Chapter 37: Post-Anesthesia Care Unit

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INTRODUCTION

FOCUS POINTS

1. Preparation for recovery begins before the child arrives in the preoperative area for surgery.
2. The postanesthesia care unit (PACU) must be equipped and staffed for full resuscitation if that becomes necessary.
3. Good communication between anesthesia and recovery staff at handoff from the operating room (OR) is crucial.
4. Perioperative agitation is common in children and is multifactorial; emergence delirium is a specific entity in the postoperative period that may be best managed by prophylaxis.
5. There are many causes for respiratory insufficiency in the postoperative period. Management should focus on rapid diagnosis and symptomatic treatment.
6. Postoperative nausea or vomiting (PONV) is more common in children than in adults. Identified risk factors should be sought and prophylaxis considered if found.
7. Children can have difficulty communicating pain; a multimodal approach to analgesia in the perioperative period offers many benefits.
8. Good communication with parents on PACU discharge is necessary to achieve an acceptable post-op course.

Preparation for recovery begins long before the child arrives on the unit; there are a number of things that can be done starting in the preoperative area that will influence emergence and wakeup. There is some evidence that a quiet induction in a calm child is more likely to result in a quieter wakeup.[1,2] It also appears to be the case that slower, more gradual emergence combined with minimal stimulus during that emergence may also decrease agitation in the PACU.[3] Preemptive pain management will decrease pain as an element, and PONV prophylaxis, including avoidance of risks factors and medications, can also be valuable especially in those at higher risk.

PACU SETUP

Physical Space Requirements

The PACU should ideally be located in close proximity to the operating room (OR); both to decrease transport times and to ensure readily availability of personnel and support in case of emergency. An open plan is frequently employed to facilitate monitoring, but provision should be made for either separation of spaces (ie, curtain) or physical movement to a different area to provide some privacy for child and parents in the later stages of recovery.

Personnel Requirements

Nursing staff must be competent in recognizing and initiating treatment for commonly encountered issues and recognizing when assistance is desirable/necessary. They should have experience and training in pediatric resuscitation, including airway management and cardiovascular support, in recognizing and assessing pain, and good interpersonal ability to manage parents. Skills should be frequently assessed and updated to maintain

competency; practice sessions or simulations can be invaluable. Clear delineation of physician supervision must be established and a clear policy of whom to call for assistance known to all staff. Also clearly indicated must be handoff and signout protocols.

Equipment Requirements

The recovery space must be equipped to handle all potential issues that may arise during the recovery process. Oxygen (O_2) should be provided with humidification and a blender for titration. A second O_2 source with an attached self-inflating bag ready for use is desirable. Tubing for blow-by O_2 and a variety of masks, nasal cannulas, and oral and nasal airways of different sizes should be immediately at hand. Suction must be present and functioning with appropriate size catheters for use in the child. This equipment may be present in the room but out of sight to decrease anxiety in the child and his or her family.

Full cardiopulmonary monitoring should be performed with noninvasive blood pressure (NIBP), electrocardiogram (EKG), pulse oximetry (SpO_2), respiratory rate (RR), and temperature (T). End-tidal carbon dioxide ($EtCO_2$) monitoring should be available and certainly used, at minimum, in the instrumented airway to monitor adequacy of ventilation. Nasal cannulas with capability for $EtCO_2$ monitoring along with O_2 provision are available and compatible with many monitors. The capability to monitor invasive pressure lines (when present) should be available.

Commonly used medications for the treatment of pain, PONV, and respiratory distress should be readily accessible but secure in the environment—as should medications for the reversal of narcotics, benzodiazepines, and neuromuscular blockers.

Emergency equipment, possibly most readily organized in the form of a code cart, should be present on the unit and periodically checked for completeness and expiration. This should include medications, airway management equipment, and (possibly) invasive line kits with all equipment needed for placement.

TRANSPORT TO PACU

The laryngeal mask airway or endotracheal tube, if present, can be removed deep or awake according to the judgment and preference of the provider. Once the airway is judged to be stable, the patient may be transported to the PACU. The child is placed in the stretcher in the lateral position with the neck moderately extended to decrease airway obstruction. This position also protects against oropharyngeal secretions falling onto the vocal cords and against vomiting resulting in aspiration. Guardrails should be up and padding considered to prevent a fall or injury resulting from the sudden motion of the child; keeping a hand on the child can also help in this regard. Oxygen is generally recommended for transport as children are more likely to desaturate on the way to the PACU. How the oxygen is delivered may be dependent upon acceptance by the child; nasal cannulas may work well in the older child, but “blow-by” may be the only form tolerated in younger children. Provider monitoring of respirations during transportation can be accomplished with precordial stethoscope or direct detection of exhalation on a hand under the chin. At a minimum, pulse oximetry monitoring is frequently employed for transport for any but the shortest trip to the PACU. For the more critical patient, full cardiorespiratory monitoring is recommended along with drugs and equipment for emergent reintubation. If the child is intubated, a ventilator should be confirmed to be present in the PACU before transport is undertaken, and ventilation supported or provided with a self-inflating bag. The child should be covered with a blanket during transport to keep him or her warm when traveling through a less regulated temperature environment.

PACU MANAGEMENT

Initial Care and Handoff

Upon arrival in the PACU, nursing staff should arrive immediately at the bedside. First priority should be to confirm patency of airway and adequacy of ventilation, and ensure the presence and application of O_2. Monitors should be applied and initial vitals including heart rate (HR), NIBP, SpO_2, T, and RR recorded. Etiology of agitation, if present, should be assessed and treated. Initial assessment of pain and nausea or vomiting should be made and treatment given if needed. Formal report should be given to nursing personnel once initial assessment is complete. The report should include preoperative information such as age and weight, allergies, comorbidities, and premedication given. Intraoperative information should include surgery performed, type of anesthesia and medications administered, airway management, lines, and fluids. Drips, blood products transfused, latest labs, and complications should also be included as applicable. Medications of relevance to the PACU and postoperative course of care should be

reported along with time of administration. These might include antibiotics, steroids, analgesics, anticonvulsants, and sedatives. Regional, peripheral nerve blocks or local infiltration should be reported when performed.

The Road to Recovery

Once care is turned over to the PACU staff, the child is monitored on a continuous basis until he or she is fully recovered from the anesthetic. Vitals are recorded every 15 minutes at minimum with interventions applied as needed. In the initial recovery phase, minimal stimulation is frequently applied when possible as it can result in a less agitated return to consciousness. Depending on the unit, parents may be brought to the bedside immediately upon arrival, after initial assessment and report, or when the child awakens. In all cases, it is good if they have been prepared for what they will see. If the child remains unconscious, reassurance that this is normal and that the child will wake up calmer if allowed to do so on their own should be stressed. If the child is awake and agitated, parents should be informed that this, too, is not unusual and enlist their help in calming the child.

PACU PROBLEMS

Agitation

It is essential to try to determine the etiology of agitation, as many conditions may manifest in this way. Obviously, it is easiest if the child can communicate this information themselves, but this is not always possible, especially in preverbal or neurologically challenged children. Some of the things that may present as agitation include hypoventilation with hypoxia and/or hypercarbia, pain, metabolic issues, preexisting neurological and/or behavioral conditions, and separation anxiety. Knowledge of the child's pre-op baseline, and parental presence, may help distinguish some of these, but a high degree of suspicion must be kept for the others. When no other cause of the agitation can be identified and the degree of agitation is profound, the child may be experiencing emergence delirium (ED). This is a dissociated state of consciousness with inconsolability, thrashing, and incoherence. The characteristic feature of the phenomenon is that child does not seem to be aware of its surroundings and does not recognize even his or her parents. It is generally brief in duration and self-limited, but intervention may be needed to prevent the child from injuring himself or herself or others. Complications of uncontrolled ED include increased bleeding and pain, increased medication use, increased need for staffing, increased infectious risk from pulling at dressings and drains, loss of intravenous access, and a longer PACU stay.

There are a number of theories as to the etiology of this condition, but no definitive answers. Some of the proposed causes include rapid awakening in a strange environment, variable recovery of central nervous system (CNS) function, precipitous withdrawal of agent from GABA receptors, psychomotor side effects of potent agents, and inadequately treated pain.[4] While pain may be a partial answer, the condition is also seen in pain-free settings in which anesthesia has been given.[5] Independent risk factors that have been determined or proposed include age <5 years, head and neck cases, use of inhalational agents as opposed to total intravenous anesthesia, rapid emergence, anxious child and/or parents, poor socialization, and low adaptability scores in the child.[6] Depth of anesthesia as measured by bispectral index scores (BIS) does not seem to be predictive of incidence.[7] There is some evidence that the level of anxiety on induction has a significant impact on the severity of agitation on emergence.[8] Decreasing that anxiety can be accomplished in a number of ways including sedative premedication, parental presence at induction, or distraction. If the rapidity of emergence or drug metabolism contributes to the severity of ED, then it would logically follow that slowing the emergence might mitigate some of the symptoms, and this does indeed appear to be the case. When combined with minimal stimulation as the child emerges from the anesthetic, the improvement can be significant.[9]

Among the tools that have been developed to evaluate ED, the Pediatric Anesthesia Emergence Delirium Scale (PAEDS) has high specificity and sensitivity. This tool consists of five descriptors scored on a 0–4 scale (with 4 being most abnormal):

1. The child makes eye contact with the caregiver;
2. The child's actions are purposeful;
3. The child is aware of his/her surroundings;
4. The child is restless;
5. The child is inconsolable.[10]

A wide variety of therapies have been reported to be efficacious both as prophylaxis and as treatment for ED; most medications have indeed been proposed for both.[11] Nonpharmacological management can include swaddling. Parental presence can be reassuring; allowing the parent to hold the child or get up into the stretcher with it can be very calming. These may be enough as this is a self-limited condition and is generally of short duration.

Some treatments focus on the use of analgesic strategies either preemptively or in the PACU to mitigate the severity of emergence agitation by removing the component that may be attributable to pain. Narcotics given prophylactically in the OR decrease the incidence of ED, and also work as treatment—probably through combination of analgesia and sedation.[12,13] Other analgesic agents may or may not have any impact: nonsteroidal anti-inflammatory drugs (NSAIDs)[14] and acetaminophen[15] may or may not have any consistent impact in studies on ED although they contribute to better post-op analgesia. Local infiltration, peripheral nerve blocks, and regional anesthesia done prophylactically have been shown to be effective.[16]

The other approach to treatment (with much overlap) primarily seeks to sedate the child and/or slow the wakeup from anesthesia (Table 37-1). Propofol used during the case either alone or in combination with decreased minimum alveolar concentration (MAC) of potent agent decreases incidence of ED. Propofol may be given in the form of an infusion, or as a single dose at the end of case alone to be effective.[17] A single bolus for induction does not seem to have the same prophylactic effect. As treatment in the PACU, it is very short acting, but may interrupt the agitation long enough to mitigate severity.[18] Ketamine and nalbuphine have both been successfully given prophylactically to decrease the risk of developing ED in the PACU.[19–21] Dexmedetomidine or clonidine given pre- or intraoperatively has also been shown to decrease the incidence. As a treatment in PACU, they can suffer from relatively longer durations of action and higher degree of sedation which may delay discharge, particularly in the outpatient setting.[22–24] Midazolam given as a premedication or in the OR may act as prophylaxis although reports are mixed; this may depend on the severity of preoperative anxiety and the length of the case.[25] Many other reports indicate that it increases incidence rather than decreases it. It has been given as treatment of ED in the PACU with mixed results; the level of sedation produced has led to prolonged PACU times.[26,27]

Table 37-1

Selected Medication Dosing for Emergence Delirium in PACU

Fentanyl	1 mcg/kg
Propofol	1 mg/kg
Dexmedetomidine	0.25–0.5 mcg/kg
Clonidine	2 mcg/kg
Midazolam	0.025 mg/kg
Ketamine	0.25mg/kg to 0.5 mg/kg IV
Nalbuphine	0.1 mg/kg IV

Desaturation and Respiratory Distress

A large percentage of otherwise normal children will develop desaturation during transport or during their stay in PACU if no supplemental O_2 is provided. It occurs sooner, is more pronounced, and lasts longer than in adults. The cause is usually atelectasis, but upper airway problems such as obstruction, croup, laryngospasm, bronchospasm, and apnea are also more common in children.

Atelectasis is common in the PACU and is due to loss of FRC from the combination of supine position and residual general anesthesia. This results from abdominal pressure being transmitted to the thoracic cavity via the cranially displaced diaphragm in the spontaneously breathing patient; muscle relaxant residual and narcotic administration may accentuate this effect.[28] Other factors such as mucus plugging, less well-developed diaphragmatic

musculature causing easier fatigue, and absorption atelectasis due to high FiO_2 may also contribute. Closing volume is also greater in young children in whom the elastic supporting structure of the lung is incompletely developed. This puts the infant at greater risk for atelectasis because airway closure can occur even during tidal breathing.[29]

Decreased hypopharyngeal and tongue muscle tone causing mechanical obstruction of the upper airway is present as a residual effect of anesthesia with potent agents; sedative agents, narcotics, and residual neuromuscular blockade (NMB) will exaggerate this effect. Airway manipulation consisting of chin lift and/or jaw thrust may relieve the obstruction, or bag-mask ventilatory assistance may be needed. Train-of-four monitoring can be employed as in adults to assess the degree of NMB and need for additional reversal. Naloxone and flumazenil can be given to reverse narcotic and benzodiazepines, respectively. If none of the above is effective, the child can be reintubated and ventilated until his or her ability to spontaneously maintain an adequate airway is regained.

Laryngospasm in the PACU is most frequently caused by secretions contacting the vocal cords in a heavily sedated child. It can be recognized by the presence of respiratory effort in the absence of actual air movement. Treatment includes positive pressure delivered via bag/mask for milder cases or pharmacological release with sedation, and/or succinylcholine and intubation if necessary.

Croup resulting from airway edema will most frequently present, at least early on, as adequate air movement with increased effort and high-pitched inspiratory stridor. Treatment is humidified O_2 and nebulized racemic epinephrine to decrease swelling. Steroids will not help acutely, but can be given as they will help in the longer term to decrease the swelling.

Bronchospasm is seen in the PACU not only in children with asthma and seasonal allergies, but also in those with an (known or unsuspected) upper respiratory infection, and in those exposed to cigarette smoking (or marijuana smoke). This will frequently not present initially as desaturation, but as increased work of breathing. The treatment includes albuterol nebulization treatment, O_2, and steroid for longer term stabilization.

Obstructive sleep apnea (OSA) is most commonly due to adenotonsillar hypertrophy in children; although with the increasing amount of childhood obesity, more children are presenting with a mixed form. A pre-op history of snoring, frequent arousal during sleep, daytime hyperactivity or poor attention, or bedwetting can alert one to the possible existence of this disease process.

Neonatal apnea comes in a variety of forms with different etiologies and implications. Apnea of prematurity is correlated with the degree of prematurity and corrected gestational age (CGA), as well as hemoglobulin levels. Post-anesthetic apnea rates approach normal sometime after 55 to 60 weeks CGA.[30] As the name suggests, the phenomenon is rarely seen in full-term infants and is most likely related to immaturity of brainstem respiratory control in the premature brain.[31] There does seem to be less frequent occurrence with subarachnoid blocks (SABs) as opposed to general anesthesia (GA), although this benefit is lost if sedation is given.[32] Periodic breathing can be seen in both premature infants and full-term infants as a normal pattern; pauses in breathing rarely last more than about 12 seconds and are not accompanied by bradycardia, although mild desaturations that resolve spontaneously with resumption of breathing can occur.[33] Premature infants have a biphasic response to hypercarbia on their ventilation; initially the TV increases, then the RR decreases. This response can be blunted in the presence of increased FiO_2.[31]

Central hypoventilation syndrome is related to neurological disease processes (congenital vs acquired), and is a manifestation of dysfunctional autonomic regulation of ventilation. The ventilatory response to hypercarbia is blunted, and supplemental oxygen may cause apnea. These children can be exquisitely sensitive to the central nervous syndrome depressant effects of sedatives, narcotics, hypnotics, and obviously GA. In disease of long-standing and/or poor control, significant degrees of pulmonary hypertension and heart failure may be present. The autonomic regulation of other organ systems may also be impaired leading to decreased gastric motility with increased aspiration risk, or dysfunction of cardiac rate control with bradycardia or heart block.[34]

Postoperative pulmonary edema (POPE) can be seen after tonsillectomy and adenoidectomy, or other obstructive airway mass excision such as airway papilloma. Removal of the obstructing mass causes relief of the increased end-expiratory pressure that has been ongoing and results in pulmonary edema. This is usually mild and self-limited, but may occasionally require treatment with diuretic and positive end-expiratory pressure (PEEP); occasionally a brief period of ventilation is needed while waiting for it to resolve.[35]

Hemodynamic Instability

Compared to the adult patient, cardiovascular events in the pediatric post-op population are far less common.

Bradycardia is essentially hypoxia until proven otherwise. If the saturation is adequate, other causes that may cause bradycardia, such as medication effects (narcotic), should be sought. There is not generally any need to treat the bradycardia other than addressing the cause, unless it is combined with hypotension.

Tachycardia in the recovery room may be due to hypovolemia, hyperthermia, pain, or agitation. Carefully assessing the child and his or her other vital signs can frequently direct attention to the correct cause; this should be addressed to reduce the HR.

Hypotension in the post-op period should raise concerns for hypovolemia and/or hemorrhage. Hypovolemia should be suspected in cases in which the child was NPO for a prolonged period before surgery or in which large volume shifts or blood losses were seen. A crystalloid fluid bolus is a reasonable first step in treatment of hypotension. In cases where significant blood loss occurred in the OR, or could potentially be happening in a disguised fashion in the PACU (bleeding tonsils), checking a hemoglobin level to rule out significant anemia would be appropriate.[36]

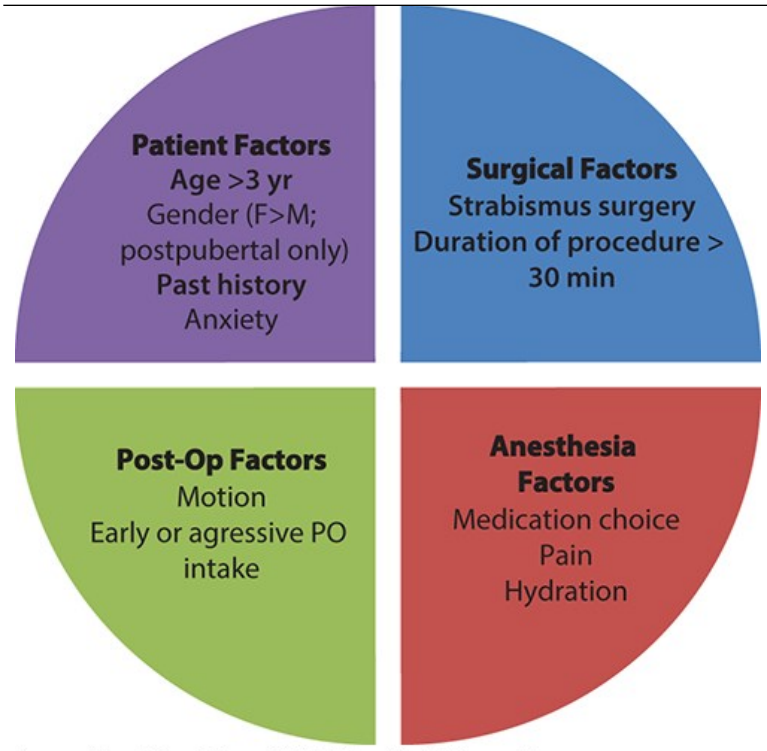
Hypertension is almost always due to pain and/or agitation, but rarer conditions should be kept in mind and ruled out if the hypertension persists despite treatment.

Postoperative Nausea and Vomiting

The incidence of PONV in young patients is generally held to be about double that of the adult population. In many studies only POV is measured due to the difficulty in identifying nausea in pediatric patients, so this rate may actually be significantly higher. In pediatric patients POV incidences are lowest below age 3 and highest in the range of 11 to 14 years with female preponderance after reaching puberty.[37] This is generally identified by both parents and the child as being one of the least satisfactory parts of their PACU experience and can contribute to unanticipated admission if uncontrolled.[38] Many of the other risk factors (Figure 37-1) identified in adults are true for children as well.[39]

Figure 37-1

Risk factors for PONV.



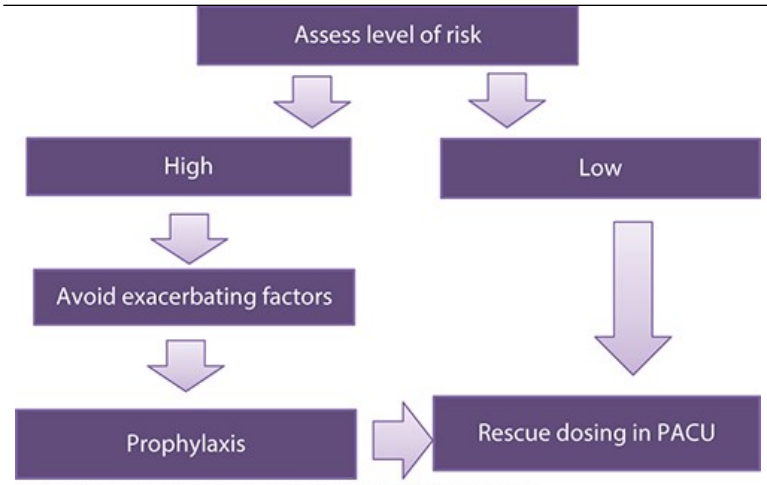
Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

Treatment

There is considerable debate about the desirability of prophylaxis for PONV as opposed to treatment; much of the conversation focuses on cost-effectiveness versus patient satisfaction. Given that there are readily identifiable risk factors for this complication, a prudent approach may be to use prophylaxis in those children identified to be at least at moderate risk (see Figure 37-2). This prophylaxis can take a multitiered approach of using regional anesthesia where possible, considering the use of nonpharmacological interventions, eliminating as many of the modifiable risk factors as possible in the OR, and antiemetic medication administration.[40–42]

Figure 37-2

An approach to PONV management.



Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

Preoperative measures that can be used to influence the frequency and severity of PONV include attention to the state of hydration and catabolic state. Prolonged NPO times should be avoided if at all possible, and IV hydration given to compensate when it does occur. Recent research is showing benefit to carbohydrate-containing drinks on the morning of surgery in the adult population; similar studies on children are currently lacking.[43] A nonpharmacological approach to PONV prophylaxis that is attracting increased interest is that of acupressure, acupoint injection, and/or acupuncture. Acupressure and acupuncture can be performed with or without electrical stimulus to intensify the effect. In adults, the stimulus is usually performed prior to induction of general anesthesia. Since needles for acupuncture are not well tolerated by younger children awake, it has been questioned whether this modality is realistically available in the pediatric population. P6 acupoint injection has proved to be as effective as droperidol even when performed under GA in children for prevention of early PONV.[44] Scopolamine in patch form at a dose of 1.5 mg is approved for use in children over 12 years old and weighing at least 40 kg. There are few studies specifically addressing the use of scopolamine in younger children. Because of the relative lack of data, scopolamine is most commonly reserved for use in adolescents who suffer from motion sickness or have a history of intractable PONV with previous surgery. The patch is ideally placed at least 2 hours preoperatively. It has the advantage of being able to provide continuous treatment into the postoperative/post-discharge period.[45]

Intraoperative choices can also affect the incidence and severity of PONV in the susceptible patient. Use of potent agent and >50% N_2O are very strong risk factors for PONV in the susceptible patient, so avoiding their use is indicated when feasible.[46] Propofol, used exclusively or as an adjunct to decreased MAC of potent agent, is very efficacious in preventing PONV; even a single bolus at the end of the case (although not solely on induction) is shown to be beneficial.[47] While pain treatment should be provided prior to emergence, decreasing the dose of, or eliminating the use of, narcotics for prophylactic analgesia and replacing them with nonsteroidal anti-inflammatory drugs (NSAIDs) and/or acetaminophen, combined with aggressive use of local infiltration or regional blocks where possible, will also contribute to decreasing PONV incidence.[46,47] For patients at moderate to high risk of PONV, recommendation has been made to use dual antiemetic prophylaxis. Ondansetron, a serotonin receptor (5HT3) antagonist, and others of its class have been shown to be more effective as a group in the prevention of vomiting than nausea and have a very good safety profile. It is for this reason they are frequently the drugs of first choice for prophylaxis in children.[48] Dexamethasone is a steroid medication with anti-inflammatory and antiemetic properties. It is effective as compared to placebo for prophylaxis of both early- and late-phase POV with no clinically significant adverse effects in otherwise healthy patients.[49] For moderate- to high-risk patients, the recommendation is for dual antiemetic prophylaxis prior to the end of surgery; dexamethasone and ondansetron are the most common combination with increased efficacy compared to the use of either alone.[50] Droperidol has been demonstrated to be effective in treating both early and late PONV. However, increased sedation, delayed emergence, and other minor CNS side effects such as anxiety and agitation have been observed. In addition, the Food and Drug Administration has added a black-box warning after some cases of arrhythmia resulting from prolonged QT were identified. The recommendations for EKG monitoring as well as the other CNS side effects have largely caused a decrease of use of this agent as a first-line agent.[51]

When the child suffers from PONV in the PACU, the approach to treatment differs depending on whether prophylactic medications had previously been used. In the previously untreated child, a dose of ondansetron is a first-line treatment, with dexamethasone often being the second choice. In the child who has been previously given antiemetics, a different class of medication should be given unless more than 6 hours have passed since the time of

initial dosing (see Table 37-2).

Table 37-2

Selected Antiemetic Dosing

Ondansetron	0.10 to 0.15 mg/kg to 4 mg
Dexamethasone	0.25 mg/kg to 10 mg
Diphenhydramine	0.5 to 1 mg/kg
Dolasetron	0.35 mg/kg to 12.5 mg
Granisetron	10 mcg/kg
Droperidol	10–15 mcg/kg

Temperature Instability

Hypothermia is a frequent finding in the postanesthesia recovery unit. This is not only a concern from a comfort standpoint, but also a concern because of decreased metabolism of certain drugs, and slower awakening as well as evidence of poorer wound healing and increased risk of postoperative wound infections.[52] The best treatment is prevention by paying close attention in the OR to temperature preservation strategies. If present in the PACU, covering the child with warm blankets is efficacious in milder cases; the application of a forced-air warming blanket may be needed in more severe cases.

Hyperthermia can also be a concern because while it may merely be a result of overaggressive warming, it can also be an indicator of inflammation or infection. Over-aggressive warming can usually be managed simply by removing some of the covering blankets. Inflammation may respond to antipyretics, while infection may require antibiotics. More serious concerns such as malignant hyperthermia should always be considered, especially if conservative measures fail to result in a decrease in temperature (or if it keeps increasing).

Pain and Discomfort

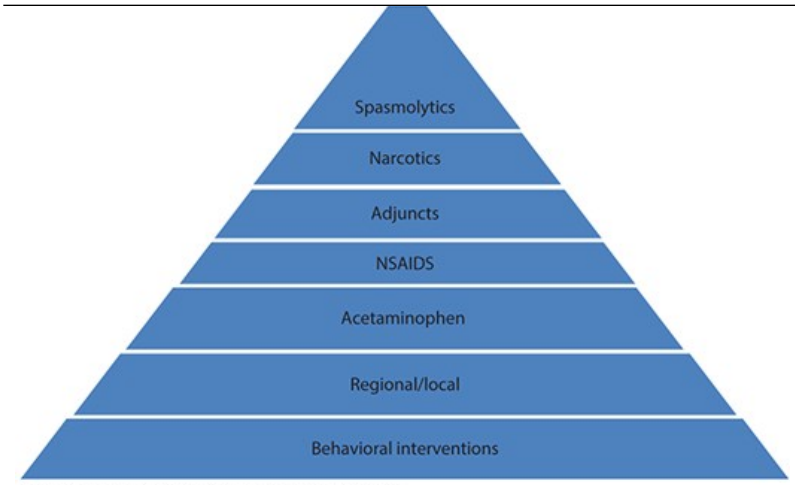
Measurement/assessment of pain in children can be challenging due to variation in individual manifestations and communication ability, and the difficulty of differentiating from anxiety, fear, agitation, and disorientation. Cultural factors, and cognitive delay or preexisting psychological and/or social effects also contribute to the difficulty.[53]

There are a number of validated tools including the observational tools such as Premature Infant Pain Profile (PIPP);[54] Face, Legs, Activity, Cry, Consolability Scale (FLACC);[55] and Children's Hospital of Eastern Ontario Pain Scale (CHEOPS);[56] and the self-report tools such as Faces Pain Scale,[57] Visual Analogue Scale,[58,59] and the Numerical Rating Scale[60] among many others. These are geared to different ages and developmental stages.[61] It should be noted that measurement of pain in the post-anesthetic state can be even more challenging than usual due to residual drug effects.

When managing postoperative pain in children, the most common approach is to use a multimodal approach including behavioral interventions, local anesthetic infiltration, peripheral nerve block as single or continuous infusion, NSAIDs, acetaminophen, adjuncts such as dexmedetomidine or dexamethasone, opioids, and possibly antispasmodics (Figure 37-3).[62,63]

Figure 37-3

Multimodal approach to analgesia.



Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

Preparing both the child and the parents ahead of time for discomfort and or numbness (in the case of local anesthetic usage) when the child awakens can significantly decrease the distress in the PACU, as can distraction and parental comforting. Having the parent at the bedside to comfort them and calm them when they awaken from anesthesia can help with the fear. Distraction methods such as TV or tablet use can also be useful.

Regional analgesia can be a very effective way of preventing pain in the PACU. Placing blocks in the pre-op area or in the PACU is often not as successful as in adult patients due to inability of children to tolerate or cooperate by holding still; older adolescents may allow placement with sufficient sedation. An alternative is to place the nerve block/regional anesthesia in the OR under GA either at the start of the case or prior to emergence. There have been concerns raised about safety of placing blocks under GA, but there does not seem to be any difference in complication rates when compared with awake placement.[64] It also allows extending the benefits of regional to children who would not otherwise be eligible. Placement at the beginning of the case can decrease the amount of medications needed in the OR and potentially decrease the incidence of PONV and other medication adverse effects.

Nonsteroidal anti-inflammatory drugs, most commonly ketorolac or ibuprofen, can be used throughout the perioperative period. Ibuprofen can be given orally either in the preoperative area prior to induction, particularly for shorter cases, or in the PACU. Ketorolac can be given in the OR or PACU via the intravenous route. There have been concerns raised about increased bleeding, renal risk, and orthopedic healing with the use of ketorolac, which have led some to limit its use in the perioperative period.[65]

Paracetamol and its prodrug acetaminophen can be given throughout the perioperative period in oral, intravenous, or rectal form. The rectal form of administration is more effective in the infant than in older children, but suffers from variable absorption. Numerous studies have demonstrated safety with higher rectal doses, but concern remains for hepatotoxicity if the cumulative dose exceeds 100 mg/kg/day.[66]

Several medications potentiate analgesic effects of other medications allowing lower doses to be effectively used (see Table 37-3). Perioperative systemic administration of alpha-2 antagonists (dexmedetomidine, clonidine) is associated with a useful potentiation of both systemic analgesics (particularly opioids) and local anesthetic sensory block in neuraxial and perineural routes.[67] Patients treated with dexamethasone have been found to experience less postoperative pain, require less postoperative opioids, have longer time to first analgesic dose, need less rescue analgesia, and have shorter PACU stays. The effect of dexamethasone is believed to be attributable to the anti-inflammatory properties of the medication. Although this effect is small, it tends to be stronger with earlier dosing.[68] Ketamine, a phencyclidine derivative, is useful as an adjunct analgesic that can prevent the development of opioid tolerance and hyperalgesia by inhibition of the NMDA receptors.[69]

Table 37-3

Selected Analgesic Dosing for Pediatric Patients

Acetaminophen	10–15 mg/kg (PO, IV, PR)
Ketamine	0.5–1 mg/kg IV
Ibuprofen	5–10 mg/kg PO
Ketorolac	0.5–1 mg/kg IV or IM
Morphine	50–100 mcg/kg IV
Oxycodone	0.1 mg/kg PO

Narcotics can be given in either the PO or IV form. The most commonly used narcotics in pediatric perioperative period are fentanyl, morphine, and hydromorphone in the IV form, and oxycodone or hydromorphone (in older children) in oral preparations. Due to variable metabolism leading to increased risk in some children (particularly after tonsillectomy), most pediatric practitioners now avoid codeine.

A number of procedures, such as ureteral reimplantation, dorsal rhizotomy, some orthopedic procedures, and posterior cervical decompression, can result in significant amounts of muscle spasm contributing to post-op pain. Children undergoing these procedures may benefit from spasmolytic medications such as diazepam.[70]

Discharge from PACU

Appropriateness for discharge from PACU is most often assessed using a postanesthesia recovery score. The most commonly used is the modified Aldrete Score which measures BP, respiration, consciousness, O_2 saturation, and motor activity on a 0–2 scale for a total maximum score of 10.[71] These scores are best combined with individual assessment of fitness for discharge with allowances being made for such considerations as preoperative baseline condition and whether the child is an inpatient or being discharged home into parental care. Recovery is usually divided into two stages: Stage I and Stage II (see Table 37-4).

Table 37-4

Sample Criteria for Discharge from PACU

Stage I (discharge to Stage II or floor)	Stage II (discharge home)
Awake or easily aroused	Intact gag reflex, swallowing, and cough allowing for oral intake
Airway maintained with intact protective reflexes	Ambulation/movement baseline/appropriate for development
SpO_2 >95% (room air) or stable at preoperative level (with or without supplemental O_2)	If regional anesthesia used, must demonstrate returning motor function
Normothermia	Minimal nausea or vomiting
Pain controlled	No signs of respiratory distress
Nausea/vomiting controlled	Oriented for developmental stage
No active bleeding	Voiding not necessary, but helpful
Hemodynamically stable within 20% of baseline	Hemodynamically stable within 20% of baseline

When the child is deemed ready for discharge, parents should be given instructions regarding fluid intake, pain and PONV management, as well as any special instructions in regard to the surgical procedure such as developments to be concerned about, wound care, and bathing. These should be provided verbally with time given for questions and for clarification. The instructions should then also be provided in written form for the parents to refer to when home; it can be helpful if a time schedule for pain medications is included. In the case of a foreign language–speaking family, if possible it can be very helpful to provide written instructions in their native language.

Unplanned Admission

A large proportion of pediatric surgeries are scheduled as outpatient cases; a significant concern with such cases is the unanticipated admission. This may be a result of unmanageable pain, PONV, inadequate oral intake, respiratory complications, surgical complications such as bleeding, or social reasons. The frequency of such admissions is a quality measure in addition to having significant familial implications. It also frequently results in prolonged PACU stay while waiting for a bed to become available. Common strategies to minimize the number of unanticipated admissions are more aggressive prophylaxis for PONV, generous use of regional anesthesia, and the use of non-narcotic analgesics whenever possible.[72]

Follow-Up Phone Call or Visit

Part of the practice of anesthesia is keeping track of complications. The post-op visit or phone call allows follow-up on issues such as recall, PONV, and pain-control/regional function as well as satisfaction with care.

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