scores as the primary outcome. Harsha et al,[8] highlighted the importance of multimodal and regional analgesia for rib fracture pain, mentioning tramadol as an effective option and suggesting continuous infusion is more effective, which supports our findings.

Our study's observation of superior pain relief with continuous tramadol infusion stands in contrast to the findings of Manuel Taboada et al,[9] who concluded that in continuous popliteal sciatic nerve blocks, automated boluses of local anesthetic alongside patient-controlled analgesia (PCA) achieved comparable pain relief to continuous infusion with PCA, but with reduced local anesthetic usage and fewer PCA demands. Their research centered on local anesthetics, unlike our focus on tramadol. Likewise, Ram Jagannadhan et al,[10] reported that intermittent bolus and continuous infusion techniques for local anesthetic delivery in peripheral and truncal nerve blocks exhibited similar effectiveness in alleviating pain, with tramadol being a frequently used supplementary medication. This contradicts our finding of notably lower VAS scores at 24, 48, and 72 hours with continuous tramadol infusion compared to intermittent bolus for rib fracture pain. Our study demonstrated that continuous infusion of tramadol provided superior pain relief at all time points compared to intermittent bolus administration.

Our study's observation of enhanced pain relief through continuous tramadol infusion diverges from the conclusions of Idrees et al,[11] who found that intramuscular bolus and intravenous infusion of tramadol provided comparable pain reduction and analgesic usage following lower abdominal surgeries, noting no significant differences in pain scores over 24 hours or in average analgesia at 6 and 12 hours between the two methods. Similarly, Robert Parker et al,[12] found no improvement in pain management with routine continuous opioid infusion combined with PCA compared to PCA alone after abdominal hysterectomy, suggesting that continuous infusion does not invariably offer benefits. In contrast, Wang et al,[13] reported that a low-dose continuous tramadol infusion (0.1 mg/kg/h), when combined with preemptive tramadol and morphine PCA, improved analgesia and lowered morphine consumption in the initial 24 hours post-abdominal

hysterectomy compared to a regimen lacking preemptive tramadol. While their study incorporated continuous infusion within a multimodal strategy, it did not directly compare continuous infusion with intermittent bolus of tramadol alone. Minkowitz et al.'s,[14] trial in the US on intravenous tramadol for postoperative pain emphasized its safety and patient satisfaction but did not evaluate different administration techniques. Consequently, while certain studies indicate similar effectiveness between various tramadol delivery methods or underscore its role in multimodal pain relief, our results uniquely demonstrate the superiority of continuous intravenous infusion over intermittent bolus administration for managing pain in patients with up to three fractured ribs.

Table 2: Studies comparing tramadol infusions and various pain outcomes

Study	Variable	Key Findings
Idrees et al. [11]	Pain scores at 6, 12, and 24 hours	No significant difference between IM bolus and IV infusion of tramadol
Robert Parker et al. [12]	PCA with continuous infusion vs. without opioid	No added benefit of routine continuous opioid infusion
Wang et al.[13]	Tramadol 0.1 mg/kg/h infusion + PCA vs. PCA alone	Improved analgesia, reduced morphine use with preemptive tramadol
Minkowitz et al. [14]	IV tramadol safety and patient satisfaction	Did not compare administration techniques

Our study's demographic findings align with those reported by Van Vledder et al,[15] who observed a significant proportion of rib fracture cases in younger adults, although their study emphasized elderly patients..

One limitation of our study is the use of a single-center design, which may restrict the generalizability of our findings to other healthcare settings with different patient populations, analgesic protocols, or trauma management approaches. The study was conducted at a tertiary care hospital, where the availability of trained personnel, monitoring facilities, and adherence to strict analgesic guidelines may differ from resource-limited settings, potentially influencing the effectiveness and safety of tramadol administration.

CONCLUSION

Our study demonstrated that continuous tramadol infusion provided superior pain relief compared to intermittent bolus administration in patients with up to three rib fractures. The significant reduction in pain scores at all assessed time points suggests that continuous infusion ensures a more stable plasma concentration, minimizing fluctuations that can lead to breakthrough pain or opioid-induced hyperalgesia. By maintaining consistent analgesic levels, continuous infusion enhances early pain control and sustains its effectiveness over time, reducing the need for additional interventions and improving overall patient comfort. The observed advantage of continuous infusion supports its role as a preferred method for managing rib fracture pain, especially in trauma patients where optimal pain relief is essential for preventing respiratory complications and facilitating recovery. Furthermore, the findings highlight the pharmacokinetic benefits of continuous tramadol administration, which provides prolonged receptor occupancy and avoids abrupt peaks and troughs associated with bolus dosing.

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