RESEARCH PAPER

Pre-Emptive Intravenous Ibuprofen Versus Paracetamol For Postoperative Analgesia In Percutaneous Nephrolithotomy - A Prospective Comparative Study

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Abstract

Background: Patients who undergo percutaneous nephrolithotomy (pcnl) procedure experience postoperative pain at moderate to severe levels because the operation causes renal capsular distension and parenchymal damage and tract expansion and nephrostomy tube insertion. Pre-emptive analgesia provides effective pain relief which decreases central sensitization and decreases postoperative opioid use and enhances patient recovery. Hospitals use intravenous paracetamol and ibuprofen as non-opioid pain medication, but research on their effectiveness to prevent pain during pcnl procedures remains scarce.

Objective: The study aimed to compare the effectiveness of pre-emptive intravenous ibuprofen and paracetamol for postoperative pain relief in patients who undergo pcnl operations under general anaesthesia.

Methods: We used a single-centre hospital location to conduct a forward-looking study which compared two groups of adult patients who required elective pcnl operations under general anaesthesia. The participants received random assignment (1:1) that allowed them to choose between intravenous ibuprofen 400 mg (group i) or intravenous paracetamol 1000 mg (group ii) which they would take 30 minutes before their surgery started. The main goal of the study measured total opioid usage by patients during their first day after surgery. The study measured secondary outcomes through visual analogue scale (vas) pain scores which assessed pain during rest and after movement as well as the time required to receive first pain relief and patient satisfaction and negative effects.

Results: Sixty patients were equally allocated to the ibuprofen ($n = 30$) and paracetamol ($n = 30$) groups. The two groups showed comparable baseline demographic and perioperative characteristics (all $p > 0.05$). The ibuprofen group showed significantly lower total 24-hour postoperative opioid consumption compared to the paracetamol group (78.2 ± 14.6 mg vs 112.4 ± 18.9 mg; $p < 0.001$). The ibuprofen group maintained lower vas pain scores throughout all postoperative time points ($p < 0.001$). The time to first rescue analgesia was significantly longer with ibuprofen (182.6 ± 28.4 min vs 118.3 ± 24.7 min; $p < 0.001$). The ibuprofen group achieved higher patient satisfaction scores while both groups experienced a low rate of adverse effects which remained similar between them.

Conclusion: The study found that preemptive single dose intravenous ibuprofen 400mg gave better pain relief to patients who underwent pcnl surgery than standard dose paracetamol while maintaining same level of safety.

Keywords: Ibuprofen, Paracetamol, Pre-Emptive Analgesia, Percutaneous Nephrolithotomy.

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a well-established minimally invasive procedure for the management of large and complex renal calculi. Despite its minimally invasive nature, postoperative pain remains a significant clinical concern due to factors such as renal capsular dilation, nephrostomy tube placement, and tract-related tissue trauma [1]. Effective postoperative analgesia is essential not only for patient comfort but also for early mobilization, reduced hospital stay, and prevention of complications such as pulmonary dysfunction and delayed recovery [2]. Traditionally, opioids have been the mainstay for managing postoperative pain following PCNL; however, their use is associated with a range of adverse effects including respiratory depression, nausea, vomiting, pruritus, and potential for dependence, thereby necessitating the exploration of safer, opioid-sparing alternatives [3].

In recent years, multimodal analgesia has gained prominence as an effective strategy for postoperative pain control. This approach involves the use of different classes of analgesics acting through various mechanisms to achieve synergistic pain relief while minimizing side effects [4]. Among non-opioid analgesics, intravenous (IV) paracetamol and IV ibuprofen have emerged as valuable agents due to their efficacy, safety profile, and opioid-sparing properties. Paracetamol exerts its analgesic effect primarily through central inhibition of prostaglandin synthesis and modulation of serotonergic pathways, making it particularly useful for mild to moderate pain [5]. On the other hand, ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID), provides analgesia through peripheral cyclooxygenase (COX) inhibition, thereby reducing inflammation and nociceptive signaling at the site of tissue injury [6].

Pre-emptive analgesia, defined as the administration of analgesic agents prior to surgical stimulus, aims to prevent central sensitization and reduce postoperative pain intensity and analgesic requirements [7]. Both IV ibuprofen and paracetamol have been studied in this context, with evidence suggesting improved postoperative outcomes when administered preoperatively [8]. However, there remains limited comparative data specifically evaluating the efficacy of pre-emptive IV ibuprofen versus paracetamol in patients undergoing PCNL.

Given the differing mechanisms of action and pharmacodynamic profiles of these two agents, a direct comparison is clinically relevant to determine the more effective option for postoperative analgesia in PCNL. This prospective comparative study is therefore designed to evaluate and compare the analgesic efficacy, duration of pain relief, and opioid-sparing effects of pre-emptive intravenous ibuprofen and paracetamol in patients undergoing percutaneous nephrolithotomy [9,10].

MATERIALS AND METHODS

We conducted this hospital-based prospective comparative study at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee (IHEC: AV/IHEC/01/2024/23) and registration with the Clinical Trials Registry of India (CTRI: 2025/07/08991). The study was carried out over a period of 18 months. Written informed consent was obtained from all participants prior to enrollment. The study population comprised adult patients aged between 18 and 60 years, belonging to the American Society of Anesthesiologists (ASA) physical status I, II, or III, who were scheduled to undergo elective percutaneous nephrolithotomy (PCNL) under general anaesthesia. Patients were excluded if they had known hypersensitivity to ibuprofen or paracetamol, chronic kidney or liver disease, peptic ulcer disease, bleeding disorders, a history of chronic opioid or nonsteroidal anti-inflammatory drug (NSAID) use, psychiatric illness, or inability to comprehend pain assessment scales.

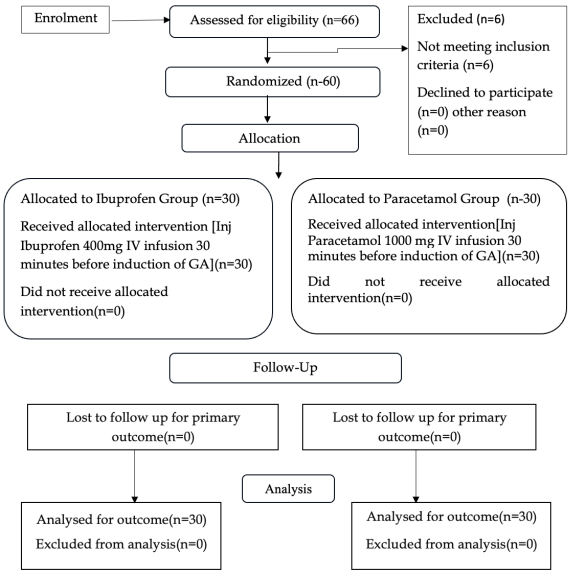
The sample size was calculated based on prior research by Koteshwar CM et al. [11], which evaluated postoperative pain scores between two groups. Accordingly, a total of 60 patients were included in the study, with 30 patients allocated to each group. Participants were recruited using a convenience sampling method, and randomization was performed using a computer-generated randomization sequence. The study followed a double-blind design, wherein both the patients and the anaesthesiologist involved in postoperative assessment and data collection were blinded to group allocation.

Patients in Group I received 400 mg intravenous ibuprofen diluted in 100 mL, administered 30 minutes prior to induction of anaesthesia over 10 minutes. Patients in Group II received 1000 mg intravenous paracetamol in 100 mL, administered in a similar manner. All patients adhered to standard nil-per-oral (NPO) guidelines and received uniform general anaesthesia as per institutional protocol. Intraoperative monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography, ensuring standardized perioperative care.

Postoperative pain was assessed using the Visual Analogue Scale (VAS), where a score of 0 indicated no pain and 10 indicated the worst imaginable pain. Pain scores were recorded both at rest and during movement at predetermined intervals over the first 24 hours following surgery. Rescue analgesia was provided with intravenous tramadol at a dose of 1 mg/kg when the VAS score was ≥4. The time to first rescue analgesia and total opioid consumption within 24 hours were documented. Patient satisfaction was evaluated using a 5-point Likert scale. Additionally, patients were monitored for adverse effects such as nausea, vomiting, sedation, pruritus, gastritis, and respiratory depression during the postoperative period.

Statistical analysis was performed using SPSS software (Version 29). Continuous variables were expressed as mean ± standard deviation, and comparisons between groups were made using Student's t-test. Categorical variables were analyzed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Figure 1. CONSORT FLOW CHART:



RESULTS

Table 1. Demographic and Baseline Characteristics

Variable	Ibuprofen Group (Mean ± SD)	Paracetamol Group (Mean ± SD)	p-valu
Age (years)	41.6 ± 9.2	42.3 ± 8.7	0.74
Weight (kg)	63.8 ± 7.6	64.5 ± 8.1	0.69
Gender (M/F)	18 / 12	17 / 13	0.79
ASA I / II / III	14 / 12 / 4	13 / 13 / 4	0.91
Duration of surgery (min)	96.4 ± 12.8	98.1 ± 13.2	0.58

Group	Ibuprofen Group (Mean ± SD)	Paracetamol Group (Mean ± SD)	P-value
Total tramadol consumption(mg)	78.2 ± 14.6	112.4 ± 18.9	<0.05

Table 2. Total Postoperative Opioid Consumption (24 hours)

Table 3. Time to First Rescue Analgesia

Parameter	Ibuprofen	Paracetamol	p-value
Time to first rescue analgesia (min)	182.6 ± 28.4	118.3 ± 24.7	<0.001

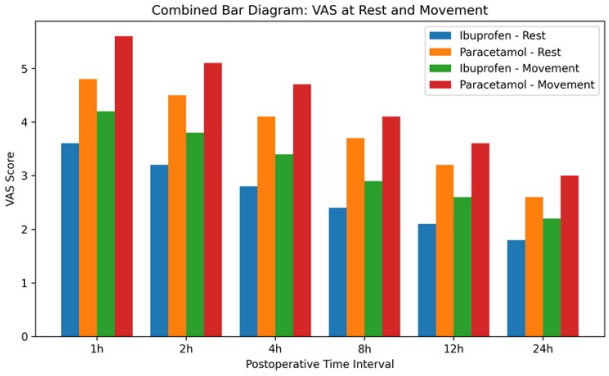


Figure 2. Bar Diagram of VAS Scores (Rest and Movement)

This figure shows the comparison of VAS scores at rest and on movement between Ibuprofen and Paracetamol groups across postoperative time intervals.

The study included 60 patients who required elective percutaneous nephrolithotomy because the researchers divided the participants into two equal groups which included the Ibuprofen group and the paracetamol group. The study accomplished complete participant tracking because all enrolled participants completed the study, and complete data were available for final analysis.

The two groups showed matching demographic and perioperative features (Table 1). The two groups showed no statistically significant differences regarding age (41.6 ± 9.2 vs 42.3 ± 8.7 years; $p = 0.74$), body weight (63.8 ± 7.6 vs 64.5 ± 8.1 kg; $p = 0.69$), gender distribution (18/12 vs 17/13; $p = 0.79$), ASA ($p = 0.91$), or duration of surgery (96.4 ± 12.8 vs 98.1 ± 13.2 minutes; $p = 0.58$), indicating that the groups were well matched prior to intervention.

The Ibuprofen group used fewer opioids for the first 24 hours after surgery than the Paracetamol group which consumed 78.2 ± 14.6 mg of opioids compared to 112.4 ± 18.9 mg ($p < 0.001$) (Table 2). The study results showed that preemptive intravenous Ibuprofen provided a substantial opioid-sparing effect.

Postoperative pain assessment through the visual analogue scale (VAS) at rest showed lower results for the Ibuprofen group throughout all measurement times (Figure 2). The mean VAS scores at 1 hour showed results of 3.6 ± 0.9 for the Ibuprofen group and 4.8 ± 1.1 for the paracetamol group ($p < 0.001$) which continued until 24 hours postoperatively when the scores showed 1.8 ± 0.4 for the ibuprofen group and 2.6 ± 0.6 for the paracetamol group ($p < 0.001$). The Ibuprofen group showed a longer duration until they receive their first rescue analgesia compared to the Paracetamol group (Ibuprofen group 182.6 ± 28.4 minutes vs Paracetamol group 118.3 ± 24.7 minutes). The mean difference between these two groups showed a statistically significant result with P value of less than 0.001 (Table 3).

The Ibuprofen group achieved better patient satisfaction scores than the Paracetamol group which showed that 60 percent of Ibuprofen patients were "very satisfied" while only 26.7 percent of Paracetamol patients reported that level of satisfaction.

The two groups showed similar low rates of postoperative adverse effects which appeared at a similar rate. The study found no statistical evidence to support the existence of differences between groups regarding the occurrence of nausea and vomiting or sedation or pruritus or gastritis (all $p > 0.05$). No patient in either group experienced respiratory depression.

DISCUSSION

Patients who received intravenous ibuprofen in the present study demonstrated consistently lower postoperative pain scores at both rest and movement, reduced opioid consumption, delayed requirement of rescue analgesia, and higher overall patient satisfaction, without a corresponding increase in adverse effects. These findings can be explained by the pathophysiology of pain following percutaneous nephrolithotomy (PCNL), where renal capsular distension, parenchymal tract dilatation, nephrostomy tube placement, and subsequent inflammatory mediator release contribute significantly to postoperative nociception. The comparable baseline demographic and clinical characteristics between the two groups in our study suggest that the observed differences in analgesic outcomes are attributable primarily to the pharmacological effects of the study drugs rather than confounding variables, which is consistent with prior comparative analyses [12,13].

Our findings align closely with those of Ucar et al. [14], who conducted a randomized controlled trial in PCNL patients and reported significantly lower postoperative opioid requirements in patients receiving intravenous ibuprofen compared to paracetamol. Similarly, Singla et al. [15] and Southworth et al. [16] demonstrated that intravenous ibuprofen reduced opioid consumption by approximately 25–35% in postoperative patients, reinforcing its opioid-sparing effect observed in the present study. This reduction is clinically important, as it minimizes opioid-related adverse effects and enhances recovery.

The superior analgesic efficacy of ibuprofen observed in our study can be attributed to its mechanism of action involving peripheral cyclooxygenase (COX) inhibition, leading to decreased prostaglandin synthesis at the site of surgical trauma. In contrast, paracetamol primarily exerts central analgesic effects with limited peripheral anti-inflammatory action. This pharmacodynamic difference becomes particularly relevant in procedures

like PCNL, which involve significant tissue inflammation. The prolonged duration of analgesia and better dynamic pain control seen with ibuprofen in our study are in agreement with findings by Rainsford [17], who highlighted the strong anti-inflammatory and sustained analgesic properties of ibuprofen.

Although intravenous paracetamol has been shown to be effective in reducing postoperative pain, its efficacy appears comparatively limited in surgeries with a strong inflammatory component. Gousheh et al. [18] reported that while pre-emptive intravenous paracetamol significantly reduced early postoperative pain compared to placebo, its effect was less pronounced than that of NSAIDs in inflammatory conditions. Likewise, a meta-analysis by Apfel et al. [19] concluded that although paracetamol reduces postoperative pain and opioid requirements, NSAIDs provide superior analgesia in surgeries associated with significant inflammation.

An important observation in our study was the significantly lower pain scores during movement in the ibuprofen group, indicating improved dynamic analgesia. Effective control of movement-related pain is crucial for early ambulation, improved respiratory function, and reduced postoperative complications. This finding is supported by Kang et al. [20], who demonstrated that NSAIDs are more effective than paracetamol in controlling dynamic postoperative pain.

Patient satisfaction, a key indicator of overall analgesic success, was also higher in the ibuprofen group in our study. This can be attributed to better pain control, reduced opioid requirement, and fewer distressing side effects. Comparable results were reported by Gupta et al. [15] and Jain et al. [13], who found higher satisfaction scores among patients receiving NSAID-based analgesia compared to paracetamol.

Overall, the present study findings are consistent with existing literature, demonstrating that pre-emptive intravenous ibuprofen provides superior postoperative analgesia compared to paracetamol in PCNL patients, particularly in terms of pain reduction, opioid-sparing effect, and patient satisfaction, without increasing adverse effects.

LIMITATION

Long-term analgesic efficacy or its effects on pain relief in the postoperative period past 24 hours was not tested. It did not include the measurement of renal inflammation or biochemical studies, which may have added more to the clarification of analgesic efficacy mechanisms.

CONCLUSION

We conclude that, the present study demonstrates that pre-emptive intravenous ibuprofen provides superior postoperative analgesia compared to intravenous paracetamol in patients undergoing percutaneous nephrolithotomy. Ibuprofen was associated with significantly lower pain scores at rest and during movement, reduced opioid consumption, prolonged time to first rescue analgesia, and higher patient satisfaction, without an increase in adverse effects. The enhanced analgesic efficacy of ibuprofen can be attributed to its potent peripheral anti-inflammatory action, which is particularly beneficial in procedures like PCNL that involve significant tissue trauma and inflammatory response. These findings support the use of intravenous ibuprofen as a more effective component of multimodal analgesia for postoperative pain management in PCNL. Incorporating ibuprofen into standard analgesic protocols may improve patient comfort, facilitate early recovery, and reduce opioid-related complications, thereby contributing to better overall surgical outcomes.

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