



Enhancing pediatric postoperative pain management: strategies, challenges, and innovations – a comprehensive review and observational study

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Children's postoperative pain is an important issue in perioperative management, with potential impacts on both physiological and psychological development. It may lead to sleep disturbances, wound dehiscence, bleeding, and delayed recovery in children^[1]. Management of postoperative pain in children is an essential task aimed at effectively alleviating and controlling the potential pain experienced by children after surgery. With the continuous advancement of medical technology and societal emphasis on patient comfort, postoperative pain management has become a significant aspect of clinical practice. Managing postoperative pain in children faces challenges such as the complexity of pain assessment, the necessity of personalized management, and gaps in knowledge regarding non-pharmacological treatments. Difficulty in pain assessment primarily stems from limitations in children's ability to self-assess, necessitating the use of more targeted assessment tools for different age groups. Personalized management is particularly important considering the variability among children, making it essential to devise customized treatment plans. We emphasize the importance of individualized management, comprehensive analgesic strategies, preoperative education, and family support and propose strategies and recommendations to enhance the management of postoperative pain in children. Through in-depth research on the management of postoperative pain in children, our aim is to provide guidance for clinicians, nursing staff, and researchers, facilitate the improvement of postoperative pain management in children, and enhance their quality of life and recovery outcomes after surgery.

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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International Journal of Surgery (2024) 110:4543–4546

Received 27 February 2024; Accepted 25 April 2024

Published online 9 May 2024

<http://dx.doi.org/10.1097/JS9.0000000000001585>

For a long time, postoperative pain in children has been severely overlooked, especially since some children, particularly infants and toddlers, may not actively complain of pain. Assessing pain in children is relatively more challenging compared to adults. Self-assessment is the primary method for evaluating pain and is applicable to children aged 8 and above. Commonly used methods include the Visual Analog Scale (VAS), Numeric Rating Scale (NRS), and Manchester Pain Scale^[2]. Behavioral assessment methods include CRIES, FLACC, CHEOPS, and Comfort scores, which assess the child based on factors such as facial expression, behavior, and crying^[3]. Assessment Methods for Pain Management in Children are presented in Table 1. Currently, there is no ideal assessment scale applicable to all types of pain or all age groups of children. The impact of postoperative pain on children's physiological health is multifaceted. Pain can lead to changes in immune function, thereby affecting children's immune responses. Research indicates that persistent pain states can activate the immune system and inflammatory responses, making children more susceptible to infections and diseases^[4]. Pain can lead to loss of appetite and decreased food intake, subsequently affecting children's nutritional status and postoperative recovery, increasing the risk of complications such as wound dehiscence. Additionally, postoperative pain can trigger anxiety and depression in children^[5]. Persistent pain can cause children to feel fearful, helpless, and depressed, thereby affecting their emotional state and mental health. Pain also disrupts children's sleep, leading to difficulties falling asleep, shallow sleep, and frequent awakenings.

Preoperative preparation and education play crucial roles in the management of postoperative pain in children. Preoperative preparation involves assessing the child's pain sensitivity and special needs to develop personalized pain management plans. Preoperative education provides information to both the child and parents about the surgical process and postoperative pain management to enhance their understanding and cooperation. We utilize multimedia educational resources, such as videos and animations, to provide detailed information and guidance about the surgical process and postoperative pain management to children and parents. This approach is vivid and intuitive, enhancing understanding and willingness to cooperate. We design child-friendly educational tools, such as comic books, games, and toys, to convey knowledge through interaction and entertainment, reducing fear and anxiety. We emphasize parental involvement and training to help them understand the importance of pain management and enhance support and cooperation. Through adequate preoperative education, anxiety and fear

Table 1
Assessment methods for pain management in children

Valuation tool name	Brief description	Applicable age range
Visual Analog Scale (VAS)	Patients indicate the intensity of pain by pointing to a point on a line, with endpoints indicating 'no pain' and 'worst imaginable pain'	Children aged 8 and above
Numeric Rating Scale (NRS)	Patients rate their pain intensity on a scale from 0 'no pain' to 10 'worst pain'	Children aged 8 and above
Manchester Pain Scale	Assesses children's pain by combining facial expressions, body movements, and comfort	All ages of children
CRIES Score	Designed for newborns, including cry, oxygen requirement, heart rate, expression, and sleep state	Newborns
FLACC Score	Scores based on facial expressions, leg movements, activity, cry, and comfort	Children aged 3 months to 7 years
CHEOPS Score	Evaluates pain in children based on cry, facial expression, movement, sleep state, and interaction with parents	Children aged 1 and above
Comfort Score	Mainly used to assess comfort and pain in children in intensive care units, including alertness, tranquility, breathing, movement, muscle tone, and facial expression	All ages of children
Non-Communicating Children's Pain Checklist (NCCPC-PV)	Designed for non-communicating children, assessing pain through observed behaviors	Non-communicating children of all ages
Pediatric Pain Profile (PPP)	Helps children express pain intensity through a series of pictures	Children aged 4 and above
Premature Infant Pain Profile – Revised (PIPP-R)	For premature and full-term infants, including heart rate, oxygen saturation, brow bulge, eye squeeze, sleep state, and nurse-assessed pain behavior	Premature and full-term newborns

about surgery and pain in children and parents can be reduced, leading to increased confidence and cooperation in coping with postoperative pain^[6].

The severity of postoperative pain in children varies depending on the type and extent of surgery. Postoperative pain typically occurs within 24–72 h after surgery and may persist for days or weeks. The principles of pediatric postoperative analgesia involve employing a multimodal approach, which combines different drugs or methods to synergistically achieve optimal analgesic effects with minimal adverse reactions. Commonly used drugs include non-steroidal anti-inflammatory drugs (NSAIDs) (such as acetaminophen, ibuprofen), tramadol, codeine, potent opioids (such as morphine, fentanyl, sufentanil, hydromorphone), and dexmedetomidine. Common methods include regional blocks, epidural analgesia, and intravenous analgesia. Although there is relatively limited evidence from evidence-based medicine, studies have shown that the combined use of NSAIDs (acetaminophen, ibuprofen) can better alleviate postoperative pain in children and reduce adverse reactions^[7]. Therefore, the American Pain Society strongly recommends its use as a routine medication in pediatric postoperative multimodal analgesia^[8]. In addition, the use of regional nerve blocks in the perioperative period for children has also been promoted, with studies demonstrating its optimization of postoperative pain management. While continuous peripheral nerve catheters have shown good efficacy in pediatric postoperative analgesia, they may be associated with complications such as catheter malfunction or block failure. Therefore, anesthesiologists should consider performing appropriate regional nerve blocks based on the surgical site, especially for children expected to experience prolonged postoperative pain, where catheter placement with continuous infusion of local anesthetics should be considered. Ultrasound-guided nerve blocks are widely used in children, improving the success rate of nerve blocks, prolonging the duration of drug action, and offering greater safety, visibility, and efficiency. Ultrasound guidance enables real-time monitoring of nerve block localization and drug diffusion, resulting in better analgesic effects for children under general anesthesia or sedation^[9]. Children's physiology impacts drug selection and safety. High metabolism requires dosage adjustments based on age and weight. Immature organ function raises

toxicity risks. Individualized management considers factors like pain perception and medical condition to optimize pain relief while minimizing side effects.

Non-pharmacological therapies play a crucial role in pediatric postoperative pain management, including behavioral and cognitive interventions. Behavioral interventions focus on reducing pain stimuli by providing a comfortable environment, avoiding bright lights, noise, and excessive touching. In pediatric postoperative pain management, utilizing cognitive-behavioral therapy involves educating children about pain cognition and teaching effective coping strategies, such as deep breathing and relaxation training, to alleviate pain sensations and anxiety. Additionally, employing distraction techniques and entertainment therapies like music therapy and games helps redirect children's attention, reducing pain perception and enhancing psychological comfort. Methods such as sweet-tasting solutions, kangaroo care, and non-nutritive sucking are also effective. Cognitive interventions involve creating a relaxed, free, and open medical environment, allowing parental presence, educating parents about pain-related knowledge, and providing proper encouragement and support, which help reduce anxiety and fear in children^[10]. Other methods such as hypnosis, imagery, role-playing, relaxation training, and distraction techniques are also effective in alleviating pain in children. The summary of measures for pediatric postoperative pain management is shown in Table 2.

Individualized management is particularly important in the management of postoperative pain in children. Due to limitations in children's self-assessment abilities, particularly in younger or less developed children, and significant differences in pain manifestations among different age groups, more targeted assessment tools are needed. Taking into account factors such as cultural backgrounds and family environments, it's crucial to prioritize individual differences in pain assessment and treatment, implementing targeted interventions for optimal pain relief. Comprehensive pain management strategies are indispensable; by combining different drugs or methods, we can achieve optimal analgesic effects while minimizing adverse reactions. Additionally, the importance of preoperative education cannot be underestimated; adequate information and support can reduce preoperative anxiety and fear in both children and parents,

Table 2
Summary of measures for pediatric postoperative pain management

Measures	Description
Multimodal Pain Management	Utilizing a combination of various drugs and methods to alleviate pain while minimizing adverse reactions
Pharmacological Treatment	Commonly used drugs include NSAIDs, potent opioids, local anesthetics, etc., selecting appropriate medications based on the severity of pain, age, and physiological characteristics of the child
Regional Nerve Blocks	This includes local anesthetic injections or continuous nerve block techniques to alleviate postoperative pain by blocking pain signal transmission
Intravenous Analgesia	Administering medication through the intravenous route, commonly used for postoperative pain relief, including drugs such as morphine, fentanyl, etc.
Cognitive-Behavioral Therapy	Educating children on coping strategies such as deep breathing, relaxation training, etc., to help alleviate pain perception
Entertainment Therapy and Distraction Techniques	Utilizing entertainment methods such as music therapy, games, etc., to distract children's attention and reduce pain perception
Parental Involvement and Support	Emphasizing the involvement and support of parents, providing emotional and psychological support during postoperative pain management for children
Individualized Treatment	Tailoring treatment based on the child's physiological characteristics, age, pain severity, surgical type, etc., to achieve optimal therapeutic outcomes

increasing their confidence and willingness to cooperate with postoperative pain management. Family support and involvement are crucial for children's recovery; their understanding and support can help children better cope with postoperative pain and promote recovery. Finally, non-pharmacological treatment methods also play an important role in the management of postoperative pain in children, helping to alleviate pain by reducing pain stimuli or altering children's perception of pain. In summary, our clinical guidelines aim to provide practical guidance for clinicians, nursing staff, and researchers, promoting the improvement of postoperative pain management in children and further enhancing patients' quality of life and postoperative recovery outcomes.

In summary, the management of postoperative pain in children is crucial but challenging. Individualized care, comprehensive pain management strategies, preoperative education, and family support are essential. Through relentless efforts, we aim to further improve the level and effectiveness of postoperative pain management in children, contributing more to their health and recovery.

Ethical approval

No ethical approval is required for these types of articles.

Consent

No consent is required for these types of articles.

Source of funding

No funding was received.

Author contribution

C.T.: conceptualization and writing; J.L.: design and conceptualization; C.T. and Y.C.: review, editing, and supervision.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research registration unique identifying number (UIN)

- 1. Name of the registry: not applicable.
- 2. Unique identifying number or registration ID: not applicable.
- 3. Hyperlink to your specific registration (must be publicly accessible and will be checked): not applicable.

Guarantor

Chengpin Tao.

Data availability statement

No data was generated during the writing of this study.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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