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Postoperative Pain Control in Children

A Guide to Drug Choice

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Abstract

Postoperative pain in children can usually be well controlled with a combination of analgesics, including acetaminophen (paracetamol), NSAIDs, opioids, and local/regional anesthesia. Recent research has shown that the dosage of acetaminophen required to provide analgesia is higher than the traditional dosages used for the regulation of elevated body temperature. Rectal administration of acetaminophen gives a lower and more variable bioavailability compared with oral administration. There is growing experience with the use of NSAIDs in children and several studies have demonstrated the relatively strong analgesic potential of these drugs. Titration of opioids to analgesic effect, and the use of nurse- and patient-controlled continuous opioid infusions in children have gained widespread use and, with proper education and supervision, are considered excellent methods of pain control. Local peripheral and central blocks decrease the need for anesthetics during surgery and provide effective postoperative pain relief.

There has been a rapid development in the management of pediatric pain within the last 20 years. This is not based on the development of new drugs for pain treatment, but rather on a growing knowledge of how to assess pain in children and how to apply drugs for pain treatment in various age groups, together with increased knowledge of pharmacokinetics and pharmacodynamics. There has also been a development of psychologic methods to alleviate fear and distress, which should be included in the therapeutic arsenal. Several questions concerning dosage, and the combination of drugs with other methods of pain control remain unanswered; however, with education and training of hospital staff, it is reasonable to state that we have the ability to provide good postoperative analgesia after a majority of surgical interventions. We would like to stress the importance of pain assessment; without proper pain assessment there can be no good quality pain relief.[1] In children aged between 4 and 5 years, self-report measures are used to assess the intensity of pain. In infants and smaller children, behavioral and physiologic signs of pain indicate pain reactivity and pain-related stress.

1. Non-Opioids

During the last few decades we have learnt to combine different analgesic drugs, and to use simple analgesics as a first step. The effectiveness of different analgesics for postoperative pain treatment has been statistically calculated from studies in adults, and expressed as the number-needed-to-treat [figure 1].[2] This figure gives an indication of the analgesic efficacy of acetaminophen (paracetamol) and NSAIDs, which, besides morphine, are the most well documented and often used drugs for the treatment of postoperative pain in children. In adults, a combination of acetaminophen and a NSAID has better analgesic efficacy than each drug alone.[3] A similar study in children did not show any benefit of combining acetaminophen with NSAIDs. In this study the dosage of acetaminophen was probably too low to provide analgesia.[4] Recent studies have indicated that acetaminophen doses recommended by the manufacturer are not sufficient to give pain relief.[5]

1.1 Acetaminophen (Paracetamol)

Acetaminophen is a metabolite of phenacetin, an analgesic no longer in use because of its negative adverse effects. Like most of our commonly used analgesics, acetaminophen is an old drug, developed more than 100 years ago. Acetaminophen is probably now the most widely used analgesic and antipyretic drug worldwide. It has replaced aspirin (acetylsalicylic acid), especially for pediatric use, because of a suspected link between Reye's syndrome and aspirin.[6]

Several analgesics for children, including acetaminophen and NSAIDs, have primarily been used for antipyretic purposes, and pharmacodynamic studies have focused on this effect. It is not known if the antipyretic dose is also an effective analgesic dose, but studies have indicated that children need higher doses than those previously recommended.[5] Even so, acetaminophen is a weak analgesic and is often insufficient as a sole agent for the treatment of postoperative pain.

The exact mechanism of action of acetaminophen is unknown, but there is now more evidence for a central rather than a peripheral effect.[5] The drug exerts no peripheral inhibition of prostaglandin synthesis, like NSAIDs, and has less anti-inflammatory effect.

1.1.1 Pharmacokinetics

Acetaminophen is absorbed both by rectal and oral administration. The bioavailability after rectal administration is highly variable and the relative fraction of oral-to-rectal bioavailability is

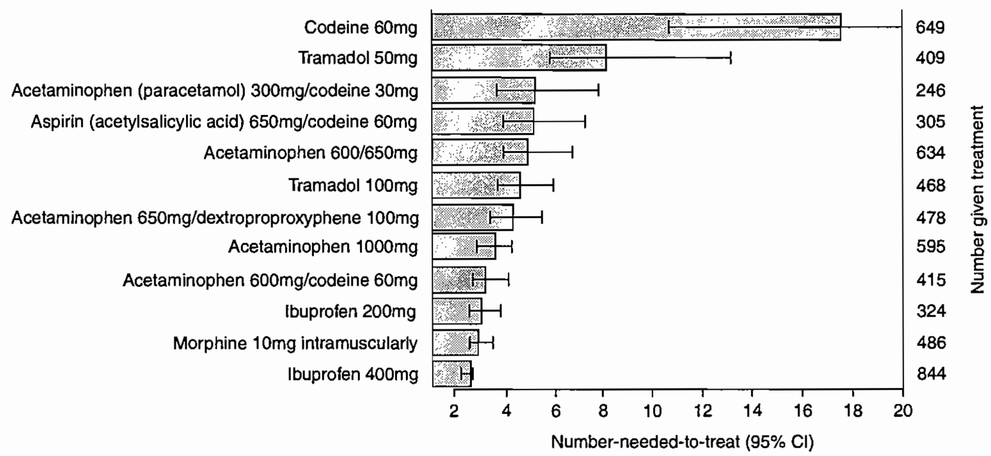

Fig. 1. Relative efficacy of single doses of analgesics compared with placebo to produce at least 50% pain relief in moderate or severe postoperative pain (oral doses except for morphine) [reproduced from McQuay et al.,[2] with permission from the US Cancer Pain Relief Committee].

reported to be only 0.54.[7] In neonates the fraction is higher.[8] Intravenous administration of the prodrug propacetamol provides the best bioavailability of acetaminophen. One gram of propacetamol is transformed by hydrolysis to 0.5g of acetaminophen in the bloodstream.[9]

Maximum serum concentration after oral administration is reached in 30–60 minutes. A delay is experienced after rectal administration, varying from 1 to 2.5 hours. After the maximum serum level has been achieved there is a delay to maximal analgesic effect, probably secondary to the blood-brain barrier passage; thus, in most cases acetaminophen should be given well before surgery and preferably by mouth.

Acetaminophen is metabolized mainly by glucuronidation in the liver, and plasma half-life is 2–3 hours for both adults and children. In newborns, the metabolism is mainly by sulfation. The plasma half-life is slightly prolonged in newborns, and further prolonged in premature babies – the more premature, the longer the half-life.[10]

1.1.2 Adverse Effects and Toxicity

Adverse effects are uncommon and the only known contraindication is drug hypersensitivity, which is extremely rare. An adverse effect of the intravenous preparation propacetamol is a burning sensation at the injection site.

Acetaminophen has a narrow therapeutic range and, in case of overdose, can cause severe liver failure because of the accumulation of a hepatotoxic metabolite. A daily dose of more than 150 mg/kg can cause reversible liver damage.[11] Multiple doses may result in accumulation in ill children;[12] however, it is rare that small children experience intoxication with lethal consequences and there are hints that small children are less sensitive to the toxic effect.[13]

1.1.3 Clinical Use

Several different recommendations concerning dosage exist and this is an indication that the best dosage regimen is still unknown. Presently used dosages are shown in table I; thus, the total dose for short-term postoperative pain treatment is 90 mg/kg orally, and 100 mg/kg rectally on the first day, including the loading dose. For practical and pharmacokinetic reasons, the dose is divided into four doses daily. Long-term rectal use is not recommended due to a large variability in absorption and likely discomfort for this form of administration. These dosages seem safe until further knowledge is provided concerning possible drug accumulation after repeated doses over several days. For neonates and febrile, dehydrated children the dosage is restricted to 60 mg/kg/day.[14]

The intravenous dosage of propacetamol for infants >3 months of age and children is 30 mg/kg four times daily.

Table I. Presently recommended dosages of acetaminophen (paracetamol) for postoperative pain relief in children[15]a

Route of administration	Loading dose (mg/kg)	Short-term maintenance (mg/kg/day)	Long-term maintenance (mg/kg/day)
Oral	25–30	80	60
Rectal	35–40	80	Not recommended

a Oral route of administration is preferable because of the wide variations in bioavailability with the rectal route.

1.2 NSAIDs

NSAIDs have become increasingly popular for postoperative pain relief in children during the last 10 years. They provide analgesic, anti-inflammatory, and antipyretic effects, primarily by blocking cyclo-oxygenase (COX) activity and thereby the synthesis of prostaglandins and thromboxane. Two COX isoenzymes have been identified, namely COX-1 and COX-2. Selective COX-2 inhibitors with less adverse effects, principally on the gastrointestinal tract, have been introduced. There is not much published experience of their use in children to date.

1.2.1 Pharmacokinetics

The pharmacokinetics of NSAIDs in children have been studied, but the relationship between serum concentration and analgesic effect has been poorly described. Pharmacokinetic results indicate that a relatively higher dosage compared with that in adults is needed, probably because of a higher volume of distribution in infants and children. Compared with adults, the volume of distribution and clearance of NSAIDs such as ibuprofen, diclofenac, and ketorolac is increased in children, but the elimination half-life is similar.[16-18] In infants, the elimination rate is about the same as in older children. Ibuprofen has been studied from the age of 3 months, and ketoprofen from 6 months.[19,20] Routine use of NSAIDs in neonates is not recommended because of the risk of developing renal failure and platelet dysfunction.[21]

1.2.2 Adverse Effects

NSAIDs lack the respiratory, sedative, and emetic adverse effects of opioids, but have other adverse effects. The most important of these are reduced platelet aggregation and prolonged capillary bleeding time, hypersensitivity reactions, inhibition of prostaglandin-mediated renal function, and gastric irritation. NSAIDs should be used with caution in children undergoing surgical procedures that are expected to involve considerable dissection of tissues, and in children with any pre-existing coagulation defect. In particular, the use of ketorolac has been associated with a high incidence of bleeding.[22] Renal toxicity is low in healthy children, but NSAIDs should be avoided in patients with severe renal disease, dehydration, or heart failure. NSAIDs are contraindicated for children with allergic symptoms from aspirin, and it is recommended that they be used with caution in patients with asthma, in whom hypersensitivity symptoms are more common;[23] however, no clinically significant incidence of bronchospasm was found in 70 children with asthma given a single therapeutic dose of diclofenac.[24] NSAIDs do not produce more gastrointestinal problems than placebo when used for 1–3 days for postoperative pain.[1]

1.2.3 Clinical Use

NSAIDs are effective in the management of mild to moderate postoperative pain. In severe pain requiring opioid medication, the administration of NSAIDs may improve analgesia and has an opioid-sparing effect. For optimal effect, the timing of administration is important since NSAIDs require time to block the prostaglandin synthesis and inhibit pain pathways. Although clinical studies of pre-emptive analgesia remain inconclusive, preoperative administration is usually necessary in order to get immediate postoperative effect.

In children aged ≥1 year, prophylactic administration of rectal ibuprofen 40 mg/kg/day in four divided doses was found to improve pain relief after minor surgery and to have a morphine-sparing effect compared with placebo.[25] Preoperative administration of rectal (2 mg/kg) or intramuscular (1 mg/kg) diclofenac has been reported to give effective postoperative analgesia after tonsillectomy and to decrease the need for postoperative analgesia.[22] The addition of rectal diclofenac 1 mg/kg every 8 hours in children using patient-controlled analgesia (PCA) with morphine improved postoperative analgesia despite lower morphine consumption.[4] Diclofenac is an alternative to caudal analgesia following lower abdominal or penile surgery. A combination of rectal diclofenac 1 mg/kg and caudal anesthesia was superior to caudal block alone.[26] Ketorolac is available for intravenous administration. Doses of 0.5–1.5 mg/kg for postoperative analgesia have been found to be effective in several studies.[22,27] Ketoprofen has also been shown to be a well tolerated and effective analgesic in children when administered both intravenously and orally.[28,29]

Although opioid-sparing effects with NSAIDs have been described, studies remain inconclusive concerning a reduction in adverse effects. Incidences of postoperative nausea and vomiting (PONV) have been reduced, unchanged, and even increased with the addition of NSAIDs to morphine.[4,30,31]

The currently used pediatric dosages are shown in table II. A lack of pharmacokinetic studies and available formulations for oral and rectal administration limit the use of NSAIDs in infants, with the exception of ibuprofen.

1.3 Clonidine

Clonidine is a α_2-adrenoreceptor agonist with analgesic, sedative, and cardiovascular effects. Since the spinal cord is the major

Table II. Currently used pediatric dosages of NSAIDs for postoperative pain[29,30,32]

NSAID (route of administration)	Single dose (mg/kg)	Number of daily doses	Maximum dosage (mg/kg/day)
Diclofenac (po or pr)	1–2	1–3	2–4
Ibuprofen (po or pr)	5–10	3–4	40
Ketorolac (po)	0.2–0.5	3–4	1
Ketoprofen (po)	1–2.5	2–3	5

po = orally; **pr** = rectally.

site of the analgesic action, it is preferable to give clonidine by the epidural route, and it has mostly been used in combination with a local anesthetic. Intravenous or oral clonidine is an excellent treatment option for opioid withdrawal symptoms. It can also be given as a supplement to opioids in order to reduce the need for these agents. Currently used dosages are 1–3 μg/kg three to four times daily for both oral and intravenous administration.[33] Oral premedication with clonidine 4 μg/kg has also been found to decrease postoperative analgesic requirements.[34]

2. Opioids

In general, it is very safe to treat children in pain with opioids. There is no indication that children over 6 months of age are more sensitive to the respiratory depressant effects than adults. In neonates, especially premature infants, morphine should be used with caution because of an increased sensitivity to the respiratory depressant effects. As in adults, opioids are used for moderate and severe postoperative pain in children. The weak opioids (codeine and tramadol) play a minor role in the treatment of postoperative pain since their analgesic efficacy is usually not sufficient after major surgery. Morphine is by far the most commonly used drug of the strong opioids and, based on extensive knowledge, is the drug of choice.

2.1 Codeine

Codeine, in combination with acetaminophen, has an analgesic effect that is slightly more than that of acetaminophen given alone. About 10% of a given dose will be transformed to morphine; however, some individuals are unable to convert codeine to morphine. Codeine can be used together with acetaminophen as an alternative in those infants in whom NSAIDs are contraindicated. It is unclear whether possible adverse effects such as nausea and constipation will outweigh the small beneficial effect.[35] The recommended dosage is 1 mg/kg four times daily.

2.2 Tramadol

Tramadol has a weak blocking effect at the μ-opioid receptor, as well as a stimulating effect on the descending inhibitory pain mechanisms. Its use has been documented in children in intravenous and oral dosages of 1–2 mg/kg three times daily. Tramadol has no clinically relevant depressant effects on respiration, but is associated with a high incidence of nausea and vomiting.[36] As with other opioids, the analgesic effect and adverse effects are dose dependent. There are no indications that tramadol offers any advantages over morphine in equipotent doses.

2.3 Morphine

Morphine is the opioid of choice for use in children and remains an excellent drug for analgesia after major surgery. By careful titration of morphine dosage to pain control, and good routines for patient supervision, the respiratory depressant effect of morphine can be minimized. Morphine for postoperative pain can be given as repeated intravenous injections, as a continuous infusion, or by PCA. Oral morphine administration requires a time-consuming titration because of variable bioavailability, but can be considered in patients with a prolonged need for morphine. Intramuscular use should be avoided because of pain at the injection site and the difficulty in titrating the dose. Both epidural and intrathecal use of morphine, as well as other opioids, have been described, but this is not common practice outside specialized pediatric centers.[37,38]

2.3.1 Pharmacokinetics

The pharmacokinetics of morphine are well known in children of various age groups.[39] The most important aspect is the prolonged half-life (4–8 hours) in newborn infants, and the variability in metabolism in infants up to the age of 6 months. From this age the morphine pharmacokinetics are similar to those in older children and adults, with a plasma half-life of 2–3 hours.

2.3.2 Respiratory Depression

For a long time, fear of respiratory depression prevented the proper use of opioids in children; however, increased experience and studies of the use of opioids in children, together with increased knowledge of their pharmacokinetics during the last 20 years, has contributed to a reduction in the exaggerated fear of respiratory depression and led to more effective use of opioids in the management of acute pain.

For most children with acute pain the risk of respiratory depression is very low, but cannot be neglected. Acute pain stimulates respiration and counteracts the depressive effects of opioids. This means that the dose required must be titrated against the level of pain, and if the pain suddenly disappears for other reasons, the risk of respiratory depression may increase. For postoperative pain treatment, daily opioid doses should be decreased over time, following the normal course of diminishing pain.

Respiratory depression is usually preceded by sedation, and observation of the child with regard to this parameter is important, especially in children who cannot express their pain verbally. Adding sedatives to a patient taking opioids will increase the respiratory depressant effects of opioids and should not be done without supervision.

Neonates, particularly premature infants, have an increased sensitivity to the respiratory depressant effect of morphine. They require reduced doses and should be continuously monitored when morphine is used.

2.3.3 Other Adverse Effects

The most common adverse effects in the treatment of acute pain are nausea and vomiting. Unfortunately, there is no ideal single regimen to completely avoid this adverse effect and a combination of antiemetic drugs is probably necessary for both prophylaxis and therapeutic use.[40] Other adverse effects are pruritus, urinary retention, and psychomimetic effects. In patients with these adverse effects, a change to another strong opioid should be considered.

When used for short-term postoperative pain treatment, the development of tolerance and withdrawal effects is rarely seen. In the case of prolonged continuous intravenous administration for protracted postoperative pain of more than 5–7 days' duration, the dosage should be tapered.

2.3.4 Clinical Use

The dosage of morphine should always be individualized. Studies of morphine used for self-administration have shown that the dose needed, even for the same type of surgery, varies 10-fold (figure 2).[31] Pain is a most powerful physiologic antidote to the respiratory depressant effect of morphine, and by titration of the dose this adverse effect can be minimized. Close cooperation between the prescribing physician and the nurse responsible for both the care of the child and pain assessment is a prerequisite for proper dose titration.

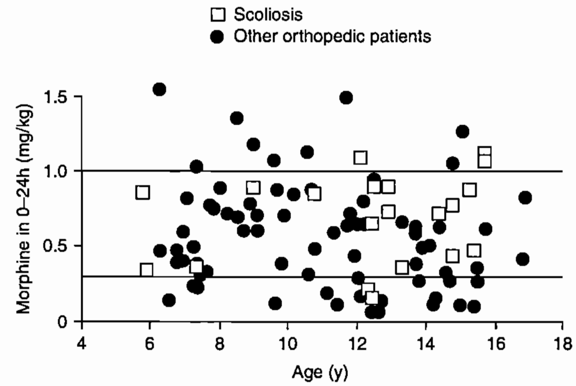

Fig. 2. Individual need for morphine (self-administered by a PCA device) in scoliosis and other major orthopedic surgical patients during the first postoperative day. Note the huge individual variation in morphine requirement, and that the age of a child did not have any influence on this requirement (reproduced from Teira,[31] with permission from Blackwell Science). **PCA** = patient-controlled analgesia.

Intermittent intravenous injections can be used when postoperative pain is moderate and the need for an opioid is assumed to be of short duration. The optimal dose can easily be titrated since the maximum effect, as well as the potential sedative and respiratory depressant effects, of a given dose will occur within a few minutes. In order to avoid severe breakthrough pain, a prescription for repeated by-the-clock administration is preferable to 'as needed' administration in the treatment of severe pain.

Suggestions for the safe use of morphine for intermittent intravenous administration are as follows:

- calculate the planned dose range carefully. A common dose is between 50–200 μg/kg;
- dilute the morphine to 1 mg/mL. Use small volume syringes for small children;
- start by slowly giving 50 μg/kg intravenously. Repeat this dose after 5–10 minutes if the effect is insufficient;
- continue to give fractions of 25 μg/kg until pain relief is achieved. If high doses (>300 μg/kg) are needed, rule out postoperative complications;
- terminate the injection if the child becomes sedated.

Techniques for continuous intravenous infusion after major surgery have gained in popularity. With education and training of staff, and proper supervision, continuous morphine infusions can be safely used in ordinary wards.[41] After loading doses of 100–200 μg/kg, infusion rates of 10–40 μg/kg/h usually provide satisfactory analgesia. Occasionally, infusion rates of 40–60 μg/

kg/h are needed. If pain is severe, these rates are usually well tolerated, but continuous supervision is mandatory. The infusion rate should always be titrated to assessed pain, and can be nurse-controlled within a certain range. If the infusion rate needs to be increased, a bolus dose should be given in order to decrease the time needed to obtain an adequate morphine serum level.

In neonates, the risk of respiratory depression limits the dose and these children should always have continuous supervision when morphine is used. Single doses of 20–30 μg/kg and infusion rates of 5–10 μg/kg/h are usually well tolerated for postoperative pain relief.

PCA is an attractive option for pain control in children >5-6 years of age.[42] Information about the method should always be given before surgery and the nurse responsible must make sure that the child understands the idea and practicalities of self-administration.

PCA is preferably started in the postoperative ward by giving loading doses, typically 100–200 μg/kg, until the child appears comfortable. The infusion pump device is set to provide bolus doses with a predetermined time interval, usually 5–8 minutes. Recommended bolus doses range between 10 and 25 μg/kg. The risks and benefits of a background infusion are still under debate. A low continuous infusion of 4 μg/kg/h does not seem to increase the incidence of adverse effects, and gives less hypoxemia and a better sleep pattern than no background infusion.[43]

Oral morphine is given in dosages of 200–500 μg/kg three to four times daily.

2.4 Alternatives to Morphine

When the individual child does not tolerate morphine and strong opioids are needed, meperidine (pethidine), ketobemidone, and fentanyl can be used. Ketobemidone is very similar to morphine and can be used in equipotent doses. Meperidine has a shorter half-life (1.5 hours) and can be used in single doses of 0.2–1.0 mg/kg. Continuous infusion should be avoided because of the risk of accumulation of metabolites. Fentanyl is a short-acting opioid with an analgesic property 100 times that of morphine. Continuous infusion of fentanyl is used to provide analgesia and sedation in intubated and mechanically ventilated patients.

2.5 Spinal Administration of Opioids

As in adults, epidural administration of opioids in children, with or without a local anesthetic, is an excellent method in skilled hands and with proper supervision. Epidural administration of opioids combined with a local anesthetic has been shown to provide superior analgesia and more rapid recovery than systemic administration of opioids in adults.[44] Fentanyl and hydromorphone results in less pruritus, nausea, and urinary retention than morphine.[37] Fentanyl is short-acting and should be given as an infusion in dosages of 2–5 μg/kg/h. Morphine can be given as single injections two to three times daily. For single-dose caudal epidural analgesia, morphine is the longest-acting agent and doses of 30–50 μg/kg have been used.[45] Postoperative intrathecal use of morphine has been principally described in children undergoing spinal fusion.[46]

3. Regional Anesthesia

In children, central and peripheral blocks are mainly used as a supplement to general anesthesia. An adequate nerve block may decrease the need for anesthetics during surgery, and also relieve postoperative pain. Postoperative epidural block with bupivacaine caused less sedation and improved ventilation and oxygenation than morphine infusion in infants after abdominal surgery.[47]

3.1 Drugs

Bupivacaine is the most commonly used and best-documented long-acting local anesthetic drug in children.[48] More recently, ropivacaine has been found to produce less motor block, with a wider margin of safety.[49] Basic studies of the pharmacokinetics of ropivacaine in children have been published.[50]

Mepivacaine and lidocaine (lignocaine) are short-acting agents and are usually used for local infiltration.

3.2 Blocks

Caudal block is commonly used for minor surgery below the umbilicus, such as lower abdominal, urologic, and lower limb surgery. It has been used for several years and has been found to be a reliable and well tolerated method of pain control in large series of patients.[51,52] Bupivacaine 2.5 mg/mL and ropivacaine 2 mg/mL at a dose of 1 mL/kg produce effective postoperative pain relief after lower abdominal surgery, while a dose of 0.5 mL/kg is usually sufficient for lower extremity and penile surgery. The duration of analgesia after caudal block for both bupivacaine and ropivacaine is around 4 hours.[53] This may be prolonged by adding ketamine or clonidine.[54] It is also possible to place a catheter in the sacral canal for continuous infusion of local anesthetics over a period of 2–3 days. In newborns the catheter can easily be advanced to lumbar or thoracic levels, which also produces postoperative analgesia after abdominal and thoracic surgery.[55]

Ilioinguinal and iliohypogastric nerve block are used for postoperative pain relief following orchidopexy and inguinal hernia repair. Penile block is an effective method following circumcision.[56] A simple adjunct for providing analgesia in the immediate postoperative period is wound infiltration.[57] If properly performed, these techniques provide excellent analgesia during the first postoperative hours; however, it is most important to administer systemic analgesics in appropriate time for optimal effect when the effect of the block wears off.

Continuous lumbar epidural block provides effective pain relief for infants and children undergoing major abdominal, genitourologic, and lower limb orthopedic surgery. After many years' experience it can be concluded that the following doses of bupivacaine have considerable safety margins:

- newborn: single bolus dose 1.5–2.0 mg/kg, continuous infusion 0.2 mg/kg/h
- children: single bolus dose 2.5 mg/kg, continuous infusion 0.4 mg/kg/h.

With proper observation and management protocol, lumbar epidural anesthesia can be safely administered on surgical wards. For upper abdominal and thoracic surgery, a thoracic epidural approach can be used, but this is commonly reserved for older children who can cooperate with the insertion procedure in order to avoid neurologic damage. Alternatively, a paravertebral block is a well-tolerated and effective method of pain relief after thoracic and upper abdominal surgery.[58]

3.3 Topical Anesthesia

Topical applications of local anesthetics have a short analgesic effect and are usually not a sufficient sole agent for pain relief. After circumcision, topical application of lidocaine resulted in a pain-free period of about 40 minutes.[59] Topical tetracaine (amethocaine) and subconjunctival bupivacaine reduced pain scores in the immediate postoperative period after strabismus surgery compared with placebo, although no long-lasting effects were found.[60]

4. Postoperative Analgesia

Good postoperative care in hospital involves professional management of pain with the help of nurses experienced in pain assessment, and the administration of suitable analgesics. In outpatient pediatric surgery, parents have to take considerable responsibility for postoperative pain relief. In order to minimize postoperative discomfort, it is very important that the parents get specific information and instructions about pain assessment and analgesic treatment, and that they know where to turn in case of inadequate pain relief or other queries.

Analgesic recommendations for different types of surgery are summarized in table III.

4.1 Ear, Nose, Throat, and Dental Surgery

Myringotomy, with or without the placement of grommets, is the most frequent procedure performed under general anesthesia in children. Acetaminophen 30 mg/kg orally given 1–2 hours before the procedure is usually adequate for pain relief in the immediate postoperative period. Since in most patients the pain is of short duration, further doses can be given as needed.

Adenoidectomy is also a very common day-case surgical procedure during childhood. In a survey, 80% of children had pain on the day after surgery. On the third postoperative day almost all children were free of pain, having returned to normal activity. Acetaminophen and/or NSAIDs prescribed at regular time intervals during the first 2 days provided effective pain relief.[61]

Adequate pain relief for children undergoing tonsillectomy/adenotonsillectomy is a challenge. The operation causes consider-

Table III. Management of postoperative pain – common recommendations

Minor surgery
Acetaminophen and a NSAID
plus
Peripheral nerve block, caudal block, or wound infiltration, when applicable
plus
Intravenous opioids in single doses, when needed
Major surgery – abdominal, thoracic, orthopedic, or urogenital
Acetaminophen and a NSAID
plus
Opioids
continuous intravenous opioid in children <6 years of age
patient-controlled analgesia with opioid in children >6 years of age
or
Regional anesthesia
continuous epidural analgesia, or
continuous paravertebral analgesia

able pain which may last for more than 7 days.[62] If performed on a day-case basis, but also after inpatient surgery, it is mandatory for the parents to be provided with careful and specific information about postoperative analgesia. Regular administration of acetaminophen in dosages of 60 mg/kg/day orally or 90 mg/kg/day rectally was better than acetaminophen administered as needed in one trial. In spite of this, a considerable proportion of children rated pain as severe.[63] Consequently, acetaminophen will not provide sufficient analgesia for all children. NSAIDs have been investigated as an alternative to opioids and have been reported to give similar analgesia following tonsillectomy.[22] The use of NSAIDs for this procedure has been questioned because of their effect on platelet aggregation and the possibility of increased risk of bleeding. The literature confirms that hemorrhagic events occur, but there is no strong evidence that NSAIDs give rise to more clinically important bleeding than other analgesics.[22]

Several studies have shown beneficial effects of intravenous dexamethasone 0.5–1 mg/kg on vomiting, and also on pain following tonsillectomy.[64,65] Other studies have failed to demonstrate any advantage of dexamethasone.[66] Intraoperative infiltration with a local anesthetic may reduce immediate postoperative pain, but has not been shown to influence the long-lasting analgesia.[62,67]

Although many attempts have been made to improve analgesia after tonsillectomy, there is no ideal mode. Acetaminophen in adequate doses, combined with a NSAID or codeine, administered regularly for at least 3–4 days if needed, is the common way to manage pain, although it is not optimal for all children. In the immediate postoperative period, intravenous morphine is required for some children.

Dental surgery is associated with a high incidence of PONV because of the mechanical stimulation in the pharynx and ingested blood. Preoperative administration of acetaminophen in combination with a NSAID reduces the immediate postoperative pain. Further analgesics can be administered as required.

4.2 Lower Abdominal Surgery

The incidence of pain after repair of inguinal hernia and hydrocele varies, but the pain is seldom severe and usually abates after 1–2 days.[68,69] Regional anesthesia is suitable for postoperative pain relief. Several methods have been used, such as ilioinguinal and iliohypogastric nerve block, caudal block, and local infiltration. All these methods have been shown to be effective. Acetaminophen or a NSAID should be given in time to achieve the optimal effect when the local block wears off, and be regularly administered thereafter for at least 1–2 days.

Orchidopexy involves a more extensive tissue trauma than hernia/hydrocele repair, and is reported to be more painful.[68,69] Regional anesthesia is also suitable for this procedure. Both caudal block and ilioinguinal and iliohypogastric nerve block offer satisfactory analgesia. Further treatment with acetaminophen and/or a NSAID regularly over a period of 2–3 days is usually needed.

4.3 Penile Surgery

Circumcision or preputial plastic surgery is mostly performed on a day-case basis. Both caudal block and penile block are well established methods for these operations.[70] Topical application of local anesthetics is not sufficient as a sole method of pain relief until a few days after surgery, and must be combined with systemic analgesics in the initial days; however, topical anesthetics are suitable for pain relief during micturition if applied 5–10 minutes in advance.

Acetaminophen usually offers adequate pain relief during the first postoperative days; however, in some patients there is a need for NSAIDs to be administered.[69]

Repair of hypospadia requires in-hospital service. Caudal block combined with non-opioid analgesia is sufficient in most patients, but intravenous opioids may be necessary.

4.4 Ophthalmologic Surgery

PONV is a very frequent problem after strabismus surgery. Without prophylactic antiemetics very high incidences of PONV have been reported, although the type of anesthesia also has a strong influence on the incidence. A minimal supply of opioids is desirable both pre-, intra- and postoperatively. Intraoperative intravenous administration of NSAIDs (ketorolac and ketoprofen) has resulted in a reduced opioid requirement and less PONV.[71] Acetaminophen, in combination with a NSAID, is usually sufficient on the first postoperative day, and thereafter, acetaminophen should be administered on a regular basis for the next 1–2 days. Topical application of local anesthetics or diclofenac may have an adjunctive effect.[60,72]

4.5 Appendectomy

The intensity and duration of pain after appendectomy vary to a great extent. Children appear to require and demand less analgesia than adults following appendectomy.[73] Regular administration of acetaminophen plus a NSAID, combined with an intravenous opioid when needed, is sufficient for some children, while others require regularly prescribed morphine or a continuous morphine infusion.

4.6 Major Abdominal, Orthopaedic, Urologic, and Thoracic Surgery

After major surgery, opioids given intermittently or continuously, as a continuous infusion or by PCA, give satisfactory pain relief provided the dosage is adjusted to the individual's needs. In order to reduce the opioid requirement, it is recommended they be administered in combination with a NSAID and/or acetaminophen.[3]

For orthopedic surgery in the lower extremities, and pelvis, lower abdominal, and urogenital surgery, a lumbar epidural block is ideal. Adding an opioid to bupivacaine in the epidural block will give better analgesia and allow a lower dose of bupivacaine to be used, thereby resulting in less motor block, but may result in a higher incidence of nausea and vomiting compared with bupivacaine only.[74] A thoracic epidural block is an alternative for thoracic and upper abdominal surgery, but this method should only be practiced by those familiar with the method. After renal surgery, cholecystectomy, and unilateral thoracic surgery, a paravertebral thoracic block with a continuous infusion of bupivacaine may be a safe and effective method for pain relief.[58]

Following major surgery, continuous opioid medication or epidural infusion is usually needed for at least 2–3 days, followed by the administration of intermittent opioids, acetaminophen, and/or NSAIDs.

5. What to Do if the Pain Relief is Inadequate

There can be a number of reasons for inadequate pain relief. Firstly, check that prescribed analgesics have actually been given; technical problems with infusion pumps and indwelling catheters should be ruled out. There may be complications such as fracture dislocation, anastomosis leakage, ileus, pressure from plaster, or an infection causing pain. Small children, who are unable to express themselves, may be distressed for other reasons such as urinary retention, hunger, fear, separation from parents, etc. If the child remains in obvious pain, add morphine or increase the morphine dose under supervision, then re-evaluate the situation.

6. Conclusions

The provision of good postoperative analgesia in children requires adequate administration of analgesic drugs adjusted to the child's individual need and medical condition. Prevention of the expected postoperative pain by regular administration of adequate doses and combinations of analgesics, together with pain assessment and the use of local and regional blocks when applicable, is the best way to minimize postoperative pain.

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