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## Postoperative pain: factors and tools to improve pain management in children

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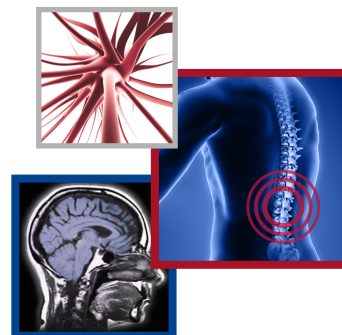
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### Practice points

#### Background

- Outpatient surgeries are becoming more common and therefore postoperative pain management is transitioned to parents and/or guardians which has been correlated to suboptimal pain management.

#### Recommendations for pain assessment

- Because children express pain in variable ways depending on their age and developmental abilities, there are multiple ways to assess pain.

#### Cultural factors & pain

- Cultural factors such as language, socioeconomic status, stoic beliefs and biological differences (e.g., oxytocin) among groups may predispose parents and healthcare providers to treat child's pain suboptimally.

#### Parent pain management of child pain

- Parental beliefs about medications, misconceptions about pain expression and the opioid crisis modulation of parental attitudes have led parents to suboptimally treat pain.

#### Tools & technological interventions targeting parental management of children's pain

- Tools and technological interventions have been developed to help parents assess and treat their child's pain.

#### Best practices

- Child postoperative pain is complex, and therefore, its essential for healthcare providers and parents to work together to assess and treat pain considering cultural and developmental factors, along with accessible tools to further improve pain management.

Outpatient surgery has made it increasingly common for parents to manage pain in the home setting. Studies have shown that parents often under treat pain, leaving children vulnerable to the negative side effects of suboptimal pain management. Multiple factors affect pain management like child's age and developmental stage, language, cultural values like stoicism, parental beliefs about medication, biological differences among groups, etc. Understanding all the factors involved can help healthcare providers and parents better understand pain and contribute to optimal pain management. Multiple tools and technological interventions have been created to help create a better understanding of pain and a holistic approach to care.

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Although pain is an evolutionarily beneficial sensation that can promote avoidance behavior towards harmful stimulus [1], it is also an unpleasant sensory and emotional experience [2] that can lead to a variety of potentially negative sequelae [3]. Thus, rather than attempting to eradicate the pain experience, it is necessary to develop strategies to manage pain in the most efficient and optimal way possible. Despite the fact that pain is a universal experience, there are a variety of factors that impact pain experience. These include, but are not limited to prior

pain experience, age and development, ethnic and cultural background and beliefs about pain [4,5]. In addition, adults charged with managing children's pain, including healthcare providers and caregivers are influenced by their own experiences with and beliefs about pain and may also be subject to variations in hospital practice, including the growing awareness of the opioid crisis in the context of pain management [6]. Thus, adequately managing pain in children is complex and evidence suggests that pain is overwhelmingly undertreated in children, particularly in the home setting [7].

Surgery is a common medical procedure that subjects children to pain, with over 85% of children experiencing pain postoperatively [8,9] and 63% experiencing clinically significant pain upon transition to home [8,10–12]. Furthermore, the implications of postoperative pain are not limited to immediate consequences. Poorly managed postoperative pain could lead to unanticipated hospitalization [13], development of chronic pain [14], increased sensitivity to pain [15] and increased pain and anxiety during medical events that take place later in life [16]. It is especially important to advocate for optimal pain management for children because consequences of untreated pain can lead to maladaptive behavioral changes, increased reliance on analgesics and delayed postoperative recovery [16]. Children who have inadequate pain management may also be subject to a decrease in immune and neuroendocrine function later on in life [17]. Upon discharge following a surgical procedure, the burden of pain management is transferred from the healthcare provider to the parent, making it even more imperative that parents have knowledge in the most appropriate methods of assessing children's pain. Therefore, the purpose of this paper is to highlight pain management as a complex and multifaceted phenomena and to provide recommendations of factors that are necessary to consider in optimal pain management, including developmental stages, methods for pain assessment, cultural factors, parental practice of pain management at home and available tools.

### Pain assessment

It is important to note that children express pain in varying ways that are dependent on age and developmental stage [18]. Modes of pain expression include, but are not limited to, verbalizing, crying and wailing. Behavior change may also be a strong indicator for parents to know that their child is in pain; in the case of older children, silence may be observed in conjunction with behavioral withdrawal when experiencing pain [19]. These differential expressions of pain based on developmental stages have implications for how parents assess children's pain severity. For parents and caregivers, pain is more easily assessed when the child is able to vocalize their pain experience; however, frequency of verbalizing pain experience is highly dependent on the age and cognitive developmental stage of the child [20]. When children are unable to vocalize their pain verbally (e.g., infants, cognitively impaired and sedated children), assessment of pain is more difficult for both healthcare providers and parents because pain assessment is not as simple as asking the child about their discomfort.

Historically, self report has been considered the gold standard for assessment of pain severity. However, this poses an obstacle for children who lack the ability to verbally report their pain due to age or developmental delay/cognitive impairment. Moreover, in recent years it has been proposed that relying on self-reported pain severity for intervention leads to an oversimplification of the pain experience as a whole [21] since children interpret pain scores in varying ways. That said, self-reported pain should still be the cornerstone of assessment in conjunction with contextual factors, clinical history and previous response to pain experiences [21,22]. Several child-report pain measures have been developed to assess ratings of pain severity in preschool/school-aged children. These include the Wong–Baker FACES Scale (used for children aged 3 and older) [23] and the Faces Pain Scale-Revised (used for children aged 4–12) [24]. These scales allow children to point to their level of pain depicted through faces. Moreover, for children over the age of 7 the Visual Analog Scale is a tool that allows children to point to their level of pain on a line 100-mm long with one end representing 'no pain' and the other representing 'worst pain' [25].

There are a number of validated observational tools that are currently used for pain assessment in non- and preverbal children. For infants, the Neonatal Infant Pain Scale [26] and the Face, Legs, Activity, Cry and Consolability (FLACC) scale (used for children under 4) [27] each provide observers with a checklist to assess pain-related behaviors. It is worth mentioning that recent findings have shown that the FLACC is most useful when used by nonexperienced rather than experienced nurses [28]. Nonetheless, the FLACC remains the most widely used tool in the hospital setting [29]. Observational measures can also be utilized for children with cognitive disabilities. For example, the Non-communicating Children's Pain Checklist, an observational measure and the FLACC have both been utilized to assess pain in children with disabilities [30–32].

The Parents Postoperative Pain Measure (PPPM), is a 15-item checklist containing behaviors that indicate pain (e.g., whining and holding the body area in pain) and behaviors that indicate recovery. Parents Postoperative Pain

Table 1. Pain assessment approaches.

Approach	Tool/measure	Description
Healthcare provider report	Faces, Legs, Activity, Cry, and Consolability Scale [38]	A validated observational tool used for pain assessment in non- and preverbal children, for ages 4 and under and/or for children with cognitive disabilities. Observers select pain-related behaviors from a checklist for a total score between 0 and 10
	Non-Communicating Children's Scale [39]	An observational pain measure used for children with cognitive disabilities. This measure prompts healthcare professionals to award a score of 0–3 (0 being not often and 3 being very often) to assess how often vocal, social, facial, activity and physiological indicators of pain occur. The score is summed to yield an overall pain score
	Context, Assess Pain Expression, Risk Factors, Emotional Factors, and Sociocultural factors [36]	A bundled approach that values the context, pain expression assessment, risk factors, emotional factors and sociocultural factors to yield an accurate assessment for pain
Parent report	Hierarchical approach [36]	A hierarchical approach, similar to CARES in its components, ranks self report as the highest factor when assessing pain in children
	Parents Postoperative Pain Measure [33]	A 15-item checklist designed for children ages 7–12 years containing behaviors that indicate pain and recovery (e.g., whining), allowing parents to assess their child's pain. It is the only validated measure for parental report in research studies. Scores range from 0 to 15; >6 = clinically significant pain
	Wong Baker Faces Scale [40]	A self-report scale designed for children ages 3 and older. Children point to their level of pain depicted through six faces differing in their facial expression and corresponding numerical value ranging from 0 to 10
	Faces Pain Scale-Revised [41]	A self-report scale used for children ages 4 and older that allows children to point to their level of pain depicted through six faces differing in their facial expression and corresponding numerical values ranging from 0 to 10
Child report	Visual Analog Scale [42]	A self-report scale that allows children to select their level of pain based on a 100-mm horizontal line with anchors at each end such that 0 = no pain experienced and 100 = worst pain experienced. This scale is used for children over the age of 7
	Blood pressure [34]	Changes in blood pressure and heart rate may indicate severity of pain experienced through an objective lens
	Functional MRI [35]	Neuroimaging can allow healthcare providers to measure changes in chemical pathways to obtain an objective measure of pain severity

Measure (PPPM) has been an essential tool in research studies because it is the only validated measure for parental report of child pain [9–11,33]. This tool is useful because it allows parents to correlate behavior with pain levels and lead to better assessment of pain medication postsurgery.

Physiological measures can also be helpful to take a more holistic approach when treating pain. Changes in blood pressure and heart rate can aid in determining the severity and impact of pain [34]. In addition, neuroimaging has bridged the gap between brain activity and pain experience by allowing researchers to measure changes in endogenous chemical pathways in response to painful experiences. There is no specific 'pain center' in the brain, but rather six areas of the brain including the thalamus and anterior cingulate cortex that consistently respond to acute pain [35]. Physiological measures outlined above can be utilized in conjunction with self-assessment tools and observational measures to adequately treat pain.

Finally, both a bundled and hierarchical approach have been propositioned to assess pain holistically [21]. The bundled approach centers on the acronym 'CARES' which stands for 'Context, Assess Pain Expression, Risk Factors, Emotional Factors and Sociocultural factors'. Each of these components are taken into consideration together to yield an accurate assessment for pain. In contrast, the hierarchical approach, advocated by the American Society for Pain Management in Nursing [36], brings the same factors as 'CARES' into consideration, but with self report being of most importance to care-providers when assessing pain [37]. Clinical judgment is a catalytic factor for effective evaluation in both of these two propositioned heuristic approaches which requests the need for a simplified yet multifaceted process in addressing pain management. A summary of assessment tools for pain is included in Table 1.

### Cultural factors & pain

There are many cultural factors such as language, socioeconomic status (SES), stoicism and biological differences (levels of oxytocin) among groups that can impact pain experience [43–46]. Language is an important cultural mediator that can affect how parents manage pain. Language fluency can impact health literacy and ability to adequately convey/comprehend recommendations for pain management that may lead to inadequate pain management (e.g., low medication adherence) [43]. Moreover, it has been observed that Spanish-speaking parents

may be more likely to experience misconceptions regarding analgesic use for children (e.g., fear of medication side effects) compared with English-speaking parents, ultimately contributing to providing fewer doses of analgesics after children's surgery [47]. English-speaking Hispanic parents have been found to be less likely to use analgesics for their child's pain compared with English-speaking White parents and Spanish-speaking Hispanic parents [48]. A possible reason for this observation may be that English-speaking Hispanic parents are bicultural, which places parents between two possible modes of treating pain, traditional with respect to their Hispanic culture and more conventional methods utilized in Western medicine [49]. Thus, it is important to consider how acculturation may impact children's pain management practice in the home setting.

Cultural values such as stoicism, enduring pain without expression or complaint, in Hispanic culture may play a role in pain expression and therefore affect pain management [45]. It is important to note; however, that stoicism is a multidimensional moderator that also includes sociocultural factors (e.g., employment and community) [50]. When faced with pain, individuals from a Hispanic culture often face this adversity in a stoic manner believing that lower pain expression is a reflection of personal strength and pride [45]. In a cohort of Hispanic adults undergoing cancer pain management, stoicism was observed to be a common response to pain [45]. Given that stoicism may be common in Hispanic culture, stoicism expressed by children may lead parents to believe that their child is not experiencing pain and therefore administer less medication for their pain [49]. Stoicism could be an explanatory variable in a study showing that Hispanic children who underwent outpatient tonsillectomy and adenoidectomy received suboptimal pain management [10]. Further research is necessary to show this correlation. Because pain expression is often gauged by observing child behavior or verbal expression [20], children who experience stoicism may be at a disadvantage. Therefore, paying attention to cultural factors like stoicism will be useful for both parents and healthcare providers.

Biological processes may have an influence on how different ethnicities perceive pain as well as experience it. For example, oxytocin, commonly known as the good-feeling neuromodulator, has been shown to inhibit pain sensation [51]. Oxytocin is produced and released from the hypothalamus, having downstream effects in the spinal cord and blood stream, inhibiting pain sensation by repressing pain fibers with oxytocin; therefore, preventing nociceptive signals from being perceived (limited to mechanical and thermal sensitivities in inflammatory responses) [51]. Historically, it has been shown that African Americans have a tendency to experience more pain than non-Hispanic whites [46]. In a study comparing oxytocin levels in African American women versus white women when undergoing a pain task, African Americans had lower levels of oxytocin [46]. Moreover, this result also reflects the fact that African American women had lower pain tolerance to the experimental stressors [46]. This research shows that there may be biological processes that differ, affecting how different racial/ethnic groups may experience pain sensitivity.

Although cultural and socioeconomic factors may be difficult to parse out, distinguishable characteristics of each are important in determining a child's pain experience. Several studies have shown the association between SES and the experience of pain. Specifically, it has been observed that individuals living in less affluent socioeconomic areas experience a higher prevalence of pain [44]. On an individual level, lower SES based on education [52] and income [53] has been correlated with a higher frequency and intensity of pain. Families with lower SES may have more limited resources and lower health literacy that ultimately impacts children's pain experience and management.

### Parent management of child pain

Because there has been a shift to conducting surgeries for children on an outpatient basis [54], parents are left with the responsibility to manage their child's pain at home. It has been observed; however, that parents often provide suboptimal pain management. For example, children undergoing tonsillectomy and adenoidectomy, a common pediatric surgical procedure, were given fewer doses than the optimal number parents are instructed to administer [10]. Of the doses provided, 70% were considered subtherapeutic, leaving pain untreated [48]. It has also been observed that parents may modify provider pain management instructions. More specifically, parents may provide alternative pain medications (e.g., over-the-counter instead of prescription) or provide medications less frequently over a longer period of time [55–59]. Parents have been shown to display misconceptions such as medications should be given only if their child is displaying intolerable pain or less medication is better [60]. It is also possible that parents have fears of possible addiction. In addition, parents often believe that children cry when they are in pain and therefore may not provide medication when their child is quiet, but may still be experiencing pain [60]. Moreover, parents may hold ideas that children complain and express their pain for other reasons such as wanting attention [60]. Thus, parents who are not able to detect pain will likely be unable to optimally treat pain

adequately. In addition, these misconceptions have been linked to the provision of fewer analgesics to children after surgery [48].

It is difficult to directly pinpoint the causes of suboptimal pain management at home by parents, because in addition to parental attitudes, child responsiveness and systemic factors influence medication administration and therefore, pain management. For instance, a child may refuse to take medications resulting in inadequate doses. Systemic factors such as difficulty obtaining medications may consequently affect medication administration [61]. With such a wide range of contributing factors, it is clear that pain management is difficult and therefore, should be viewed with a holistic lens. In order to appropriately consider a multifaceted approach, it is necessary to understand familial context and educate on the risks of suboptimal pain management.

The opioid epidemic may further influence parental attitudes towards administering proper analgesic dosages to their children in the home setting. This epidemic has affected children and adolescents; hospitalizations caused by opioid poisonings have nearly doubled over a span of 15 years from 1997 to 2012 [62]. More recently, hospitalizations for opioid poisoning increased from 6.7 per 10,000 admissions in 2004 to 10.9 per 10,000 admissions in 2015 [63]. Although episodes of opioid poisoning are greater in older adolescents (15–19 years of age), the greatest jump in opioid poisonings occurred in children aged 1–4 years [62]. These trends indicate that pain management is not only about preventing suboptimal pain management by under treating pain, but also preventing medication overuse. Because of increased incidence of use and abuse of opioid medications, parental attitudes affected by the opioid crises may influence proper dosage given postsurgery, whether that be under treatment or over treatment.

Although there is substantial evidence that parents tend to provide suboptimal treatment in the home setting, a recent study has shown that parents may be better at estimating children's pain compared with physicians [64]. Moreover, a recent qualitative study by Rabbitts and colleagues demonstrated that parents felt unprepared for managing pain and regaining functional abilities after their child's surgery [65]. This study highlighted the need for more intervention preparing children and families for surgery and managing recovery at home. Any efforts to optimize postoperative pain management in children in the home setting must therefore include appropriate psychosocial intervention to address the needs of children and caregivers in managing the demands of pain management and recovery at home as well as understanding appropriate pain assessment and dosing in order to provide adequate medication and/or nonpharmaceutical treatment.

### Tools & technological interventions targeting parental management of children's pain

To address analgesic safety and improve analgesic decision-making, Scenario-Tailored Opioid Messaging Program (STOMP) was developed [66]. STOMP is a nonclinical intervention that was given to parents while in the surgical or general pediatric waiting rooms. STOMP consists of a scenario-tailored message feedback based on interactive decision-making exercises, where parents are presented with scenarios and make decisions accordingly. After each scenario, feedback is presented assessing the risks associated with their decisions and ways to reduce risks for future similar scenarios. Parents who underwent the intervention became significantly risk avoidant (e.g., withheld medication to children displaying excessive sedation) compared with baseline and they were more likely to provide medications in situations where drug administration was safe (e.g., lack of excessive sedation) [66]. This intervention improved decision-making competency and shows promising ideas that can improve parental pain management. STOMP emphasizes the significance of providing pain management information in various ways like using an interactive scenario program. The implications of this program can be incorporated into home interventions for caregivers treating a child that has undergone surgery to improve pain management.

Moreover, there are a variety of nonpharmacological strategies for pain management that can be used by parents in the home setting. These include behavioral strategies, such as distraction and imagery, and physical intervention including heat and ice. However, ensuring parents are well-equipped to use such strategies can be difficult in a busy clinical setting. Thus, parent-focused interventions have been developed relying on technology to arm parents with the necessary pain management skills for children after surgery. For example, our research team has created a Web-based Tailored Intervention for Preparation of Parents and Children for Outpatient Surgery (WebTIPS), a web-based behavioral preoperative preparation program for children and parents that provides information and coping skills training before, during and after an operation [67]. WebTIPS is tailored to the individual child considering anxiety, temperament and surgery type. It is also tailored to parents by taking account for variable coping style, pain management attitudes, baseline anxiety and other measures. In a small-scale trial, this program proved effective in reducing both parent's and children's preoperative anxiety along with decreased emergence delirium in children [67], factors that are known to be associated with postoperative pain. In an age in which web use



is common, tools like these can be used as proactive measures to alleviate concerns before operation procedures and provide postoperative pain management education. WebTIPS contains modules focused specifically on managing pain in the home setting and a current multisite trial funded by the National Institutes of Health is underway to examine the impact of WebTIPS on children's pain after surgery.

Our team has also created Pain Buddy, an interactive, animated application that uses an avatar to guide children through an application to assess and manage pain. This application allows children to report their daily pain and symptoms, allows healthcare professionals to monitor symptoms and intervene to manage pain in real time and provides cognitive and behavioral skills training as means for coping with pain. To increase user adherence, an incentive system has been implemented to motivate children to continue using the application [68]. Pain Buddy was developed for children undergoing cancer treatment, but has wide ranging applicability to manage pain in children in the home setting associated with a variety of medical conditions and procedures, and is a means of equipping both parents and children with the needed knowledge and skills to optimize pain management at home.

### Future directions

Ensuring proper assessment of children's postoperative pain at home is catalytic in adequately treating pain. Standardizing children's postoperative pain management can be a critical first step, although ensuring the translation of such protocols into practice is crucial. In addition, educating parents and children in proper pain management is vital, given the shift to outpatient care that has occurred across medical settings. Technology is highly prominent in societal use; therefore, using it to educate parents on validated pain scales and the various ways a child expresses pain can deem beneficial when children are in pain but are unable to verbally express their discomfort. Furthermore, technological interventions, such as WebTIPs, are promising tools to optimize home pain management after surgery to both combat misconceptions about pain and ensure adequate knowledge in pain assessment and management in children. Use of technology also provides a wealth of opportunities to incorporate multimodal assessment that may be helpful in assessment of pain in children, given variations in pain based on surgical experience, age, ethnicity, temperament and behavioral patterns. When used in conjunction with proper analgesic administration, implementing technological applications that provide behavioral pain management strategies such as distraction, imagery and relaxation can reduce children's acute pain. Using this multimodal approach of combining pharmacological and nonpharmacological pain management strategies, child's pain can be managed more efficiently. In addition to educating parents in the home setting, assumptions cannot be made in the hospital setting about parental understanding of the appropriate analgesic dosages to give to their child. Because analgesic administration is variable depending on a child's age and weight, healthcare providers must ensure that parents understand how to administer analgesics to their child correctly and mend any concerns parents have for administering these medications to their children. When answering concerns, healthcare providers must be aware of cultural factors that can influence how parents treat their child's pain; it is vital that instructions for analgesic use are given to parents in their language of choice.

### Conclusion

Pain is common among children and today children's surgeries have increasingly been conducted in an outpatient basis, leaving the responsibility of pain management in the hands of parents. Moreover, providing optimal pain management is imperative given poorly managed pain in children after surgery has negative consequences such as delayed postoperative recovery or overdose in cases of medication overuse. There are many factors that affect how parents handle pain management in the home setting, including child development, culture and parental beliefs/experience that together affect children's pain management. Assessment and treatment of pain is difficult for both healthcare providers and caregivers because of differing developmental stages of children and the broad spectrum of disabilities that exist in the young population. Today, many tools for pain assessment have been standardized in child healthcare. In addition to child developmental factors affecting pain management, there are various cultural factors that may moderate the effects of pain management, specifically, language. Non-English speakers may be at a disadvantage when understanding healthcare provider instructions and recommendations for optimal pain management in the home setting. In addition, cultural values may impact beliefs about pain expression and treatment. Similarly, parental attitudes towards opioid usage may be heavily influenced by the opioid crises. Although limited literature is available on this topic, it is important to understand the influence of healthcare issues in the world and how they may create misconceptions. Accordingly, treating pain is a multimodal process; therefore, proper pain assessment and education are catalytic in a child's overall well-being. Technology has shaped

the world in many ways, but its impact on educating parents in the healthcare field is of utmost importance to emphasize. Within the next 5–10 years, we expect that technological innovations will allow for online sources and tablet applications to help parents and providers improve pain management. With the overwhelming evidence showcasing the advantages of personalized medicine, these tools are expected to become more personalized to each patient based on factors such as culture, age, ethnicity and cognitive development [69]. These tools will better prepare children and their families for surgical procedures and guide parents and providers in improving the postsurgery experience of children. With the current rise in technological innovations it is expected to see further healthcare technological interventions that lead to better outcomes for children of different ages and of different cultural backgrounds in order to help eliminate health disparities.

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