

Research Article

Implementing ERAS in Pediatric Surgery: The Impact of Standardized Nonopioid Pain Protocols On Postoperative Recovery

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ABSTRACT

Objective: To evaluate the implementation of an Enhanced Recovery after Surgery pathway using standardized nonopioid analgesia and to assess its association with postoperative recovery in pediatric surgical patients.

Methods: A prospective hospital based study was conducted at Lady Reading Hospital Peshawar from 23 March 2025 to 23 February 2026. A total of 97 pediatric patients undergoing surgery were included. A standardized Enhanced Recovery after Surgery pathway was implemented with emphasis on nonopioid analgesia early oral intake early mobilization and predefined discharge criteria. Postoperative pain scores rescue opioid requirements oral intake mobilization hospital stay and complications were assessed.

Results: Standardized nonopioid analgesia was achieved in 94 patients (96.9%). Rescue opioid medication was required in 14 patients (14.4%). Mean pain scores decreased from 3.1 ± 1.2 at 6 hours to 1.9 ± 0.9 at 24 hours. Early oral intake was achieved in 84 patients (86.6%) while 81 patients (83.5%) were mobilized within 24 hours. Mean hospital stay was 2.7 ± 1.4 days. High pathway adherence was associated with earlier oral intake and mobilization and shorter hospital stay.

Conclusion: Standardized nonopioid analgesia within an Enhanced Recovery After Surgery pathway was associated with favorable postoperative recovery in children. Reduced opioid rescue requirements and earlier functional recovery were observed.

Keywords: Pediatric Surgery, Enhanced Recovery, Nonopioid Analgesia, Postoperative Pain, Early Mobilization, Surgical Recovery.

INTRODUCTION

Enhanced Recovery After Surgery has been developed as a structured approach for improving perioperative care through coordinated interventions across the surgical pathway. Its principles have been increasingly applied in pediatric surgery because postoperative recovery is influenced by pain control nutrition mobilization fluid management and early return to normal activity. In children these processes are further affected by age related physiology communication barriers anxiety and variable responses to analgesic medicines. ERAS pathways have therefore been adapted to provide predictable care while reducing avoidable interventions. Evidence from pediatric studies has suggested that shorter hospital stay faster feeding and earlier functional recovery can be achieved when several recovery measures are implemented together.¹

Pain management has remained a central component of ERAS because uncontrolled pain can delay mobilization impair feeding increase stress responses and prolong hospitalization. Opioids have traditionally been used for moderate and severe postoperative pain. However opioid exposure has been associated with sedation respiratory depression nausea vomiting constipation urinary retention and delayed mobilization. In children these effects may be particularly important because age related pharmacological variation can make dose selection difficult. Concern regarding opioid related adverse effects has encouraged the development of opioid sparing and nonopioid analgesic strategies. Systemic acetaminophen nonsteroidal anti inflammatory medicines regional anesthesia local anesthetic techniques and selected adjunctive medicines have therefore been incorporated into multimodal pathways.²

A standardized nonopioid pain protocol can provide a consistent framework for analgesic administration before and after surgery. Regular administration rather than treatment only after severe pain has developed may allow analgesia to be maintained throughout the postoperative period. Such an approach can also reduce variation between clinicians and can support clearer communication between surgeons anesthetists nurses patients and caregivers. Regional techniques can be incorporated when appropriate. Local anesthetic infiltration can also be used when suitable. Nonpharmacological measures can complement pharmacological treatment through reassurance distraction parental involvement age appropriate communication and comfort measures. These interventions can be integrated within ERAS without making opioid therapy unavailable when clinically necessary.³

The rationale for opioid minimization is not based on complete avoidance of opioids in every child. Breakthrough pain may still require rescue analgesia. Instead opioid exposure can be reduced through planned use of medicines that act through different mechanisms. The total analgesic requirement can thereby be lowered while adequate pain relief is maintained. Pediatric evidence has supported the effectiveness of systemic opioid sparing analgesics although the available literature has remained less extensive than the adult literature. This limitation is important because children cannot always be considered as small adults. Differences in developmental pharmacology pain expression and procedure related needs require pediatric specific pathways.⁴

ERAS represents more than an analgesic protocol. Preoperative education can be provided to children and caregivers so that expectations regarding pain feeding mobility and discharge can be established. Unnecessary fasting can be reduced when safe. Appropriate nutrition can be supported. Intraoperative fluid management can be standardized. Minimally invasive techniques can be used when suitable. Postoperative feeding can be initiated according to procedure specific criteria. Early mobilization can be encouraged. Unnecessary tubes and drains can be avoided. Discharge criteria can be defined before surgery. When these measures are combined with standardized analgesia recovery can become less dependent on individual clinician preference.⁵

The pediatric ERAS literature has shown encouraging findings. Earlier reviews identified reductions in length of stay and faster return to feeding and bowel function after implementation of fast track pathways. Subsequent systematic reviews and meta analyses have provided stronger evidence that ERAS programs can reduce opioid consumption and hospital stay without a clear increase in complications or readmission. Improvements have also been reported in time to enteral feeding and other markers of functional recovery. These findings support the feasibility of ERAS in pediatric surgical populations. However variation in protocol components and differences between procedures have limited the ability to determine which individual elements provide the greatest benefit.⁶

Analgesic standardization is especially relevant because postoperative pain management can vary substantially between healthcare settings. Differences may occur in medicine selection dosing intervals rescue medication thresholds and documentation. Such variation can lead to inconsistent pain control and unnecessary opioid administration. A standardized pathway can reduce these differences by establishing predefined analgesic schedules and escalation criteria. Pain assessment can be performed using age appropriate validated scales. Treatment response can then be documented systematically. Rescue opioid use can be recorded as an outcome rather than being treated as an unavoidable routine component of postoperative care. This approach can make the effect of opioid sparing interventions more measurable.⁷

Despite these advances important gaps remain in pediatric ERAS research. Earlier investigations were frequently limited by small sample sizes retrospective designs heterogeneous procedures and incomplete reporting of individual ERAS components. Some studies evaluated complete pathways while others assessed selected interventions. Consequently the independent contribution of standardized nonopioid analgesia has remained difficult to establish. Recent reviews have continued to identify substantial variation in the composition and implementation of pediatric ERAS pathways. The level of adherence has also differed between institutions. These differences suggest that successful implementation depends not only on the selection of evidence based interventions but also on standardized processes that can be reliably followed by multidisciplinary teams.⁸

Another research gap concerns the relationship between standardized pain management and broader postoperative recovery. Pain intensity is important but it does not fully represent recovery. Time to mobilization oral intake return of bowel function requirement for rescue analgesia duration of hospitalization and postoperative complications can provide a broader assessment. Patient and caregiver satisfaction may also be relevant because pediatric recovery occurs within a family centred environment. Evidence has often been reported for several of these outcomes separately. A more integrated assessment is required to determine whether a standardized nonopioid protocol contributes to measurable improvements across the recovery pathway.⁹ Implementation is also an important unanswered issue. Evidence based recommendations may not produce consistent results when they are not translated into practical bedside processes. Protocol adherence can be affected by staff education availability of medicines communication between departments documentation systems and caregiver understanding. Continuous audit and feedback may therefore be required. Local adaptation can be necessary because pediatric surgical services differ in available expertise and resources. The protocol must also allow clinical judgment when contraindications or unexpected postoperative events occur. Standardization should support safe decision making rather than replace individualized assessment.¹⁰

There is also limited evidence from many resource constrained healthcare environments where staffing patterns medication availability and postoperative monitoring may differ from those reported in high resource institutions. This creates a need for practical pediatric ERAS pathways that can be implemented using commonly available nonopioid analgesics and clearly defined clinical criteria. Such pathways could be particularly valuable where prolonged hospitalization increases costs and limits bed availability. Evaluation of implementation should therefore include clinical outcomes as well as protocol adherence and opioid exposure. Local evidence can assist in determining whether findings from international pediatric ERAS studies can be reproduced within different healthcare systems. The present study was therefore designed to evaluate the implementation of a standardized nonopioid pain protocol within an ERAS pathway for pediatric surgical patients. The

objective of the study was to determine whether standardized nonopioid analgesia was associated with improved postoperative recovery as reflected by pain control opioid rescue requirements mobilization oral intake length of hospital stay and postoperative complications. The study was also intended to assess whether a structured multidisciplinary pathway could provide consistent postoperative analgesic care while supporting early functional recovery in children undergoing surgery.

MATERIALS AND METHODS

Study Design and Setting

A prospective hospital based study was conducted to evaluate the implementation of an Enhanced Recovery after Surgery pathway incorporating a standardized nonopioid pain protocol in pediatric surgical patients. The study was conducted from 23 March 2025 to 23 February 2026 at Lady Reading Hospital Peshawar. A total of 97 pediatric patients undergoing surgical procedures were included in the study. The study was conducted within the pediatric surgical service with coordination between the surgical team and anesthesia team. Postoperative care was provided according to the standardized ERAS pathway. The pathway was designed to promote effective pain control while minimizing unnecessary opioid exposure and supporting early postoperative recovery.

Study Population

The study population consisted of pediatric patients admitted for surgical management during the study period. Patients undergoing elective surgical procedures were assessed for eligibility before enrollment. The perioperative pathway was applied through coordinated preoperative intraoperative and postoperative measures. Particular attention was given to postoperative analgesia early oral intake mobilization monitoring and discharge readiness. Pain assessment was performed using an age appropriate pain assessment method. The clinical response to analgesic treatment was documented during the postoperative period.

Inclusion Criteria

Patients were eligible for inclusion when they were pediatric patients undergoing a planned surgical procedure during the study period. Patients of either sex were considered eligible. Patients were included when postoperative pain assessment could be performed using an appropriate age related assessment method.

Patients were also required to have adequate postoperative monitoring within the hospital. Patients whose surgical procedures were considered suitable for application of the ERAS pathway were included. Written informed consent was obtained from the parent or legal guardian before participation in the study.

Exclusion Criteria

Patients were excluded when emergency surgery was required because adequate preoperative implementation of the ERAS pathway could not be achieved. Patients with known hypersensitivity or contraindication to the nonopioid analgesic agents included in the protocol were excluded. Patients with significant hepatic renal or gastrointestinal disease that could limit the safe administration of selected analgesic medicines were excluded. Patients receiving long term opioid therapy before surgery were excluded because baseline opioid exposure could influence postoperative analgesic requirements. Patients with severe developmental or communication limitations that prevented reliable pain assessment were excluded when an appropriate alternative assessment could not be established. Patients whose clinical records were substantially incomplete were also excluded from the final analysis.

Eras Protocol

The ERAS pathway was implemented as a multidisciplinary perioperative care strategy. Preoperative assessment was performed before surgery and relevant information was provided to parents or caregivers. Unnecessary prolonged fasting was avoided when clinically appropriate. Intraoperative management was performed according to standard pediatric anesthetic and surgical practice. Appropriate fluid management and prevention of perioperative complications were emphasized. Postoperative feeding was resumed when clinically appropriate according to the type of surgical procedure and the condition of the patient. Early mobilization was encouraged according to age and surgical tolerance. Unnecessary invasive devices were removed when clinically appropriate.

Standardized Nonopioid Pain Protocol

Postoperative analgesia was primarily based on a standardized nonopioid regimen. Analgesic treatment was selected according to patient age body weight surgical procedure and clinical condition. Regular nonopioid analgesia was provided rather than relying exclusively on

medication administered after severe pain had developed. Acetaminophen and nonsteroidal anti inflammatory medication were used when clinically appropriate and when no contraindication was present. Local anesthetic techniques were used when considered appropriate by the anesthesia or surgical team. Nonpharmacological measures such as reassurance parental support distraction and age appropriate communication were also encouraged. Opioids were not routinely administered and were reserved for clinically significant breakthrough pain when adequate analgesia could not be achieved through the standardized nonopioid pathway.

Outcome Assessment

Postoperative recovery was assessed using predefined clinical outcomes. Postoperative pain intensity was recorded at appropriate intervals using an age appropriate pain assessment scale. Requirement for rescue opioid medication was documented. Time to initiation of oral feeding was recorded. Time to mobilization was assessed according to the patient's clinical condition and age. Length of hospital stay was calculated from the date of surgery until discharge. Postoperative complications were recorded during hospitalization. Any clinically significant adverse effects associated with analgesic therapy were also documented. The need for unplanned escalation of analgesic treatment was recorded as an additional indicator of protocol effectiveness.

Data Collection

Patient demographic and clinical information was collected using a structured data collection proforma. Variables included age sex type of surgical procedure and relevant perioperative clinical information. Postoperative pain scores were recorded according to the standardized assessment schedule. Analgesic medicines and rescue medication requirements were documented. Recovery milestones including oral feeding mobilization and discharge readiness were recorded. Postoperative complications and adverse analgesic effects were documented throughout the hospital stay. Data were reviewed for completeness before entry into the study database.

Statistical Analysis

Data were entered into a computerized database and analyzed using an appropriate statistical software package. Continuous variables were summarized using mean with

standard deviation or median with interquartile range according to the distribution of the data. Categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed before selection of statistical tests. Appropriate comparative tests were applied according to the type and distribution of variables. Continuous variables were analyzed using the independent sample t test when normally distributed and the Mann Whitney U test when distributional assumptions were not satisfied. Categorical variables were analyzed using the chi square test or Fisher exact test where appropriate. A p value of less than 0.05 was considered statistically significant.

Quality Assurance

Quality assurance measures were applied throughout the study. A standardized data collection form was used to reduce variation in documentation. Staff involved in postoperative care were familiarized with the ERAS pathway and the standardized analgesic protocol. Pain assessment was performed using an appropriate validated age specific method. Data were checked for completeness and consistency before statistical analysis. Any protocol deviations were documented and reviewed. Clinical judgment remained applicable when individual patient circumstances required modification of the pathway.

Ethical Considerations

Ethical approval was obtained from the relevant institutional ethical review authority before commencement of the study. The study was conducted according to accepted principles of medical research and patient confidentiality. Written informed consent was obtained from

the parent or legal guardian of each participating child. Assent was obtained from children when appropriate according to their age and level of understanding. Patient identity was protected during data collection and analysis. Personal identifiers were not included in the analytical dataset. Participation was voluntary and refusal to participate did not affect the standard of medical care. The standardized nonopioid protocol was implemented only when considered clinically safe and appropriate for the individual patient.

Data Confidentiality

All collected information was treated as confidential. Study data were accessible only to authorized members of the research team. Patient records were reviewed only for purposes related to the study. Electronic data were maintained in a secure location with restricted access. Study findings were reported in aggregate form so that individual patients could not be identified. The collected information was used solely for research and quality improvement purposes related to pediatric perioperative recovery.

RESULTS

Patient Demographic and Clinical Characteristics

A total of 97 pediatric patients were included in the final analysis. The mean age was 8.1 ± 3.7 years. Male patients represented 55.7% of the cohort while female patients represented 44.3%. Elective abdominal procedures constituted the largest procedural group. Most patients completed the standardized ERAS pathway without major protocol deviation. Baseline characteristics are presented in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Variable	Value
Total patients	97
Mean age	8.1 ± 3.7 years
Male	54 (55.7%)
Female	43 (44.3%)
Age 1–5 years	21 (21.6%)
Age 6–10 years	43 (44.3%)
Age 11–15 years	33 (34.0%)
Elective abdominal surgery	39 (40.2%)
Urological surgery	21 (21.6%)
Hernia related surgery	19 (19.6%)
Other pediatric procedures	18 (18.6%)

The cohort demonstrated a broad pediatric age distribution. Children aged 6 to 10 years formed the largest age group. The distribution of procedures reflected the range of operations managed by the pediatric surgical service. The demographic profile indicated that the standardized protocol was applied across different pediatric age groups and surgical categories.

Implementation of the ERAS Pathway

Adherence to individual ERAS components was assessed throughout the perioperative period. Preoperative counseling was documented in most patients. Appropriate perioperative fluid management and early postoperative oral intake were achieved in the majority. Early mobilization was also frequently documented. The highest adherence was observed for standardized postoperative analgesia. The implementation findings are summarized in Table 2.

Table 2: Adherence to Individual ERAS Components

ERAS Component	Patients (%)
Preoperative counseling	91 (93.8%)
Appropriate fasting protocol	88 (90.7%)
Standardized nonopioid analgesia	94 (96.9%)
Appropriate intraoperative fluid management	89 (91.8%)
Early oral intake	84 (86.6%)
Early mobilization	81 (83.5%)
Avoidance of unnecessary tubes or drains	86 (88.7%)
ERAS pathway completed without major deviation	79 (81.4%)

Overall adherence to the ERAS pathway was high. Standardized nonopioid analgesia was achieved in 96.9% of patients. Early oral intake and early mobilization showed lower adherence because these components were influenced by procedure related factors and individual clinical recovery. Major protocol deviation occurred in 18.6% of patients. The documented deviations were mainly related to delay feeding or delayed mobilization.

Postoperative Pain Control and Rescue Analgesia

Postoperative pain was assessed using an age appropriate pain assessment scale. Pain scores generally remained within an acceptable range during the postoperative period. Most patients achieved adequate analgesia with the standardized nonopioid regimen. Rescue opioid administration was required in a minority of patients. The findings related to postoperative analgesia are presented in Table 3.

Table 3: Postoperative Pain Outcomes and Analgesic Requirements

Outcome	Value
Mean postoperative pain score at 6 hours	3.1 ± 1.2
Mean postoperative pain score at 12 hours	2.6 ± 1.1
Mean postoperative pain score at 24 hours	1.9 ± 0.9
Patients requiring rescue opioid	14 (14.4%)
Patients requiring no opioid rescue	83 (85.6%)
Mean number of rescue opioid doses	0.21 ± 0.48
Analgesia related adverse effects	7 (7.2%)

A progressive reduction in mean pain scores was observed during the first postoperative day. Rescue opioid medication was required in 14 patients. Most patients therefore achieved satisfactory pain control without opioid rescue. Analgesia related adverse effects were uncommon. The reported adverse effects consisted mainly of nausea and mild gastrointestinal symptoms. No major respiratory complication attributable to analgesic therapy was recorded.

Postoperative Recovery Outcomes

Recovery milestones were evaluated through oral feeding mobilization and hospital discharge. Most patients tolerated early oral intake and achieved mobilization during the early postoperative period. The median hospital stay was short for the majority of the cohort. The observed recovery outcomes are shown in Table 4.

Table 4: Postoperative Recovery Outcomes

Recovery Outcome	Value
Oral intake within 12 hours	84 (86.6%)
Mobilization within 24 hours	81 (83.5%)
Median time to oral intake	8 hours
Median time to mobilization	18 hours
Mean length of hospital stay	2.7 ± 1.4 days
Discharge within expected ERAS period	79 (81.4%)
Unplanned prolonged hospitalization	18 (18.6%)
Readmission within 30 days	3 (3.1%)

Early oral intake was achieved in 86.6% of patients. Mobilization within 24 hours was documented in 83.5%. The mean length of hospital stay was 2.7 ± 1.4 days. Most patients were discharged within the expected recovery period. Prolonged hospitalization occurred in 18 patients. The causes included delayed feeding and procedure related recovery. Three patients were readmitted within 30 days.

Postoperative Complications

Postoperative complications were recorded until discharge and during the available follow up period. Most patients experienced an uncomplicated recovery. Minor complications were more frequent than major complications. No mortality was observed. The complication profile is presented in Table 5.

Table 5: Postoperative Complications

Complication	Patients (%)
No postoperative complication	87 (89.7%)
Nausea or vomiting	4 (4.1%)
Surgical site infection	3 (3.1%)
Postoperative ileus	2 (2.1%)
Urinary complication	1 (1.0%)
Other minor complication	0 (0.0%)
Mortality	0 (0.0%)

An uncomplicated postoperative course was observed in 89.7% of patients. Nausea or vomiting was the most frequently documented complication. Surgical site infection occurred in three patients. Postoperative ileus occurred in two patients. One urinary complication was documented. No mortality was recorded during the study period. No major analgesia related respiratory complication was identified.

Statistical analysis demonstrated significant associations between successful ERAS adherence and selected recovery outcomes. Patients who completed the pathway without major deviation demonstrated earlier oral intake and earlier mobilization. Their hospital stay was also shorter. Rescue opioid requirements were lower among patients with high adherence. The comparative analysis is presented in Table 6.

Statistical Analysis of Recovery Outcomes

Table 6: Statistical Comparison According To ERAS Pathway Adherence

Outcome	High adherence	Major deviation	p-value
Oral intake within 12 hours	77 (97.5%)	7 (38.9%)	<0.001
Mobilization within 24 hours	75 (94.9%)	6 (33.3%)	<0.001
Rescue opioid requirement	7 (8.9%)	7 (38.9%)	0.003
Mean hospital stay	2.3 ± 0.8 days	4.4 ± 1.8 days	<0.001
Readmission	2 (2.5%)	1 (5.6%)	0.51

Patients with high pathway adherence demonstrated significantly earlier oral intake and mobilization. Rescue opioid requirement was also significantly lower in this group. A significant difference was observed in mean

hospital stay. No statistically significant difference was identified in readmission rates. These findings indicated that greater adherence to the standardized ERAS pathway was

associated with improved early postoperative recovery.

Overall Findings

The overall findings demonstrated successful implementation of the ERAS pathway among the pediatric surgical population. Standardized nonopioid analgesia was achieved in the majority of patients. More than four fifths of patients achieved early oral intake and early mobilization. Opioid rescue therapy was required in a relatively small proportion of patients. The mean duration of hospitalization remained limited. Most patients experienced an uncomplicated postoperative course.

The statistical analysis further demonstrated that patients with higher ERAS adherence experienced more favorable recovery milestones. Earlier oral intake and mobilization were observed in the high adherence group. A significant reduction in rescue opioid requirement was also observed. Hospital stay was significantly shorter among patients with high adherence. These findings suggested that consistent implementation of a standardized perioperative pathway may support faster postoperative recovery while reducing reliance on opioid analgesia.

The findings also demonstrated that the benefits of ERAS extended beyond pain management. Early feeding and mobilization were achieved in most patients. Low postoperative complication rates were observed. Readmission remained uncommon. These outcomes support the potential value of integrating standardized nonopioid analgesia with other ERAS components rather than evaluating analgesia as an isolated intervention.

The results therefore indicated that implementation of a structured pediatric ERAS pathway was feasible within the study setting. High adherence was associated with favorable postoperative recovery indicators. Standardized nonopioid pain management appeared to reduce the requirement for rescue opioid therapy while maintaining acceptable postoperative pain control. The findings provide a basis for further evaluation of pediatric ERAS protocols in larger prospective studies and across different surgical populations.

DISCUSSION

The present study evaluated the implementation of an Enhanced Recovery After Surgery pathway incorporating standardized nonopioid pain management in pediatric surgical patients. A total of 97 children were

assessed during the study period. The findings demonstrated that implementation of the pathway was feasible within a pediatric surgical service. High adherence was observed for standardized nonopioid analgesia and other important ERAS components. Early oral intake and early mobilization were achieved in most patients. Rescue opioid administration was required in only a minority of patients. These findings indicate that structured perioperative care can support recovery while limiting routine opioid exposure in children.

The demographic distribution in the present study demonstrated representation across several pediatric age groups. Children between 6 and 10 years formed the largest proportion of the cohort. A modest male predominance was observed. Similar demographic patterns have been reported in pediatric surgical populations where boys frequently constitute a slightly larger proportion of surgical admissions. Such variation may reflect differences in the frequency of individual pediatric surgical conditions rather than an effect of the ERAS pathway. The broad age distribution in the present cohort also demonstrated that standardized recovery principles can be applied across different developmental stages when appropriate age specific assessment methods are used.¹¹

The high level of adherence to standardized nonopioid analgesia represented an important finding. More than 95 percent of patients received the planned analgesic pathway. Previous pediatric ERAS research has demonstrated that standardized analgesia can improve consistency in postoperative pain management and can reduce unnecessary opioid exposure.¹² The present findings are compatible with those observations. Standardized treatment schedules may reduce reliance on individual prescribing preferences. Such consistency can be particularly valuable in pediatric surgery because medication doses require consideration of body weight and developmental factors.

The reduction in pain scores during the first postoperative day provided additional evidence of satisfactory analgesic control. Mean pain scores declined progressively during the observation period. This pattern suggests that adequate analgesia was maintained while the acute postoperative pain response gradually diminished. Similar improvements in postoperative pain have been described after implementation of multimodal analgesic pathways in children.¹³ The current findings

therefore support the concept that opioid reduction does not necessarily require acceptance of inadequate pain control. Appropriate combinations of nonopioid medicines and supportive measures can provide clinically acceptable analgesia for many pediatric procedures.

Rescue opioid administration was required in 14.4 percent of patients. This finding is important because ERAS principles do not require absolute opioid avoidance. Instead opioids can be reserved for patients who experience breakthrough pain despite appropriate nonopioid treatment. Earlier investigations of pediatric multimodal analgesia have reported reductions in opioid consumption after standardized protocols were introduced.¹⁴ The relatively low requirement for rescue opioids in the current study may indicate that scheduled nonopioid treatment was effective for most patients. The finding also demonstrates the importance of maintaining access to rescue analgesia when clinically indicated.

The use of nonopioid analgesia may provide several advantages beyond reduction in opioid exposure. Opioid medicines can contribute to sedation respiratory depression nausea vomiting constipation and delayed functional recovery. Pediatric patients may be particularly vulnerable to these effects because physiological responses and drug metabolism vary with age. Previous research has therefore supported the incorporation of acetaminophen nonsteroidal anti inflammatory medicines regional techniques and local anesthetic approaches into multimodal pediatric pathways.¹⁵ The low frequency of analgesia related adverse effects observed in the present study is consistent with the safety profile reported in previous pediatric enhanced recovery research.

The present study also demonstrated that ERAS should not be viewed solely as a pain management intervention. The pathway incorporated preoperative counseling fasting optimization fluid management early feeding early mobilization and avoidance of unnecessary devices. This broader approach is consistent with the fundamental ERAS principle that postoperative recovery is influenced by multiple interacting factors. Previous pediatric studies have shown that comprehensive ERAS pathways can improve recovery milestones while reducing hospital utilization.¹⁶ The present results similarly demonstrated that

most children achieved early feeding and mobilization.

Early oral intake was achieved within 12 hours in 86.6 percent of patients. This finding supports the safety and feasibility of early feeding when procedure specific and clinical criteria are considered. Traditional postoperative practice may involve prolonged fasting because of concerns regarding nausea ileus or aspiration. Modern perioperative care has increasingly challenged unnecessary fasting and delayed feeding. Previous pediatric ERAS investigations have demonstrated earlier return to enteral nutrition following standardized recovery pathways.¹⁷ The present findings are therefore compatible with the growing evidence supporting early nutritional recovery after pediatric surgery.

Early mobilization was achieved within 24 hours in 83.5 percent of patients. Mobilization represents an important functional outcome because prolonged immobility can contribute to discomfort reduced physical activity and delayed discharge. Pediatric patients may also experience anxiety when movement is associated with pain. Effective analgesia can facilitate confidence and willingness to mobilize. Previous studies have associated ERAS implementation with earlier mobilization and improved functional recovery.¹⁸ The present findings support this relationship and suggest that effective nonopioid analgesia may facilitate early activity when combined with appropriate nursing support and caregiver involvement.

The mean hospital stay was 2.7 days. Patients with high pathway adherence had a significantly shorter hospital stay compared with patients who experienced major protocol deviations. Similar reductions in hospitalization have been reported after pediatric ERAS implementation.¹⁹ Shorter hospitalization may result from the combined effect of earlier feeding earlier mobilization improved pain control and reduced postoperative complications. It is therefore difficult to attribute the reduction in length of stay to analgesia alone. Nevertheless effective pain control may represent an important enabling component because children who remain comfortable are more likely to tolerate feeding and mobilization.

A major finding was the significant relationship between pathway adherence and early recovery. Patients with high adherence demonstrated substantially higher rates of early oral intake and mobilization. They also required

less rescue opioid therapy. These findings suggest that successful ERAS implementation depends on consistent application of multiple components rather than isolated adoption of a single intervention. Previous implementation research has shown that adherence can influence the magnitude of benefit obtained from enhanced recovery programs.²⁰ The present study provides similar evidence within a pediatric surgical population.

The occurrence of postoperative complications was low in the current cohort. Nearly 90 percent of patients experienced no documented postoperative complication. Nausea and vomiting represented the most frequent adverse clinical event. Surgical site infection and postoperative ileus were less common. No mortality was observed. Previous pediatric ERAS studies have generally reported that pathway implementation does not increase postoperative complication rates.²¹ The current findings are consistent with this observation. The low complication burden may also have contributed to earlier achievement of recovery milestones.

Readmission occurred in three patients. No statistically significant relationship was identified between ERAS adherence and readmission. This result should be interpreted carefully because the sample size was limited and the number of readmission events was small. Previous literature has generally reported that reduced hospital stay associated with ERAS can be achieved without a clear increase in readmission.²² The current findings provide similar reassurance although larger studies are required to determine whether standardized nonopioid pathways have any meaningful effect on post discharge healthcare utilization.

The implementation process itself is an important aspect of these findings. High adherence was achieved despite the practical challenges associated with pediatric perioperative care. Protocol implementation requires coordination between surgeons anesthesiologists nurses and caregivers. Staff familiarity with the pathway can reduce variation and improve compliance. Previous implementation studies have emphasized that education audit feedback and clear documentation are important for maintaining ERAS adherence.²³ The current findings reinforce the importance of multidisciplinary collaboration when standardized pediatric recovery pathways are introduced.

The study also highlights an important distinction between protocol standardization

and rigid clinical management. A standardized pathway should provide a framework for predictable care while allowing modification when patient specific factors require a different approach. Children undergoing surgery differ in age procedure severity comorbidities pain tolerance and recovery rate. The pathway must therefore remain adaptable. The low rate of major protocol deviation observed in the present study suggests that most patients could be managed successfully within the planned framework while individualized clinical judgment remained available.

The findings have practical implications for pediatric surgical services. A structured nonopioid pathway may help reduce routine opioid exposure without compromising postoperative comfort. The pathway can also provide clear expectations for feeding mobilization and discharge. Standardized documentation may improve communication between healthcare professionals and caregivers. These advantages may be particularly relevant in busy surgical units where variability in postoperative prescribing can otherwise occur.

The results should however be interpreted in the context of the study design. The sample consisted of 97 patients from a single institution. Differences in surgical procedures and patient characteristics may have influenced recovery outcomes. The absence of a larger multicenter population limits generalizability. The study also focused on early postoperative outcomes and therefore provides limited information regarding longer term functional recovery. Further research involving larger cohorts and multiple pediatric surgical centers would allow more robust assessment of pathway effectiveness.

The present findings suggest that implementation of ERAS with standardized nonopioid analgesia can be associated with improved early recovery in pediatric surgical patients. The reduction in rescue opioid requirements together with favorable pain scores indicates that opioid sparing care can be achieved without apparent compromise in postoperative analgesia. Early feeding and mobilization were also commonly achieved. The relationship between pathway adherence and shorter hospitalization further supports the value of consistent ERAS implementation.

Future research should focus on multicenter prospective evaluation with larger sample sizes and procedure specific analysis. Comparative assessment against conventional postoperative

care would provide stronger evidence regarding the independent contribution of standardized nonopioid analgesia. Longer follow up could evaluate functional recovery caregiver satisfaction and post discharge healthcare utilization. Further evaluation of protocol adherence could also identify specific barriers to implementation and determine which ERAS components provide the greatest contribution to recovery.

Overall the findings indicate that a structured pediatric ERAS pathway can be incorporated into routine surgical care with high adherence. Standardized nonopioid analgesia can form an important component of this pathway. The observed reduction in opioid rescue requirements together with earlier feeding mobilization and discharge suggests that coordinated perioperative care may improve recovery while limiting unnecessary opioid exposure.

The present study supports continued development of pediatric ERAS programs with emphasis on standardized analgesia multidisciplinary coordination and individualized

clinical safety. Broader implementation and larger comparative studies are required before the observed associations can be generalized across different pediatric surgical settings. The findings nevertheless provide useful local evidence supporting structured nonopioid pain management as part of comprehensive enhanced recovery care.

CONCLUSION

Standardized nonopioid analgesia was associated with favorable postoperative recovery in pediatric surgical patients. Earlier feeding and mobilization were achieved while opioid rescue requirements were reduced. The ERAS pathway was successfully implemented with acceptable postoperative safety outcomes.

Limitations

The study was conducted at a single center with a relatively small pediatric sample. Variation in surgical procedures may have influenced the observed recovery outcomes. The absence of a larger comparative cohort limited the strength of causal interpretation.

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