



Guidelines

Postoperative Pain Management in children: guidance from the Pain Committee of the European Society for Paediatric Anaesthesiology (ESPA Pain Management Ladder Initiative) Part II



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ABSTRACT

The ESPA Pain Management Ladder Initiative is a clinical practice advisory based upon expert consensus supported by the current literature to help ensure a basic standard of perioperative pain management for all children. In 2018 the perioperative pain management of six common pediatric surgical procedures was summarised. The current Pain Management Ladder recommendations focus on five more complex pediatric surgical procedures and suggest basic, intermediate, and advanced pain management methods. The aim of this paper is to encourage best possible pain management practice and to support institutions to create their own pain management concepts according to their financial and human resources due to the diversity of clinical settings in Europe. Furthermore, the authors underline that these recommendations are intended for inpatients only.

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Introduction

Despite efforts to improve perioperative pain management in children during the past decade [1–9], a high proportion of pediatric patients (up to 85% [10]) still suffer moderate to severe postoperative pain and 63% are suffering clinically significant pain when discharged home [11].

The reasons for inadequate perioperative pain management are diverse, differ between institutions and countries [12], and may be influenced by prior pain experience, the age, education, ethnicity, and cultural background of the patient [13], and beliefs of both the patients and the caregivers about pain [14].

A prospective mixed-method cross-sectional multicentre study in Denmark demonstrated that the postoperative pain management strategies did not meet the needs and expectations of the patients [15] because of incongruence between the intention and the implementation of postoperative pain management.

A recently published analysis of data from the multinational Pain registry “PAIN OUT infants” evaluated perioperative pain

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management after appendectomy and tonsillectomy [16]. The analysis of these data included the use of analgesics and patient-related outcomes (PRO's). More non-opioid analgesics, a single dose of dexamethasone, and fewer opioids resulted in lower postoperative pain scores, fewer adverse effects, and less pain-related functional interference. The data analysis revealed that most children received less than one full daily dose of non-opioid analgesics and up to 31% of patients indicated the desire for additional pain treatment caused by substantial deficits in the concept, application, and dosing of analgesics. This publication underlines the importance of timely and sufficient use of non-opioid analgesics and the additional use of coanalgesic drugs as well as local and regional anesthesia [16,17].

Insufficient pain management leads to immediate distress, delayed recovery, prolonged postoperative pain, and possibly the development of chronic pain [18–20]. Furthermore, it may cause immediate and long-lasting behavior changes during medical treatment especially increased fear and sensitivity to pain [21].

Adequate postoperative pain management consists of patient-tailored and intervention-specific analgesic strategies. Guidelines on perioperative pain management such as the ANZCA [8] and German [9] guidelines give detailed recommendations for the use of certain drugs and methods based on the level of evidence. The recommendations are supplemented by conclusions based on clinical experience and expert opinion. However, they do not provide procedure-specific pain management plans. The aim of the ESPA Pain Ladder initiative is to fill this gap. This document is not a guideline but intends to provide a clinical practice advisory based upon expert consensus and is supported by the current literature to help ensure a basic standard of perioperative pain management for all children.

The purpose of this paper is to support institutions to implement the best possible analgesic treatment for all children in order to meet the postulation of the Convention on the Rights of the Child [22].

Material and methods

In October 2018 the ESPA Pain Committee met in Brussels during the annual ESPA congress and decided to continue with the ESPA Pain Management Ladder Project. Following the ESPA newsletter in December 2018, ESPA members suggested a number of common pediatric surgery procedures for the second set of the ESPA Pain Management Ladders. Based on these suggestions the ESPA Pain Committee decided to create a further set of five Pain Management Ladders. Following a further newsletter, twelve ESPA members volunteered to join the ESPA Pain Management Task Force. The Executive Board of ESPA has approved this project. In March 2019 the author's instructions were distributed and teams of three task force members created a new Pain Management Ladder. Each team comprised of pediatric anesthetists experienced in perioperative pain management of children from different parts of Europe. The aim was to provide a multimodal analgesic treatment approach including local and regional anesthetic techniques [23–28].

In September 2019 the Task Force met in Rotterdam to develop a consensus on controversial points in the first draft. Due to the pandemic situation, the consensus process was slowed down and had to be continued online. In May 2022 the final draft was displayed in the members section of the ESPA website for review and comment by ESPA members. The suggestions of the ESPA members were discussed and incorporated by the Task Force and approved by the Executive Board of ESPA.

The aims of the ESPA Pain Management Ladders and how to use them in daily practice were discussed in detail in the first

publication [1]. The basic level should be achievable using drugs and methods that are safe, easy to use, and available in all institutions where complex operations are performed. This should be regarded as the minimal standard of care that needs to be provided before starting to perform these procedures in an institution. The intermediate and advanced levels are suggestions to help an institution create patient-tailored pain management for specific operations. Elective major procedures should only be performed in an institution if adequate postoperative pain management can be provided and this includes intravenous administration of opioids and non-opioid drugs in the ward. The first goal is to evaluate the existing pain management regimes using age-adapted monitoring tools, adjust the pain management if necessary, and re-evaluate for further improvement. The secondary goal is to climb up the pain ladder as far as possible using all available resources optimally including drugs, methods, and staff.

Recommendations

Local and regional anesthesia plays a major role at all three levels of the recommendations. In institutions with limited availability of ultrasound machines, caudal block or a number of peripheral nerve blocks such as femoral or fascia iliaca block may be safely performed using landmark techniques by an experienced pediatric anesthetist. Upper and lower extremity blocks may be performed with a nerve stimulator. However, ultrasound support should be used whenever available [29–31]. The authors recommend that regional blocks such as abdominal wall blocks (TAP or quadratus lumborum block) for safety reasons should only be performed if ultrasound guidance is available [32,33]. Furthermore, nerve stimulators do still have a place in the situation of "deep and steep blocks", e.g. lumbar plexus blocks. This frequently is referred to as "the dual guidance technique" [34]. The authors advocate the use of regional blocks that are well-established and frequently used in the perioperative treatment of pediatric patients. These blocks are considered safe when performed by an experienced pediatric anesthetist. In the last decade, a number of new peripheral blocks, e.g., erector spinae plane block have been introduced which may have a place in specialized centers and for particular indications such as in patients with coagulation disorders [35–38].

In perioperative pediatric pain management, adjuncts are added to the local anesthetics to potentiate and prolong the local and regional effects of these drugs [39,40]. The most frequently used adjuvant is clonidine which can be safely used via the epidural and peripheral perineural route. For caudal blocks, preservative-free ketamine/S-ketamine and alpha-2 agonists (clonidine and dexmedetomidine) have been shown to be effective adjuncts in meta-analyses. Dexmedetomidine may also be used when performing peripheral nerve blocks in children [41]. In epidural anesthesia, the rostral spread of the relatively water-soluble preservative-free morphine is used for special indications to achieve control of higher segmental pain [42–44]. If morphine is used via the epidural route, adequate monitoring (including pulse oximetry) must be provided in the postoperative period [42–44].

Non-opioid and co-analgesic drugs

The consistent intra- and postoperative use of non-opioid drugs (primarily NSAIDs, metamizole, and paracetamol) has an opioid-sparing effect [9,45]. Non-opioids together with opioids and local/regional anesthesia are the cornerstones of intraoperative pain management and are the main pier of postoperative pain management. The combined use of one or two different non-

opioid drugs together with local/regional anesthesia offers the possibility of total avoidance of intra- and postoperative opioids in special settings and for certain indications such as cleft lip and palate repair [46,47].

Intravenous lidocaine may be used during the procedure and in the early postoperative period, however, it needs adequate monitoring (continuous cardiac monitoring and patient observation) [48–50]. In situations and settings where regional anesthesia cannot be performed or is contraindicated, it could be used as part of a multimodal analgesic approach.

The intraoperative intravenous administration of alpha 2-agonists or ketamine has an opioid-sparing effect. It reduces the risk of respiratory impairment during recovery [51,52]. Furthermore, the additional sedation provided by alpha 2-agonists or

ketamine reduces agitation in the recovery room [53–57]. Ketamine is widely available and can easily be used intraoperatively in a number of procedures and at all levels of the ESPA Pain Management Ladders [58]. Furthermore, intravenous methylprednisolone or dexamethasone are known to reduce postoperative swelling. Several studies have demonstrated, that intraoperative intravenous administration of dexamethasone prolongs the analgesic effect of single-shot regional blocks [59,60].

Intra- and postoperative use of opioids

Intraoperative opioids should be used with caution (details see Table 6) and titrated to effect. The administration of opioids increases the risk of postoperative respiratory impairment and

Table 1
Cleft lip and cleft palate repair.

Cleft lip and cleft palate		
	Intraoperative	Postoperative
Basic level	Intravenous fentanyl or opioid of choice in divided doses Local wound infiltration of the surgical field (by the surgeon) of a long acting local anesthetic a) Rectal NSAID [79,80] and/or b) Rectal paracetamol [81]	PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward a) Rectal, oral or (if available) intravenous NSAID [47,82] and/or* b) Rectal, oral or (if available) intravenous paracetamol in adequate dosing during the entire postoperative period Oral, rectal or intravenous Tramadol or Intravenous nalbuphine [#] or other suitable agent (if available) as rescue ^{&}
Intermediate Level	Intravenous fentanyl or opioid of choice in divided doses Local wound infiltration of the surgical field (by the surgeon) of a long-acting local anesthetic a) Rectal or intravenous NSAID and/or b) Rectal or intravenous paracetamol [83]	PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain Ward ^{&} : a) Rectal, oral or intravenous NSAID during the entire postoperative period [47,84] and/or* b) Rectal, oral or intravenous paracetamol during the entire postoperative period Oral, rectal or intravenous Tramadol or Intravenous nalbuphine [#] or other suitable agent (if available) as rescue ^{&}
Advanced Level	- a) Rectal or intravenous NSAID and/or b) Rectal or intravenous paracetamol Regional Anesthesia of the maxillary ^α nerve at various locations with a long-acting local anesthetic. For cleft lip bilateral infraorbital nerve block [46,47,85–95] - In case of failed regional block: Fentanyl or opioid of choice in divided doses or if available continuous remifentanyl or opioid of choice	PACU: - Intravenous fentanyl or other suitable agent (if available) to treat breakthrough pain. - Ward ^{&} : - a) Rectal, oral or intravenous NSAID during the entire postoperative period and/or* - b) Rectal, oral or intravenous paracetamol during the entire postoperative period Oral, rectal or intravenous Tramadol or - Intravenous nalbuphine [#] or other suitable agent (if available) as rescue ^{&}
Comments	^α Additional infiltration of soft palate with long acting local anesthetic might be necessary If available consider at all levels: Methylprednisolone or dexamethasone to reduce postoperative swelling [96] and Intraoperative addition of alpha 2-agonists [57,97] and / or Intraoperative addition of ketamine as co-analgesic drug [97] Development of procedure-specific ERAS protocol [98,99]	* Combination of NSAID and paracetamol reduces opioid use and will be useful if iv-rescue is not available ^{&} Aim for oral administration as soon as possible [#] In infants, for older children available opioid of choice ^{&} In institutions where metamizole is available it should be used as first line rescue analgesic.

Table 2

Correction of congenital hip dislocation.

Correction of congenital hip dislocation		
Basic level:	Intraoperative: Intravenous fentanyl or opioid of choice in divided doses - Local wound infiltration of the surgical field (by the surgeon) of a long acting local anaesthetic a) Rectal NSAID and/or b) Rectal paracetamol	Postoperative: PACU: - Intravenous fentanyl or other suitable agent (if available) to treat serious break-through pain in Ward ^{&} : - a) Rectal, oral or (if available) intravenous NSAIDs and/or* - b) Rectal, oral or (if available) intravenous paracetamol during the entire postoperative period and Oral, rectal or intravenous Tramadol or other suitable agent (if available) as rescue ^{&} PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain Ward ^{&} : a) Rectal, oral or intravenous NSAID during the entire postoperative period and/or* b) Rectal, oral or intravenous paracetamol during the entire postoperative period and c/d) Oral, rectal or intravenous tramadol or other suitable agent (if available) as rescue. ^{&} PACU: Intravenous fentanyl or other suitable agents to treat break-through pain. Ward ^{&} : a/b) Intravenous/oral NSAID during the entire postoperative period and/or Intravenous/oral paracetamol in during the entire postoperative period plus c/d) Continuous nerve block or patient controlled regional anesthesia [103–106] or e) If continuous nerve block is contraindicated or unsuccessful Intravenous tramadol or other suitable agent (if available) as rescue ^{&} or Consider iv-PCA (patient controlled analgesia) including adequate monitoring [107]
Intermediate level:	a) Rectal or intravenous NSAID and/or b) Rectal or intravenous paracetamol and c) Regional anesthesia ^α with a long-acting local anesthetic combined with appropriate adjunct (clonidine) Landmark-based caudal block or epidural block [#] or Femoral nerve block (in femoral osteotomy only) or Fascia iliaca compartment block [100] d) If regional anesthesia is contraindicated: intravenous fentanyl or opioid of choice in divided doses - a) Rectal or intravenous NSAID and/or - b) Rectal or intravenous paracetamol and - c) Ultrasound-guided continuous peripheral block with a long-acting local anesthetic combined with appropriate adjunct (clonidine): • Femoral block (in femoral osteotomy only) or • Lumbar plexus block or • Suprainguinal fascia iliaca block or quadratus lumborum block [101,102] combined with psoas compartment block - d) Continuous epidural block with a long-acting local anesthetic combined with appropriate adjunct (clonidine). e) If regional anesthesia is contraindicated or unsuccessful • Fentanyl or opioid of choice in divided doses or if available • Continuous remifentanyl or opioid of choice	
Advanced level:		
Comments:	[#] Depending in the age of the patient. Caudal block for Infants and toddlers, lumbar epidural for older children. ^α If available ultrasound guidance should be used. If available consider at all levels: • Methylprednisolone or dexamethasone to reduce postoperative swelling [96] and • Intraoperative addition of alpha 2-agonists [57,97] and / or • Intraoperative addition of ketamine as co-analgesic drug [97] Development of procedure-specific ERAS protocol [65,108]	[*] Combination of NSAID and paracetamol reduces opioid use and will be useful if iv-rescue is not available. ^{&} Aim for oral administration as soon as possible. [§] In institutions where metamizole is available it should be used as first line rescue analgesic.

Table 3

Nissen fundoplication (open and laparoscopic).

Nissen fundoplication (open and laparoscopic)		
Basic level:	Intraoperative: Intravenous fentanyl or opioid of choice in divided doses Local wound infiltration/local port-side infiltration with long acting local anesthetic [109] or Intravenous lidocaine [110–116] a) Rectal NSAID and/or b) Rectal paracetamol.	Postoperative: PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward [§] : a) Rectal, oral or (if available) intravenous NSAIDs during the entire postoperative period and/or* b) Rectal, oral or (if available) intravenous paracetamol during the entire postoperative period Oral, rectal or intravenous tramadol or other suitable agent (if available) as rescue.
Intermediate level:	a) Rectal or intravenous NSAID or if not available rectal or intravenous paracetamol and/or b) Intravenous loading dose of metamizole (if available) plus - c) Regional anesthesia with a long-acting local anesthetic combined with appropriate adjunct • Ultrasound-guided bilateral peripheral block (subcostal TAP or quadratus lumborum block) ^α combined with appropriate adjunct (clonidine) (endoscopic) [117–119] • Landmark-based caudal blockade with long-acting local anaesthetics +/- adjunct (morphine if available[#]) - d) If regional anesthesia is contraindicated or unsuccessful: intravenous fentanyl or opioid of choice in divided doses	PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward [§] : a) Oral or Intravenous NSAID or paracetamol during the entire postoperative period and/or* b) Oral or Intravenous metamizole (if available) during the entire postoperative period [§] c/d) Oral, rectal or intravenous tramadol or other suitable agent if available as rescue in the ward
Advanced level:	a) Intravenous NSAID or if not available rectal or intravenous paracetamol and/or b) Intravenous loading dose of metamizole (if available) Regional anesthesia c) Ultrasound-guided bilateral peripheral block (subcostal TAP or quadratus lumborum block combined with appropriate adjunct (clonidine) (endoscopic) d) Continuous thoracic epidural analgesia with long acting local anesthetic combined with appropriate adjunct (clonidine) (open) [120–122] e) If regional anesthesia is contraindicated: • Fentanyl or opioid of choice in divided doses or if available • Continuous remifentanyl or opioid of choice	PACU: Intravenous fentanyl or other suitable agent to treat break-through pain. Ward [§] : a) Intravenous NSAID or paracetamol in adequate dosing during the entire postoperative period and/or* b) Intravenous metamizole in adequate dosing during the entire postoperative period [§] c/d/e) Intravenous tramadol or other suitable agent if available as rescue in the ward or c/e) Consider iv-PCA (patient controlled analgesia) including adequate monitoring (endoscopic) [123] d) Continuous epidural (patient controlled regional anesthesia) including adequate monitoring (open)
Comments:	[#] Only for open fundoplication in infants and small toddlers if adequate monitoring (pulse oximetry) is available for 24 h ^α For safety reason abdominal wall blocks should not be performed without ultrasound guidance If available consider at all levels: Methylprednisolone or dexamethasone to reduce postoperative swelling [96] and Intraoperative addition of alpha 2-agonists [57,97] and / or Intraoperative addition of ketamine as co-analgesic drug Development of procedure-specific ERAS protocol [64]	[*] Combination of NSAID and paracetamol might be useful if iv-rescue is not available [§] Aim for oral administration as soon as possible [§] A combination of two non-opioid drugs (NSAID, metamizole paracetamol) should always be used to reduce the need of an opioid rescue analgesic. In abdominal surgery metamizole (if available) should, due to its spasmolytic effect, be preferred over paracetamol.

PONV [61]. The intraoperative administration of PONV prophylaxis is highly recommended as part of an ERAS protocol (Enhanced recovery after surgery) [62–65]. The intraoperative continuous use of remifentanyl is controversial since it can be associated with postoperative hyperalgesia. A recently published systematic review and meta-analysis suggests that the withdrawal of remifentanyl at the end of the procedure induces a mild degree of hyperalgesia that is not clinically relevant, likely linked to a reduced pain threshold. The administration of a longer-acting opioid towards the end of the procedure as a pre-emptive postoperative dose can help to avoid a gap between intra- and postoperative analgesia [66]. According to the type of operation and the preferred age for the procedure, the ESPA Pain Committee

recommends certain opioids for postoperative pain management in the ward [12,67]. These suggestions reflect the most frequently used pain management regimens supported by the literature for a given type of operation. A detailed listing of possible drugs is attached in the tables below. After major operations, children should be managed for at least 24–48 hours in a setting where intravenous opioid administration and adequate monitoring are possible (minimum care - pulse oximetry and clinical observation, preferably - high to intermediate care). In the general ward, an oral opioid should be made available for basic-level care, with an oral and intravenous opioid for intermediate and advanced levels. In certain procedures, intravenous patient-controlled analgesia (iv-PCA) may be an option in advanced-level care [68,69].

Table 4
Thoracoscopy / Thoracotomy.

Thoracoscopy/Thoracotomy		
Basic level:	Intraoperative: Intravenous fentanyl or opioid of choice in divided doses Local wound infiltration/local port-side infiltration with long acting local anesthetic or Intravenous lidocaine [110–116] a) Rectal NSAID and/or - b) Rectal paracetamol.	Postoperative: PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward ^{&} : a) Rectal, oral or (if available) intravenous NSAID and/or* b) Rectal, oral or (if available) intravenous paracetamol during the entire postoperative period Oral and intravenous morphine or other suitable agent (if available) as rescue including adequate monitoring (pulse oximetry) PACU: Intravenous fentanyl or other suitable agent to treat break-through pain Ward ^{&} : a) Oral or intravenous NSAID or paracetamol during the entire postoperative period and/or [#] b) Oral or Intravenous metamizole (if available) during the entire postoperative period c/d) Intravenous morphine or other suitable agent if available as rescue including adequate monitoring (pulse oximetry) PACU: Intravenous fentanyl or other suitable agent to treat break-through pain Ward ^{&} : a) Intravenous NSAID or paracetamol in adequate dosing during the entire postoperative period and/or [#] b) Intravenous metamizole (if available) in adequate dosing during the entire postoperative period c) Continuous regional (patient controlled regional anesthesia) including adequate monitoring (pulse oximetry) [130,131] d) Intravenous morphine or other suitable agent if available as rescue in the ward including adequate monitoring e) Consider iv-PCA (patient controlled analgesia) including adequate monitoring [129,132]
Intermediate level:	Intravenous fentanyl or opioid of choice in divided doses a) Rectal or intravenous NSAID or if not available rectal paracetamol and/or b) intravenous loading dose of metamizole (if available) Regional anesthesia ^α : c) Landmark based intercostal block or d) Paravertebral block (single shot) with a long acting local anesthetic combined with appropriate adjunct (clonidine) if available [124,125]	
Advanced level:	a) Rectal or intravenous NSAID or if not available rectal paracetamol and/or b) Intravenous loading dose of metamizole (if available) Regional anesthesia: c) Ultrasound-guided continuous paravertebral block with a long acting local anesthetic combined with appropriate adjunct (clonidine) if available (thoracoscopic) [126–128] d) Continuous thoracic epidural analgesia with a long acting local anesthetic combined with appropriate adjunct (clonidine) if available (open) [127,129] - e) If regional anesthesia is contraindicated or unsuccessful: Fentanyl or opioid of choice in divided doses or if available - Continuous remifentanyl or opioid of choice	
Comments:	^α If available ultrasound guidance should be used. If available consider at all levels: Methylprednisolone or dexamethasone to reduce postoperative swelling [96] and Intraoperative addition of alpha 2-agonists [57,97] and / or Intraoperative addition of ketamine as co-analgesic drug Development of procedure-specific ERAS protocol [133]	* Combination of NSAID and paracetamol is recommended and might be essential if iv-rescue is not available. # A combination of two non-opioid drugs (NSAID, metamizole paracetamol) should always be used to reduce the need of an opioid rescue analgesic. & Aim for oral administration as soon as possible

Complex postoperative pain management concepts such as regional analgesia using catheter techniques, intravenous patient-controlled analgesia (PCA), and intravenous opioid administration in the ward can only be recommended if adequate monitoring (pulse oximetry and/or clinical observation) and experienced staff (preferably an Acute Pain Service team) are available around the clock. Depending on the age of the patient, PCA pumps can be programmed for nurse-controlled (NCA) or parent-controlled analgesia modes [70,71]. For details of monitoring and treatment of possible adverse effects of pain management, the ESPA Pain Management Committee suggests following already published recommendations [72–78].

The following Tables 1–6 provide the Pain Management Ladders for 5 frequently performed procedures in children.

Drug suggestions

Table 6 outlines some drug dosage suggestions for different pain management ladder levels. These suggestions are based on the available literature and ESPA does not accept any legal responsibility for these suggestions. As there are marked differences between European Countries concerning the availability and licensing of analgesic drugs the authors recommend that you consult the pharmacopeia of your country before using any of these dosage suggestions. Please be aware of the increased sensitivity to the effects of opioids in patients with obstructive sleep apnoea (OSA) which has been outlined in the previous publication [1]. Furthermore, the authors underline that these recommendations are intended for inpatients only [141–143].

Table 5

Hypospadias repair.

Hypospadias Repair		
Basic level:	Intraoperative: - a) Rectal NSAID and/or - b) Rectal paracetamol Landmark-based regional anesthesia with long-acting local anesthetics Penile block [134,135] or bilateral pudendal nerve block [59] or Intravenous lidocaine [110–116]	Postoperative: PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward [®] : a) Rectal or oral NSAIDs during the entire postoperative period and/or * b) Rectal or oral paracetamol during the entire postoperative period. Oral, rectal or intravenous Tramadol or Intravenous nalbuphine [#] or other suitable agent (if available) as rescue Ward [®] : Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. a) Oral or intravenous NSAID during the entire postoperative period and/or b) Oral or intravenous paracetamol during the entire postoperative c) Oral or intravenous metamizole during the entire postoperative period. - Oral, rectal or intravenous Tramadol or Intravenous nalbuphine [#] or other suitable agent (if available) as rescue PACU: Intravenous fentanyl or other suitable agent (if available) to treat break-through pain. Ward [®] : a) Oral or intravenous NSAIDs and/or b) Paracetamol during the entire postoperative period. - c) Intravenous or oral metamizole during the entire postoperative period. - d,f) Intravenous nalbuphine [#] or other suitable agent (if available) as rescue or - d,f) In major reconstructive surgery consider iv-PCA (patient controlled analgesia) including adequate monitoring - e) In case of epidural catheter: patient controlled regional anesthesia including adequate monitoring.
Intermediate level:	a) Intravenous or rectal NSAID. and/or b) Intravenous or rectal paracetamol. c) Alternative: loading dose of metamizole . Landmark-based or ultrasound guided caudal block ^α with long-acting local anesthetics +/- adjunct (clonidine) if available [136–138].	
Advanced level:	a) Intravenous or rectal NSAID. and/or b) Intravenous or rectal paracetamol. c) Alternative: loading dose of metamizole Regional anaesthesia ^β d) Ultrasound guided caudal block [139] or e) Continuous lumbar epidural block with long-acting local anaesthetics combined with appropriate adjunct. ^γ f) If regional anesthesia is contraindicated or unsuccessful: Fentanyl or opioid of choice in divided doses or if available Continuous remifentanyl or opioid of choice	
Comments	^α If available ultrasound guidance should be used. ^β depends on the degree of Hypospadias and the type of operation ^γ Might be an option in severe proximal / perineal abnormalities If available consider at all levels: Methylprednisolone or dexamethasone to reduce postoperative swelling [59,96] and Intraoperative addition of alpha 2-agonists [57,97] and / or Intraoperative addition of ketamine as co-analgesic drug Development of procedure-specific ERAS protocol [140]	[#] In infants, for order children use opioid of choice

Table 6

Dosage suggestions.

Dosage Suggestions	
Rectal NSAIDs (Non-steroidal anti-inflammatory drugs)	
Ibuprofen	10 mg kg ⁻¹ every 8 h
Diclofenac	0.5–1 mg kg ⁻¹ every 8 h
Naproxen	5 to 7.5 mg kg ⁻¹ every 12 h
Oral NSAIDs	
Ibuprofen	10 mg kg ⁻¹ every 8 h
Diclofenac	1 mg kg ⁻¹ every 8 h
Intravenous NSAIDs	
Ketorolac	0.5–1 mg kg ⁻¹ kg up to 30 mg for a single intraoperative dose 0.15–0.2 mg kg ⁻¹ (max 10 mg) every 6 h (short term therapy, maximum 48 h)
Ketoprofen	1 mg kg ⁻¹ every 8 h
Ibuprofen	10 mg kg ⁻¹ every 8 h
Rectal paracetamol (if rectal NSAID is not available)	
Paracetamol	20–40 mg kg ⁻¹ (15 mg kg ⁻¹ if < 10 kg) Single loading dose in association with anaesthesia; the higher dose is due to poor bioavailability from rectal route of administration
Oral paracetamol	
Paracetamol	10 to 15 mg kg ⁻¹ every 6 h (max daily dose: 60 mg/kg)
Intravenous paracetamol	
Paracetamol	loading dose: 15–20 mg kg ⁻¹ (Intravenous preparation: 10 mg ml ⁻¹) 10–15 mg kg ⁻¹ every 6–8 hours
Intraoperative Opioids depending on age of the patient and the type of procedure	
Fentanyl	1–2 micrograms kg ⁻¹
Morphine	25 to 100 micrograms kg ⁻¹ depending on age, titrated to effect
Piritramide	0.05 to 0.15 mg kg ⁻¹
Alfentanil	10 to 20 micrograms kg ⁻¹
Sufentanil	0.5–1 micrograms kg ⁻¹ bolus
Sufentanil	0.5–1 micrograms kg ⁻¹ bolus, continuous infusion of 0.5–1 micrograms kg ⁻¹ h ⁻¹
Remifentanyl	0.05 to 0.3 micrograms kg ⁻¹ min ⁻¹
Intraoperative use of Ketamine/S-Ketamine	
Ketamine	0.5 mg kg ⁻¹ may be used as adjunct to intraoperative opioids, consider reduced dose (0.25–0.5 mg kg ⁻¹) when using S-ketamine, optional followed by continuous infusion of 0.1–0.2 mg kg ⁻¹ h ⁻¹ (max: 0.4 mg kg ⁻¹ h ⁻¹)
Intraoperative use of Co-analgesic Drugs	
Lidocaine	intravenous bolus: 1.5 mg kg ⁻¹ , continuous infusion 1.5 mg/ kg ⁻¹ h ⁻¹ until the end of the procedure
Methylprednisolone	1 mg kg ⁻¹
Dexamethasone	0.15–0.25 mg kg ⁻¹ (max: 0.5 mg kg ⁻¹)
Clonidine	intravenous bolus: 1–3 micrograms kg ⁻¹
Dexmedetomidine	intravenous bolus: 0.5–1 micrograms kg ⁻¹ , continuous infusion 0.2–0.7 micrograms kg ⁻¹ h ⁻¹ until the end of the procedure
Intraoperative/postoperative intravenous Metamizole	
Metamizole	10 to 15 mg kg ⁻¹ every 8 h 2.5 mg kg ⁻¹ h ⁻¹ (continuous infusion following an intraoperative loading dose) (Due to the risk of agranulocytosis after long-term use metamizole is recommended for short term postoperative use in a hospital setting only)
Intravenous analgesics for breakthrough pain in PACU depending on age and procedure	
Fentanyl	0.5 to 1.0 micrograms kg ⁻¹ , titrated to effect
Morphine	25 to 100 micrograms kg ⁻¹ depending on age, titrated to effect
Tramadol	1 to 1.5 mg kg ⁻¹ , titrated to effect
Ketamine/S-Ketamine	0.5 mg kg ⁻¹ , titrated to effect consider reduced dose (0.25–0.5 mg kg ⁻¹) when using S-ketamine,
Piritramide	0.05 to 0.15 mg kg ⁻¹ , titrated to effect
Nalbuphine	< 3 months 0.05 mg kg ⁻¹ > 3 months 0.1 to 0.2 mg kg ⁻¹ , depending on age, titrated to effect
Intravenous analgesics for breakthrough pain in the ward, including adequate monitoring	
Tramadol	1 to 1.5 mg kg ⁻¹ , every 4–6 hours
Nalbuphine	< 3 months 0.05 mg kg ⁻¹ > 3 months 0.1 to 0.2 mg kg ⁻¹ , depending on age, every 3–4 hours
Morphine	< 3 months 25–50 micrograms kg ⁻¹ , every 4–6 hours 3–12 months 50–100 micrograms kg ⁻¹ , every 4–6 hours 1–5 years 100–150 micrograms kg ⁻¹ , every 4–6 hours 5–18 years 150–200 micrograms kg ⁻¹ , every 4–6 hours single dose adjusted according to response
Piritramide	0.05 to 0.15 mg kg ⁻¹ every 4–6 hours
Metamizole	10 to 15 mg kg ⁻¹ every 8 h
Oral analgesics for breakthrough pain in the ward	
Tramadol	1–1.5 mg kg ⁻¹ , every 4–6 hours
Metamizole	10 mg kg ⁻¹ every 8 h

Table 6 (Continued)

Dosage Suggestions		
Morphine	When changing from intravenous to oral administration the daily dose should be increased by 2–3 times due to lower bioavailability. <3 months 50–100 micrograms kg ⁻¹ , every 4–6 hours 3–12 months 100–150 micrograms kg ⁻¹ , every 4–6 hours 1–5 years 150–200 micrograms kg ⁻¹ , every 4–6 hours 5–18 years 200–300 micrograms kg ⁻¹ , (max10 mg) every 4–6 hours single dose adjusted according to response	
PCA (patient controlled analgesia) including adequate monitoring		
	Morphine PCA according to institutional standards based on the current literature Fentanyl PCA according to institutional standards based on the current literature Piritramide PCA according to institutional standards based on the current literature	
	Dosage Suggestions	Adjuvant
Long-acting local anesthetics for wound infiltration, port-side infiltration and peripheral nerve block		
Bupivacaine 0.25 %,	maximum dose 1 ml kg ⁻¹ (= 2.5 mg kg ⁻¹)	
Levo-bupivacaine 0.25 %	maximum dose 1 ml kg ⁻¹ (= 2.5 mg kg ⁻¹)	
Ropivacaine 0.2 %	maximum dose 1.5 ml kg ⁻¹ (= 3 mg kg ⁻¹)	
Long-acting local anesthetics for landmark-based maxillary nerve block and external nasal nerve block		
Bupivacaine 0.25 %	0.15 ml kg ⁻¹	
Levo-bupivacaine 0.25 %	0.15 ml kg ⁻¹	
Ropivacaine 0.2 %	0.15 ml kg ⁻¹	
Long-acting local anesthetics for thoracic epidural block		
Bupivacaine 0.25 %	0.2–0.3 ml kg ⁻¹ (max10 ml) initially	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.2–0.3 ml kg ⁻¹ (max10 ml) initially	
Ropivacaine 0.2 %	0.2–0.3 ml kg ⁻¹ (max10 ml) initially	
Long-acting local anesthetics for lumbar epidural block		
Bupivacaine 0.25 %	0.5 ml kg ⁻¹ (max15 ml) initially	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.5 ml kg ⁻¹ (max15 ml) initially	
Ropivacaine 0.2 %	0.5 ml kg ⁻¹ (max15 ml) initially	
Long-acting local anesthetics for landmark-based and ultrasound-guided caudal block		
Bupivacaine 0.25 %	1.0 ml kg ⁻¹	preservative-free Clonidine 1–2 micrograms kg ⁻¹ or
Levo-bupivacaine 0.25 %	1.0 ml kg ⁻¹	Morphine 30 to 50micrograms kg ⁻¹ (only with adequate monitoring)
Ropivacaine 0.2 %	1.0 ml kg ⁻¹	
Long-acting local anesthetics for ultrasound-guided paravertebral block		
Bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	
Ropivacaine 0.2 %	0.2–0.5 ml kg ⁻¹	
Long-acting local anesthetics for nerve stimulator guided femoral nerve block and fascia iliaca block?		
Bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	
Ropivacaine 0.2 %	0.2–0.5 ml kg ⁻¹	
Long-acting local anesthetics for ultrasound-guided fascia iliaca and quadratus lumborum block		
Bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹	
Ropivacaine 0.2 %	0.2–0.5 ml kg ⁻¹	
Long-acting local anesthetics for ultrasound guided rectus sheath block and subcostal TAP:		
Bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹ per side	preservative-free Clonidine 1 microgram kg ⁻¹ per side
Levo-bupivacaine 0.25 %	0.2–0.5 ml kg ⁻¹ per side	
Ropivacaine 0.2 %	0.2–0.5 ml kg ⁻¹ per side	
Long-acting local anesthetics for landmark based and ultrasound guided intercostal block		
Bupivacaine 0.25 %	0.1 ml kg ⁻¹	preservative-free Clonidine 1–2 micrograms kg ⁻¹
Levo-bupivacaine 0.25 %	0.1 ml kg ⁻¹	
Ropivacaine 0.2 %	0.1 ml kg ⁻¹	
Continuous or patient controlled regional anesthesia including adequate monitoring		
According to institutional standards based on the current literature Continuous rate of Bupivacaine 0.25 or Ropivacaine 0.2% (0.1–0.3 ml kg ⁻¹ h ⁻¹)		Preservative-free clonidine 0.2 to 0.4 micrograms kg ⁻¹ h ⁻¹
Dosage Suggestions antiemetic drugs		
Dexamethasone	0.15 mg kg ⁻¹ every 12 h	
Ondansetron	0.15 mg kg ⁻¹ every 8 h	not to be combined with tramadol
Metoclopramide	0.1 mg kg ⁻¹ every 8 h	not to be combined with tramadol; not if <1y old

Discussion

The recommendations of the ESPA pain management ladders are well-established pain management concepts employed in European pediatric surgery centers and their use is well documented by the literature. This document does not claim completeness and does not take into account the special conditions of patients with complex underlying diseases.

The authors are aware of the difficulties in transferring detailed and well-functioning pain management plans between hospitals. Therefore, we would like to emphasize that each institution develops its own institution-specific pain management concepts for each procedure [144,145].

The analysis of real-life data from the Pain registry "PAIN OUT infants" revealed the inadequate administration of non-opioid drugs, which are the main pier of postoperative pain management. It was demonstrated that although the significance of regional anesthesia and the efficacy of non-opioid drugs are well-known implementation of this knowledge often failed even in highly experienced centers. The intention of the authors is to improve daily clinical practice by offering treatment concepts that rely on local/regional anesthesia, the administration of a full daily dose of non-opioid drugs by the clock, and a minimum use of opioids in the postoperative period. The most important way to achieve this is an exact prescription. There has to be a detailed prescription for opioid rescue medication that should include the age- and weight-adapted single dose, the maximum daily dose, and the minimum time interval between doses. Finally, pain management protocols should be regularly evaluated and adapted as needed [146].

For assessment of the efficacy and safety of postoperative pain therapies, age adapted scores are recommended [147–154].

Conclusions

The ESPA Pain Ladder Part II is a continuation of previous recommendations for perioperative pain management in children. This is a synthesis of existing guidelines, taking into account the availability of medications and other resources, economic costs, and patient safety. We hope that the suggestions in this article will further improve pain management in children not only in Europe but also in other parts of the world.

Ethics approval

No ethics approval is required.

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Conflict of interest

Marzena Zielinska is a member of the editorial board of ACCPM. All other authors declare no conflict of interest.

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