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Current Concept Review

Preoperative Evaluation of the Child With Cerebral Palsy

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ABSTRACT

Children with cerebral palsy (CP) undergoing orthopaedic surgery require thorough preoperative evaluation to enhance outcomes and minimize risks. This comprehensive review covers various considerations. Each part of the preoperative assessment is explained, emphasizing the importance of a tailored approach to address the specific needs and complexities of children with CP. Anesthesia considerations include the pulmonary, cardiovascular, and gastrointestinal systems to reduce perioperative complications. Neurological issues, such as seizure management and medication interactions, are detailed, along with respiratory problems like aspiration and poor airway clearance, gastrointestinal concerns, nutritional status, and bowel management. Vascular considerations focus on planning access and volume resuscitation before major orthopaedic procedures. Skin-related issues, including pressure ulcers and wound healing, require preventive strategies and careful postoperative care. Other factors addressed include urinary tract problems, deep vein thrombosis risks, blood loss management, pain control, anesthesia challenges, and psychological effects. This review highlights the importance of teamwork, patient-centered care, and thorough planning to ensure the best possible outcomes for children with CP undergoing orthopaedic surgery.

Key Concepts:

(1) Children with cerebral palsy (CP) who are preparing for orthopaedic surgery need a thorough preoperative assessment.
(2) A thorough preoperative assessment is crucial to make sure that any surgical procedure is customized to the child's specific functional needs and that the risks and benefits are thoughtfully evaluated.
(3) Multidisciplinary care and focusing on patient-centered outcomes are crucial when deciding to pursue orthopaedic surgery in this high-risk population.
(4) Effective communication with the child's caregivers and health care team is vital to ensure coordinated care and a clear plan for both preoperative and postoperative management.

Introduction

Cerebral Palsy (CP) is one of the most common causes of childhood disability. Due to its medical complexity and neurological involvement, a multidisciplinary approach is recommended. However, this approach may not be available at every institution. Preoperative evaluation of children with cerebral palsy (CP) is essential to achieve the best possible outcome after orthopaedic surgery. Here are some key considerations: (see Fig. 1).

Medical history

The child's medical history should be thoroughly reviewed, including past surgeries, hospital stays, and current medications. Any

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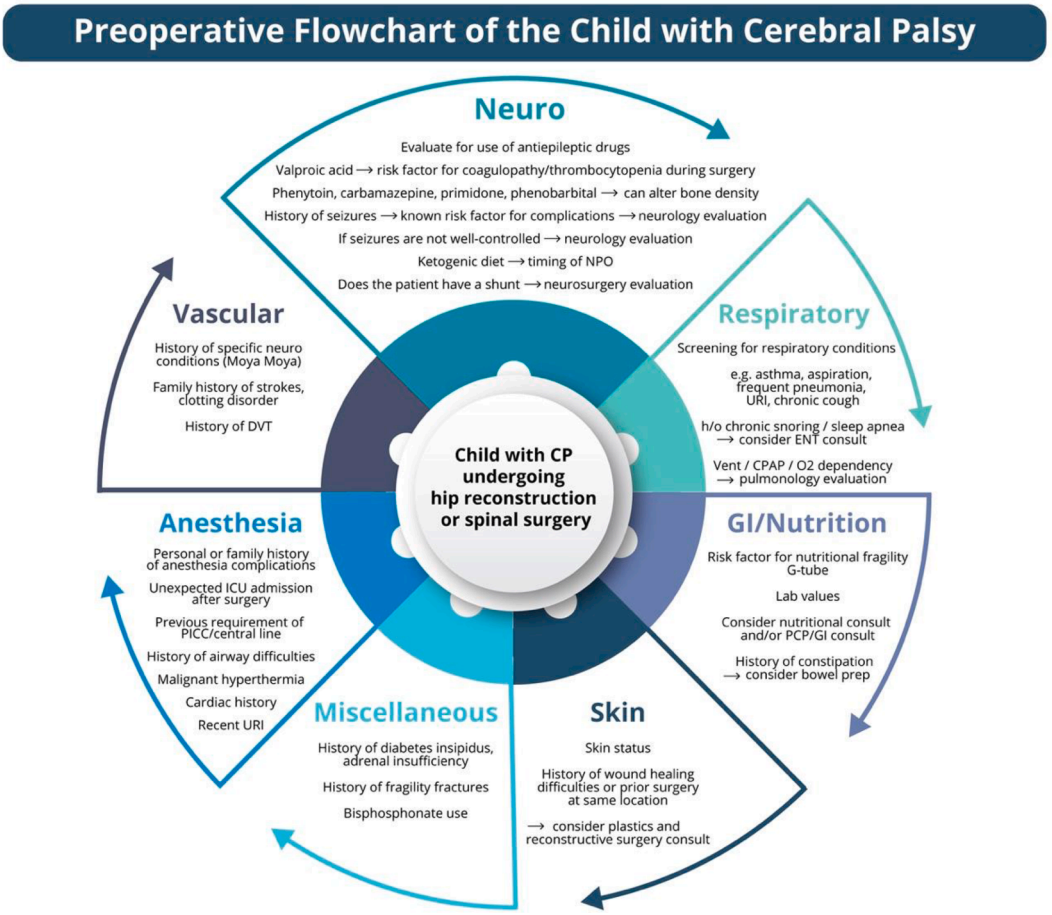

Figure 1. Credit to Aimee Son, MS, CMI.

previous surgical problems, family history of surgical issues, and medication allergies should also be documented.

Physical examination

A thorough assessment is performed to evaluate a child's overall health, including their neurological, respiratory, cardiovascular, and gastrointestinal (GI) systems. While an orthopaedic surgeon can conduct this exam, it is preferably carried out by a pediatrician or family practitioner. Ideally, this should be the child's own pediatrician who is familiar with their medical history. If available, a complex care provider at the hospital can also perform the history and physical exam. For example, it should be determined whether any accommodations are needed for a G-tube or tracheotomy tube during or before surgery. Additionally, a detailed skin check should be done to look for excoriations or atrophy around the surgical site.

Functional assessment

The child's functional abilities and limitations should be evaluated, including mobility, range of motion, muscle strength, and the ability to perform activities of daily living. The most commonly used classification system by the orthopaedic surgeons is the Gross Motor Functional Classification System (GMFCS), although the Manual Ability Classification System, the Communication Function Classification System, and the Eating and Drinking Ability Classification System are also being utilized by other neuromuscular specialties and have in common that they are standardized, reliable, and complementary to one another [1]. If surgery is performed on an ambulatory patient, a thorough gait assessment should be conducted through systematic observation, video analysis, or three-dimensional gait analysis. Patient-reported outcome measures should be used to evaluate the surgical results and their effect on participation and activity after surgery. For nonambulant children, a careful assessment of the child's functional goals should be discussed with the family before surgery to ensure expectations are appropriately set and met afterward.

Radiological evaluation

Hip surveillance with plain radiographic imaging plays a significant role in children with CP and has been well established. However, given the 2-dimensional nature of this imaging modality, the extent of acetabular dysplasia may be underestimated [2–4]. Several studies have investigated the value of cross-sectional imaging [5–7], such as computed tomography and magnetic resonance imaging (MRI). This can also be useful when addressing rotational deformities of the lower extremities. MRI may also be necessary to assess the child's soft tissues and identify underlying neurological or musculoskeletal abnormalities, and it has the advantage of not involving radiation.

Neuropsychiatric disorders can be found in up to 50% of patients with CP and frequently manifest in emotional dysregulation as well as behavioral and social interaction disorders. It may be beneficial to perform a psychological evaluation to assess the child's emotional and behavioral status and identify any potential barriers to adherence to postoperative care [8]. Moreover, a recent study by Boyer et al. [9] highlighted the influence of preoperative psychological factors on perioperative pain in children with CP. Social workers and child life specialists can also be used to determine the family's ability to cope with

a significant intervention, communicate, care for the child after surgery, have adequate and safe transportation, attend the postoperative appointment, and perform the requisite therapies.

Equipment

The preoperative period is the time to ensure the patient has the appropriate equipment for the immediate postoperative period, such as a hospital bed, reclining wheelchair, or toilet chair. This is also the time to order orthotics, which may be needed after surgery.

Anesthesia evaluation

An anesthesiologist experienced in caring for children with CP should assess the child's anesthesia risk. Some patients may even require preoperative medication for anxiety and fear before what may be their second, third, or even more surgeries.

Communication

It is crucial to coordinate with the child's caregivers and health care team to ensure all aspects of the child's care are aligned and that a clear plan exists for preoperative and postoperative management.

Overall, a thorough preoperative evaluation is crucial to ensure that any surgical procedure is customized to the child's specific functional needs and that the risks and benefits are carefully weighed.

Anesthesia considerations

Because of their often complex medical conditions and comorbidities, children with CP need an intraoperative plan that considers their pulmonary, cardiovascular, GI, and neurologic systems. A preoperative discussion between the surgical and anesthesia teams is crucial to assess expected blood loss, procedure duration, and anticipated patient pain, among other factors vital to perioperative safety. Managing hypovolemia, hypothermia, aspiration, and pain is a top priority.

Appropriate intravenous access enables accurate volume management and monitoring (consider an arterial line). Intravenous access may be difficult in children with CP secondary to contractures or scarring from multiple previous IV lines. Inhalation induction may be appropriate for children with difficult access. Active warming equipment, such as a warming mattress or forced air warmer, can help regulate patient temperature [10]. Maintaining euvolemia is essential to minimizing intraoperative and postoperative complications.

Osteotomies can lead to increased blood loss; therefore, preoperative evaluation of the patient's hemoglobin and platelet levels should be performed. Some medications, including over-the-counter products, may increase blood loss [11]. The anesthesiologist should closely monitor intraoperative hemoglobin levels. Measures to decrease blood loss, such as tranexamic acid (TXA) or other antifibrinolytic agents, can be used in addition to adequate fluid management to minimize hypovolemia. While the data supporting the use of TXA for surgery requiring lower extremity osteotomy are mixed, most larger studies show decreased intraoperative blood loss and fewer transfusions when TXA is administered intraoperatively [12–15]. The use of a cell saver should be considered.

Respiratory issues during induction and extubation must be carefully managed and are predicated on appropriate preoperative pulmonary optimization. Children with neuromuscular conditions are at higher risk for intraoperative hypoventilation, and various intraoperative strategies can help reduce pulmonary complications intraoperatively. Maintaining adequate Positive End-Expiratory Pressure (PEEP) throughout the procedure can help maintain appropriate ventilation by preventing atelectasis. Hypoventilation is also exacerbated by opiates and other medications that are respiratory depressants [16]. The choice to include regional anesthesia techniques in addition to general anesthesia can decrease the amount of opioid medication and concomitant respiratory depression [17]. Additionally, the surgical team and family should discuss possible intensive care unit admission should extubation or adequate pain control not be possible.

Intraoperative and postoperative pain management should be discussed with both the family and the anesthesia team before surgery. As aforementioned, regional anesthesia can be helpful to manage pain postoperatively. While epidural anesthesia has been a traditional adjunct to general anesthesia, regional blocks have increased in popularity with promising results in decreasing opioid usage. A recent retrospective review of children with CP undergoing hip reconstruction showed a significant decrease in the use of narcotics when lumbar plexus blocks instead of epidurals were used in conjunction with general anesthesia [18]. Fascia iliaca blocks have also demonstrated superiority to epidurals in both postoperative opioid usage and hospital length of stay [19].

A history of GI reflux, reactive airway disease, and increased secretions can make aspiration more likely during the perioperative period. If the patient is taking antireflux medications at home, they should be continued. Intravenous medications and prokinetics can be given preoperatively (ie, metoclopramide) to decrease the risk of aspiration. Selecting ketamine with glycopyrrolate for induction instead of thiopentone can help reduce secretions [17]. Appropriate suctioning after induction and before extubation can also be helpful.

Many children with CP are on antispasmodic agents (ie, Baclofen) and antiseizure medications. These should be continued on the day of surgery. A plan for administering antiseizure medications intraoperatively should be made if the child's home dose would occur at a time at which the child will be under anesthesia [17]. In addition to being aware of the perioperative bridging plan, the anesthesiologist must be mindful of the unique physiologic considerations relevant to children with CP. The minimum alveolar concentration is reduced in children with CP; specifically, the minimum alveolar concentration of halothane is 20% lower in children with CP and an additional 10% lower in those currently taking anticonvulsants. There is resistance to nondepolarizing muscle relaxants, attributable to drug interaction with anticonvulsants and chronic immobilization [20,21]. These unique biochemical interactions in children with CP must be anticipated and managed during induction and throughout a prolonged orthopaedic spine or lower extremity surgery.

Finally, consideration of a multimodal pain plan can help decrease opioid need postoperatively, which, in turn, reduces respiratory depression. Regional anesthesia, pain catheters, antispasmodic agents, and anti-inflammatories (ie, Toradol) should be maximized.

Neurological considerations

The group of children at high risk for orthopaedic hip and spine surgery includes those nonambulant children with CP (GMFCS IV and V) [22] who suffer from concomitant diseases of the central nervous system, with permanent motor and cognitive impairment [23]. Neurological impairments in children with CP are common and can be multifactorial.

The most common neurologic perioperative considerations for children with CP involve seizure management and control. Approximately 45% of children with CP suffer from concomitant seizures/epilepsy [24]. While it has been suggested that general anesthesia places children at a greater risk of developing seizures in the perioperative setting, this has not been shown in the literature [25]. Two or more unprovoked seizures characterize epilepsy. Seizures may arise from genetic, structural, metabolic, or unknown causes [26]. Seizure disorders require specific perioperative considerations by a pediatric neurologist. Some anticonvulsant medications are not available intravenously and a bridging plan should be created when a child is fasting and cannot receive their usual medications. Additionally, a rescue plan should be clearly outlined for prolonged seizure activity during the perioperative course for children with underlying epilepsy.

In addition to developing an active perioperative bridging plan for children with seizures, it is essential to appreciate the possibility of drug interactions in children exposed to long-term anticonvulsant use. Epileptic patients are exposed to an increased risk of clinically significant drug interactions, especially with traditional antiepileptic medications [27]. Carbamazepine and sodium valproate are commonly prescribed for seizure management. While carbamazepine can induce hepatic enzymes, leading to reduced vecuronium duration of action, sodium valproate is known to impair platelet function, increase the risk of bleeding, cause hepatotoxicity, and suppress bone marrow function. These adverse medication side-effects should be monitored by orthopaedic surgeons and allied health care providers responsible for care delivery throughout the perioperative course [28]. Before surgery, all children with a known history of epilepsy should be seen by their neurologist to refine the perioperative plan and perform any additional tests as indicated (shunt series, brain MRI, sleep study, etc.) to mitigate the risk of surgical cancellation in the days before surgery.

A ventriculoperitoneal shunt is used to treat hydrocephalus, a condition that occurs when excess cerebrospinal fluid builds up in the brain's ventricles. Ventriculoperitoneal shunts are often used to treat hydrocephalus in children with CP as about 15% of children with CP also have hydrocephalus [29]. The presence of a shunt prevents intracranial pressure from getting too high. Current perioperative clearance recommendations include obtaining a shunt series x-ray every 5 years. In addition to a radiographic review, perioperative nurses should ask family or caregivers about signs/symptoms associated with hydrocephalus (eg, somnolence, vomiting, irritability, poor growth, and seizures). If any abnormality is noted on the imaging, then consultation with neurosurgery is indicated.

In addition to epilepsy management, children with complex CP may have indwelling devices, such as a baclofen pump, to help manage spasticity. These devices must be interrogated before surgery, and we recommend an increase of 15%-25% before surgery to help with perioperative pain control [30]. In addition, one should avoid placing the electrocautery pad in proximity to the baclofen pump. As long as it is on the opposite flank to the patient, there is little risk of damage from the cautery machine.

Finally, in patients with more severe intellectual disabilities, preoperative anxiety can be especially difficult to evaluate and may present as irritability or aggression. The care team needs to understand how children with cognitive and communication delays express pain so that a perioperative pain management plan can be customized for each child. Careful spasticity management during the perioperative period helps address preoperative anxiety, postoperative pain, and spasms, which are a primary source of pain after surgery. It is crucial for children already taking baclofen to stay on their regular dose, and baclofen should not be stopped suddenly as seizures may occur. It is also important to document all ongoing anticonvulsant medications during the preanesthetic assessment and continue these medications throughout the perioperative period.

Respiratory considerations

Children with CP undergoing surgery may have unique respiratory considerations. Due to their neurological impairment, these children are at higher risk for altered respiratory conditions [31–34].

As discussed in the anesthesia section, muscle weakness in neuromuscular conditions can impair the complex swallowing process. Aspiration may lead to acute infection, chronic lower airway inflammation, and lung parenchymal damage in recurrent cases.

Poor airway clearance: In children with CP, the cough mechanism can be compromised, as it, like swallowing, requires a synchronized effort: contraction of expiratory abdominal and intercostal muscles, along with proper timing of these with the glottic muscle. A reduced cough reflex can result in poor protection of the lower airway and insufficient clearance of secretions.

Apnea: The respiratory center stimulates the pharyngeal muscles to stiffen before diaphragmatic contractions; however, in children with CP, this process is not functioning correctly, leading to hypoventilation and hypoxemia during sleep. A study by Garcia et al. [35] revealed that the likelihood of obstructive sleep apnea directly correlates with the severity of CP or associated epilepsy and supports the use of a routine questionnaire-based assessment for obstructive sleep apnea in this patient population.

Children with CP and respiratory conditions compromising undergoing major surgery can be at increased risk for postoperative complications, such as delayed extubation, pneumonia, and respiratory failure [36].

It is important to recognize that specific respiratory considerations can differ depending on the severity and type of CP, as well as the details of the surgical procedure. The multidisciplinary team, including the anesthesiologist, surgeon, pediatrician, and subspecialists, should work together closely to create an individualized perioperative plan for each child with CP.

Children undergoing surgery should be screened for respiratory conditions, including asthma, prior aspiration, recurrent pneumonia, increased salivation, frequent upper respiratory infections, and chronic cough. Children with a history of sleep apnea or chronic snoring should be considered for a preoperative otorhinolaryngology consultation. Children who are ventilator/CPAP-dependent or have a tracheostomy should be referred to pulmonology for preoperative clearance and checked to ensure the appropriate postoperative discharge plan to accommodate their ventilatory needs.

GI considerations

Approximately 80%-90% of children with CP experience chronic gastrointestinal (GI) disorders. Children with more severe CP (higher GMFCS level) are more likely to have GI issues or concerns. These concerns may include nutritional problems, dependence on gastrostomy tubes (G-tube, GJ-tube, or J-tube), and/or GI dysmotility, such as constipation or diarrhea. These GI issues can affect postsurgical outcomes, including wound healing, hospital length of stay, and medical complications; thus, a GI specialist should evaluate children with these issues in the pre-operative period [37–39]. While not all associated GI or perioperative risks/complications can be mitigated, a preoperative discussion to help families anticipate postoperative matters is essential for improved patient care.

Nutrition

Preoperative nutritional evaluation may include laboratory albumin, total protein, and leptin, along with specialized CP body fat measurements and body mass index (BMI), which can be challenging due to contractures limiting accurate height measurements.

Patients with CP undergoing scoliosis surgery who were preoperatively malnourished (albumin <3.5 g/L) were shown to have significantly more prolonged hospitalizations and greater rates of postoperative infection (pneumonia, urinary tract infection, and wound infection) compared to nourished patients [39]. Additionally, a low BMI (<fifth percentile World Health Organization growth chart) was a risk factor for overall complications and medical complications in patients undergoing spine procedures [40].

A recent study found no benefit in delaying hip reconstructive surgery in patients with CP with progressive hip subluxation/dislocation to improve nutrition. There was no difference in complication rates between patients who received a preoperative nutrition assessment and those who did not [41].

Even though no consensus exists regarding ordering nutritional labs preoperatively on a routine basis, the Congress of Neurological Surgeons published guidelines on dietary guidelines on the perioperative spine as malnutrition measured by serum albumin <3.5 g/dl or a serum

prealbumin <20 mg/dL was associated with a higher rate of surgical site infection and recommend assessing nutritional status with serum albumin or prealbumin preoperatively [42].

Gastrostomy dependence

Indications for placing a gastrotomy tube (G-tube or GJ-tube) vary in children with CP. While it is often necessary to prevent aspirational events related to oral intake, many children need supplemental nutrition via a G-tube because their calorie requirements are usually quickly exceeded by calorie burning. Although not always modifiable, having a G-tube does introduce a risk factor for children undergoing orthopaedic surgery, and this should be discussed with the family before surgery. Specifically, in patients undergoing spinal fusion for neuromuscular scoliosis, those with a G-tube were 2.2 times more likely to develop a GI complication than those who were fed orally [43].

GI dysmotility

Up to 75% of patients with CP have constipation preoperatively. Constipation is also a known complication after orthopaedic surgery, with multifactorial etiology including decreased motility, pharmacology (anesthetic and pain medications), autonomic dysregulation, malnutrition/hydration, etc. Furthermore, preoperative severe constipation is a risk factor for postoperative ileus in patients undergoing orthopaedic surgery [44]. Therefore, patients with CP scheduled for orthopaedic surgery should be evaluated for, or already have, a bowel regimen in place before surgery. The orthopaedic team should advise families about preparing for an intensive bowel regimen after surgery to help minimize the risk of constipation or bowel ileus complications.

Vascular considerations

Vascular considerations in patients with CP undergoing orthopaedic surgery mainly include vascular access and preexisting vascular conditions. Access can be challenging in these patients and may sometimes require the placement of peripheral or central lines, often with advanced imaging techniques. Even with ultrasound guidance, vascular access lines may be malpositioned due to contractures and spinal deformities [45]. Some centers have experience placing long-term access devices for medically complex patients undergoing surgical procedures. Still, these devices can lead to thrombosis and infection, so they should be used with caution [46–48]. In patients with a history of difficult line placement, surgeons should plan for extra time at the onset of the case or consider preadmission for vascular access placement in the interventional radiology suite.

Moyamoya syndrome is one of the more common preexisting vascular conditions in patients with spasticity. This entity predisposes patients to cerebrovascular incidents secondary to stenosis of the internal carotid arteries [49,50]. Maintenance of intravascular volume during any surgical procedure in this patient group is of utmost importance as hypovolemia or hypotension can lead to intraoperative or postoperative stroke [51]. Many hospitals have specific nil per os (NPO) guidelines for this patient group, allowing them to have clear fluids before surgical intervention and to be preadmitted for hydration in preparation for their surgery. It is recommended that any procedure on a patient with moyamoya should be performed with neurosurgeons, anesthesiologists, and intensivists familiar with caring for these complex children.

Skin considerations

Pressure ulcers are among the most common skin problems seen in children with CP who undergo surgery. Immobility and long periods of positioning during postoperative recovery can decrease blood flow and cause tissue damage, which can lead to pressure ulcers. These often develop over bony prominences such as the back, heels, and hips. To lower the risk of pressure ulcers, surgeons and health care providers should make sure the child is regularly repositioned during recovery. Pressure-relieving devices, like specialized mattresses and cushions, can also help distribute pressure more evenly. The use of hip spica casts should be limited to situations such as femoral fractures, open reduction of the hip, or poor bone quality with concern for implant stability as there is an increased risk of skin problem [52].

Children with CP may have weakened immune systems or borderline metabolic reserves, making them more vulnerable to surgical site infections. Poor wound healing, extended hospital stays, and the use of medical devices can increase the risk of Surgical Site Infections (SSI). Preventive measures, including strict sterile techniques during surgery and proper wound care afterward, are vital for reducing SSI risk. Antibiotics should be given prophylactically to prevent additional infections.

Children with CP may have heightened sensitivities, and some may be prone to allergic reactions to medications, dressings, or adhesives used during surgery or in wound management [53]. With the increased number of surgeries, there is a risk for latex allergy, which should be assessed preoperatively. Preoperative screening for allergies and the use of hypoallergenic materials can help minimize the risk of allergic reactions.

Delayed wound healing in children can stem from factors like poor blood flow, nutritional deficiencies, and limited mobility. Improving the child's nutritional status before and after surgery supports better wound healing. Careful monitoring of the wound site and prompt action at the first signs of delayed healing are essential.

Excessive scar tissue formation can occur after surgery, especially in children with CP, causing mobility and range of motion problems. Physical therapy and scar tissue massage can help break down adhesions and enhance flexibility. Silicone gel sheets and other scar management methods can also be used.

Additional considerations

Urinary tract complications

Children with CP may experience urinary incontinence or urinary retention. Nephrolithiasis (kidney stones) is an often unrecognized cause of back and flank pain. Failure to maintain adequate hydration and a poor diet may lead to this problem. Surgery, narcotic pain medication, and prolonged bladder catheterization can exacerbate these problems or cause urinary tract infections [54,55].

Deep vein thrombosis

Immobility after surgery increases the risk of developing blood clots, especially in children with CP, who may already have circulation issues due to their condition. The risk of Deep Vein Thrombosis (DVT) is only if a child's mobility pattern is changing. For GMFCS IV and V children whose baseline level of activity is low, the risk of DVT after hip and spine surgery is low unless another risk factor is present [56]. The etiology of CP may be secondary to thrombotic disorders such as factor V Leiden and these should be screened for during the preoperative history and visit [57,58].

Pain management challenges

Children with CP may struggle to communicate their pain levels effectively. Proper postsurgical pain management is essential to ensure comfort and prevent complications like reduced mobility and respiratory issues. Epidural analgesia and peripheral nerve blocks should be considered.

Psychological and emotional impact

Surgery and hospitalization can be stressful for children with CP, potentially leading to anxiety or behavioral changes during recovery.

Conclusion

This paper covers the preoperative assessment of children with CP. It highlights key considerations for achieving the best possible outcome after orthopaedic surgery. A thorough medical history review, functional evaluation, and arrangements for children with G-tubes or tracheotomy tubes are essential prior to surgery. It is vital to stress the importance of multidisciplinary care and focus on patient-centered outcomes when deciding to proceed with orthopaedic surgery in this vulnerable group.

Ethics approval and consent

The author(s) declare that no patient consent was necessary as no images or identifying information are included in the article.

Author contributions

Henry G. Chambers: Writing – original draft, Conceptualization. **Grant Hogue:** Writing – original draft, Conceptualization. **Mara Karamitopoulos:** Writing – original draft, Conceptualization. **Jill E. Larson:** Writing – original draft, Conceptualization. **Benjamin J. Shore:** Writing – original draft, Conceptualization. **Verena M. Schreiber:** Writing – original draft, Conceptualization.

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