Original Article

Continuous Analgesia through an Extrapleural Catheter: Ropivacaine Alone versus Ropivacaine with Fentanyl

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Abstract

Introduction: Thoracotomy incision causes severe debilitating pain. Local anesthetic infusion in extrapleural paravertebral space via a catheter is a good alternative for postoperative analgesia for such patients. The addition of fentanyl to the local anesthetic infusion may further augment the analgesic efficacy of this technique. The aim was to compare the analgesic efficacy of 0.375% ropivacaine with fentanyl and without fentanyl via extrapleural paravertebral catheter (EPVC) for continuous postoperative analgesia. **Materials and Methods:** This prospective comparative study included 40 patients aged 18–60 years belonging to the American Society of Anesthesiologists (ASA) Grade I, II, and III posted for thoracic surgery. All the patients received general anesthesia as per the standard institutional protocol, and intubation was done with an appropriate size double-lumen endotracheal tube after giving muscle relaxant. An extrapleural catheter was inserted by the surgeon under direct vision external to the parietal pleura just before thoracotomy closure. Patients were randomly allocated to receive an infusion of 0.375% ropivacaine at 0.15 ml/kg/h in Group R or 0.375% ropivacaine with fentanyl 2 mcg/ml at 0.15 ml/kg/h in Group R.F. The dose or rate of infusion was decreased after 2 days or chest drain removal as the pain subsided. Postoperatively, the pain was assessed using a Visual Analog Scale (VAS) at 1, 6, 12, 18, 24, 48, and 72 h after the surgery. Patients who complained of pain with a VAS score of more than or equal to 4 were given injection tramadol 1 mg/kg as rescue analgesic. The peak expiratory flow rates (PEFRs), hemodynamic parameters, and incidence of any adverse effect were compared between groups. **Results:** The analgesia duration was comparable in the two groups (3.46 h in Group R vs. 4.60 h in Group R.F, $P = 0.091$). The mean VAS score at rest as well as during cough was comparable between the two groups ($P > 0.05$). There was no statistically significant difference in the mean PEFRs between the two groups. **Conclusion:** Fentanyl 2 μg/ml does not increase the duration of analgesia when combined with ropivacaine 0.375% for continuous EPVC infusion.

Keywords: Duration of analgesia, extrapleural paravertebral space, postoperative analgesia, ropivacaine

Introduction

Thoracic surgeries, when offering life-saving interventions, are notoriously accompanied by excruciating postoperative pain. This intense suffering, a consequence of tissue trauma, inflammation, nerve damage, and rib injury, is not merely a subjective experience; it significantly impacts patient outcomes and health-care systems.[1] Severe pain compromises respiratory function, increasing the risk of complications such as pneumonia and prolonging hospital stays, adding to the already substantial burden of postoperative management.[2]

Effective pain relief is, thus, a cornerstone of optimal recovery after thoracic surgery. While systemic opioids and nonsteroidal anti-inflammatory drugs (NSAIDs) are common options, they come with limitations. Systemic opioids, while potent, carry the risk of respiratory depression, particularly concerning in this vulnerable population.[2,3] NSAIDs, on the other hand, often lack sufficient efficacy against the severe pain associated with thoracotomy incisions.[4]

In recent years, extrapleural paravertebral catheter (EPVC) has emerged as a promising alternative offering targeted pain relief with minimal complications.[5] This technique

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involves placing a catheter in the paravertebral extrapleural space, a wedge-shaped area nestled between the ribs' heads and necks.[6] This strategic location allows for direct delivery of local anesthetics to pain-generating structures, including spinal nerves and rami communicantes, effectively blocking nociceptive signals at their source.[7,8] Studies have demonstrated the remarkable efficacy of EPVC in reducing pain scores and improving lung function compared to traditional approaches.[9,10]

Furthermore, the potency and duration of EPVC analgesia can be enhanced through adjuvants such as dexamethasone, dexmedetomidine, and clonidine.[11] These agents act through various mechanisms, including reducing inflammation, enhancing neuronal inhibition, and prolonging the action of local anesthetics.[12,13] Opioids such as fentanyl have also shown promise as adjuvants, potentially adding another layer of pain relief.[13]

Motivated by the potential of EPVC and the need for optimized pain management strategies, we conducted a prospective study to compare the analgesic efficacy of 0.375% ropivacaine administered via EPVC with and without fentanyl in patients undergoing thoracic surgery. This investigation aimed to answer the crucial question: Does the addition of fentanyl to EPVC improve postoperative pain control compared to ropivacaine alone? By elucidating this, we hope to contribute to the ongoing advancement of pain management techniques for this high-risk population, ultimately alleviating the burden of postoperative pain and improving patient outcomes.

Materials and Methods

Study Design and Participants

Conducted at a premier tertiary care teaching institute in Central India, we evaluated postoperative analgesia in thoracic surgery patients over 1 year. After obtaining Institutional Ethics Committee approval (letter no. EC/MGM/Feb-20/25), 40 patients aged 18–60 years with American Society of Anesthesiologists (ASA) grades I-III were enrolled and provided informed consent. Exclusion criteria included allergies to amide local anesthetics, coagulopathy, and abnormalities in the paravertebral space. Patients were randomized into two groups, R and R.F, each consisting of 20 participants, using a chit method before surgery [Figure 1].

Anesthesia and Monitoring Protocol

Preoperative assessments were meticulously conducted, encompassing both general and systemic examinations. Standard intraoperative monitoring was established, and anesthesia was induced with propofol, followed by intubation and maintenance with a mixture of gases and sevoflurane. An extrapleural catheter was placed by the operating surgeon.

Intervention and Postoperative Evaluation

Postthoracotomy, patients in Group R received 0.375% ropivacaine, and Group R.F received the same concentration of ropivacaine with 2 mcg/ml fentanyl, both at a rate of 0.15 ml/kg/h. The infusion rate was adjusted based on pain reduction postoperatively. Pain evaluation utilized the Visual Analog Scale (VAS) postsurgery at specified intervals, and patients

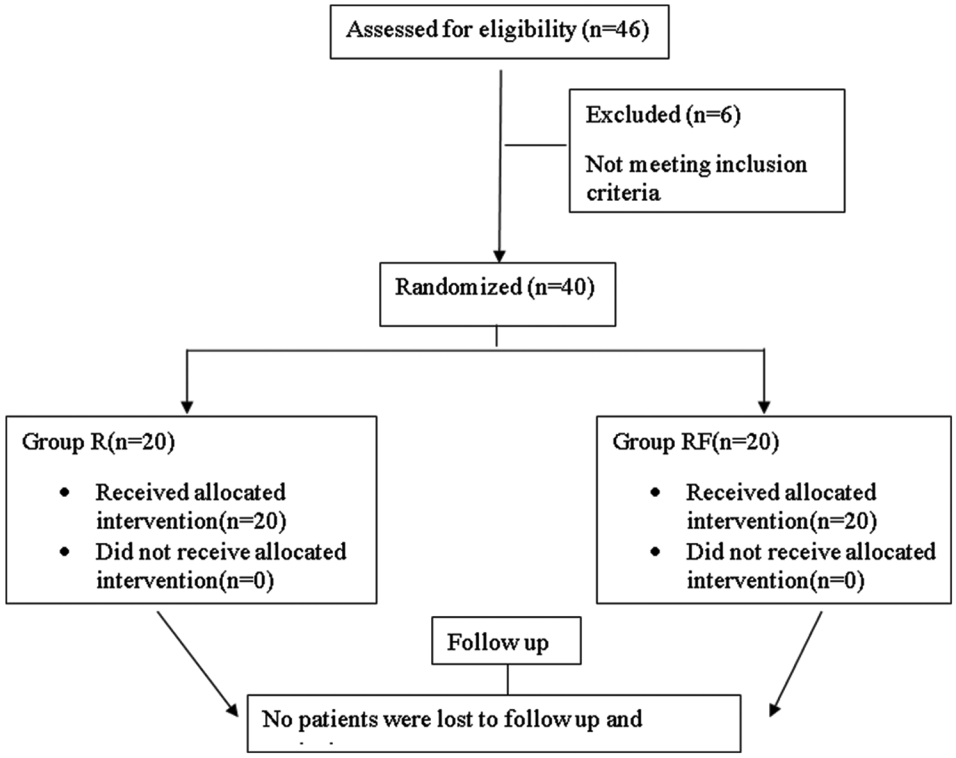

Figure 1: Consort diagram

with VAS scores ≥4 received tramadol as rescue analgesia. The study's primary endpoint was the duration of postoperative analgesia, with secondary outcomes including comparative VAS scores and peak expiratory flow rates (PEFRs) between the groups.

Results

As represented in Table 1, we compared key demographic and intraoperative characteristics between two patient groups undergoing thoracic surgery: Group R, receiving 0.375% ropivacaine, and Group R.F, given ropivacaine with fentanyl. The age distribution, with an average of approximately 35 years in Group R and 41 years in Group R.F, showed no significant difference (P = 0.109). Gender ratios and ASA grades, indicating preoperative health, were similarly balanced between the groups (gender: P = 0.337 and ASA: P = 0.311). Moreover, the duration of surgeries was comparable (P = 0.9765).

Table 2 focuses on comparing intraoperative hemodynamic and respiratory parameters between two patient groups: Group R, receiving 0.375% ropivacaine, and Group R.F, administered ropivacaine with fentanyl. The analysis revealed no significant differences in key vital parameters during surgery. Systolic blood pressure was slightly higher in Group R.F (128.11 ± 7.21) compared to Group R (125.05 ± 8.76), but this difference was not statistically significant (P = 0.237). A similar trend was observed in diastolic blood pressure, with Group R.F showing a marginally higher average (82.90 ± 5.41) than Group R (81.50 ± 5.42), again without statistical significance (P = 0.419). Heart rates and oxygen saturation levels were also comparable between the groups (heart rate: P =0.082 and oxygen saturation: P =0.214).

Table 3 provides a focused analysis on the duration of analgesia, comparing two groups of patients undergoing thoracic surgery: Group R, receiving 0.375% ropivacaine, and Group R.F, treated with ropivacaine combined with fentanyl. The primary measure was the time to first request for rescue analgesia, an indicator of the effectiveness of the pain management regimen. The results showed that the mean time to request additional pain relief was 3.46 h (±4.22 standard deviation [SD]) in Group R and slightly longer at 4.60 h (±6.95 SD) in Group R.F. However, the difference in duration of analgesia between the two groups did not reach statistical significance (P = 0.091).

Table 4 presents an in-depth comparison of pain levels, as measured by the VAS, between the two patient groups undergoing thoracic surgery: Group R, receiving 0.375% ropivacaine, and Group R.F, treated with ropivacaine and fentanyl. The VAS scores, a reliable measure of pain intensity, were recorded both at rest and during coughing at various intervals up to 72 h postsurgery. Our analysis revealed that the mean VAS scores in both scenarios were similar between the groups throughout the postoperative period. At the 1-h mark, VAS scores at rest were 5.1 (±0.91 SD) in Group R and 4.7 (±1.3 SD) in Group R.F, while during coughing, they were 6.50 (±0.83

Table 1: Patient demographic and intraoperative characteristics comparison

Characteristic	Group ropivacaine	Group R.F	*P*
Age	34.95±10.76	40.60±10.99	0.109
Sex (male/female)	13/7	10/10	0.337
ASA grade (1/2/3)	5/10/5	8/7/5	0.311
Mean duration of surgery (min)	79.73±9.93	88.73±9.97	0.9765

ASA: American Society of Anesthesiologists, R.F: Ropivacaine with fentanyl

Table 2: Intraoperative hemodynamic and respiratory parameters analysis

Parameter	Group ropivacaine	Group RF	*P*
Systolic blood pressure	125.05±8.76	128.11±7.21	0.237
Diastolic blood pressure	81.50±5.42	82.90±5.41	0.419
Heart rate	99.2±12.76	94.4±6.95	0.082
Oxygen saturation	99.65±0.49	99.45±0.51	0.214

RF: Ropivacaine with fentanyl

Table 3: Comparison of time to first rescue analgesia request

Characteristic	Group ropivacaine	Group RF	*P*
Time to first rescue analgesia (h)	3.46±4.22	4.60±6.95	0.091

RF: Ropivacaine with fentanyl

Table 4: Comparative analysis of postoperative Visual Analog Scale scores at rest and during cough

Time (h)	VAS during rest (mean±SD)			VAS during cough (mean±SD)		
	Group ropivacaine	Group RF	*P*	Group ropivacaine	Group RF	*P*
1	5.1±0.91	4.7±1.3	0.267	6.50±0.83	6.20±1.01	0.309
6	4.15±0.81	4.25±0.72	0.682	5.90±0.79	5.85±0.59	0.821
12	4.25±0.97	4.2+0.62	0.846	5.45±1.05	5.55±0.94	0.753
18	3.9±0.85	3.9±1.02	1.000	5.10±0.97	5.05±1.00	0.873
24	3.2±1.2	3.05±0.89	0.655	4.85±1.46	4.15±0.75	0.064
48	2.45±0.69	2.65±0.67	0.357	4.10±0.45	3.85±0.67	0.174
72	1.95±0.22	2.1±0.31	0.086	3.45±0.51	3.35±0.67	0.599

SD: Standard deviation, VAS: Visual Analog Scale, RF: Ropivacaine with fentanyl

SD) and 6.20 (±1.01 SD), respectively. The *P* values at all time points (ranging from 0.267 to 1.000) indicated no statistically significant differences in pain levels between the two groups.

Table 5 focuses on comparing the mean PEFRs, a key indicator of respiratory function, between two patient groups postthoracic surgery: Group R (receiving 0.375% ropivacaine) and Group R.F (administered ropivacaine with fentanyl). Measurements were taken at intervals of 12, 24, 48, and 72 h postoperatively. Our findings indicated that the PEFRs were similar between the two groups at all measured intervals. For instance, at 12 h postsurgery, Group R had a mean flow rate of 300.00 L/min (±79.07 SD), while Group R.F showed 332.50 L/min (±42.41 SD), with $P = 0.114$. This pattern of nonsignificant differences continued at 24, 48, and 72 h ($P = 0.432$, 0.495, and 0.832, respectively).

Discussion

Thoracic surgeries are known for their intense pain due to deep incisions, muscle layer disruption, and often rib resection, with pain amplified by the patient's breathing.[4,14] Managing this pain is critical not only for patient comfort but also to reduce pulmonary complications, allowing essential activities such as ambulation, deep breathing, and coughing. Chronic pain postthoracotomy can be debilitating, affecting daily life. In our study, we investigated the efficacy of local anesthetics, both with and without the addition of fentanyl, delivered via extrapleural catheters for postoperative pain relief in thoracic surgery patients.

Extrapleural catheters provide targeted analgesia directly at the pain source, avoiding the side effects of systemic opioids and complications of epidural analgesia like hypotension.[15,16]

Table 5: Postoperative peak expiratory flow rates in both groups

Time (h)	Group ropivacaine (L/min)	Group RF (L/min)	*P*
12	300.00±79.07	332.50±42.41	0.114
24	354.00±71.63	368.50±39.37	0.432
48	396.00±67.00	408.50±45.68	0.495
72	440.50±63.12	444.00±36.91	0.832

RF: Ropivacaine with fentanyl

This approach ensures sustained pain control, crucial for postoperative recovery activities and minimizing respiratory complications.[16,17]

Table 1 shows comparable patient demographics and intraoperative variables between Group R (receiving 0.375% ropivacaine) and Group R.F (ropivacaine with fentanyl). Tables 2 and 3 indicate similar intraoperative hemodynamic parameters and duration of analgesia, respectively. Table 4 demonstrates no significant differences in postoperative pain levels as measured by VAS scores, and Table 5 reflects analogous PEFRs, underscoring the similarity in respiratory function between the groups.

Pain assessment, conducted via the Visual Analog Scale (VAS) both at rest and during coughing episodes, demonstrated equivalent pain scores between the groups ($P > 0.05$) at all measured postoperative intervals, as illustrated in Figures 2 and 3. Specifically, 1 h after surgery, the average VAS score at rest for Group R was 5.0, in contrast to 4.6 for Group RF, a difference that was not statistically significant. This pattern of nonsignificant variance was consistent during coughing, with Group R reporting a VAS score of 6.4 compared to Group RF 6.0, reaffirming the similarity in pain experiences over the duration of the study ($P > 0.05$).

Group R received 0.375% ropivacaine at 0.15 ml/kg/h, while Group R.F received the same concentration of ropivacaine combined with fentanyl at 2 mcg/ml, also at 0.15 ml/kg/h. The duration of analgesia was roughly the same for both groups, with Group R at approximately 3.46 h and Group R.F at 4.60 h, indicating that the addition of fentanyl did not significantly enhance the analgesic effect of ropivacaine. Both the groups showed effective pain management and maintained adequate ventilation and cough efforts. The placement of the catheter, done under direct vision, was quick, easy, and minimized morbidity risks.

Both groups showed improvement in PEFR from 12 h to 72 h postsurgery, indicating enhanced lung function. However, the differences in the mean PEFR values were not significant, and PEFR measurements are highly effort dependent. The absence of complications such as hypotension, sedation, pruritus,

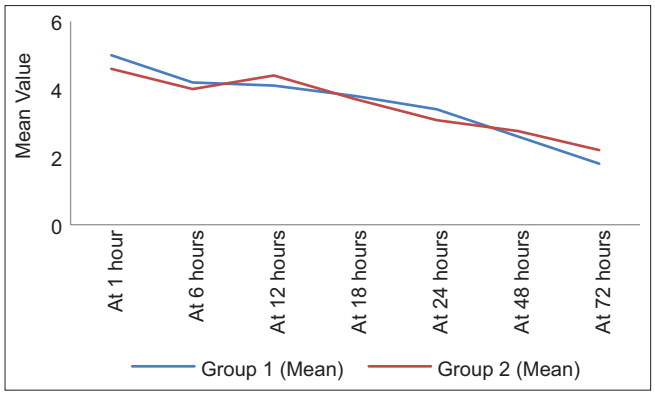

Figure 2: Comparison of mean Visual Analog Scale during rest

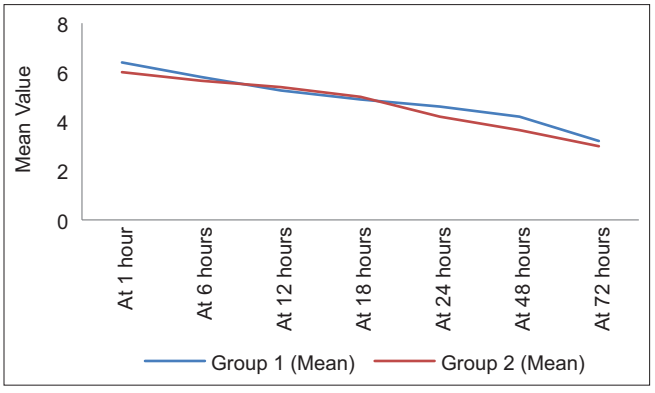

Figure 3: Comparison of mean Visual Analog Scale during cough

nausea, or urinary retention in either group underscores the safety of this technique. This finding aligns with studies from Barron *et al*.,[18] Rouzrokh *et al*.,[19] and Hotta *et al*.,[20] which suggest that extrapleural infusion of local anesthetics is a simple, low-risk technique that effectively provides pain relief and improves postoperative pulmonary function.[21-23]

Individual genetic and phenotypic differences, such as variations in μ-opioid receptors and CYP450 enzymes, can significantly impact pain perception and analgesic response.[21,22] The potential ceiling effect of ropivacaine, due to nerve receptor saturation, suggests that increasing its concentration beyond a certain point may not proportionally enhance analgesic efficacy, thereby diminishing any added benefit from fentanyl.[22,23]

Our research has several constraints, notably the absence of a comparative analysis with thoracic epidural techniques and the omission of cumulative rescue analgesic dosages. Conducted at a single institution with a modest cohort, the findings may not be universally applicable, indicating the need for a larger, multicenter study to validate these results further. Despite these limitations, the study highlights the effectiveness of extrapleural catheters in delivering focal analgesia, mitigating the adverse effects typically associated with systemic opioids and epidural methods, such as hypotension. This modality of pain management is instrumental in enhancing postsurgical recovery and reducing the incidence of respiratory complications.

Conclusion

Our study demonstrates that extrapleural catheters effectively deliver local anesthetics for postoperative pain management in thoracic surgeries, offering targeted analgesia with minimal side effects. This approach aids in enhancing postoperative recovery, maintaining respiratory function, and proving to be a safe and efficient alternative to traditional pain management methods.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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