

## Anaesthesia for paediatric orthopaedic surgery

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### INTRODUCTION

Paediatric orthopaedics in low or middle income countries (LMIC) ranges from simple fractures (but often complicated by delayed presentation, anaemia or nutritional deficiency), to chronic osteomyelitis and fracture non-union, to complex elective procedures in children with cerebral palsy. This article will consider the spectrum of disorders encountered in paediatric orthopaedic surgery in LMICs, the orthopaedic manifestations of specific conditions in childhood, specific orthopaedic procedures and anaesthetic management of these conditions. Practical aspects of regional anaesthesia are covered elsewhere in this issue of Update (page 99).

### THE SPECTRUM OF DISORDERS SEEN IN PAEDIATRIC ORTHOPAEDIC SURGERY

Conditions can be considered under the following broad headings:

- Trauma: Simple and complex fractures (acute or delayed), burns, polytrauma, traumatic paraplegia, conflict related
- Common congenital conditions: Talipes equinovarus (club foot), scoliosis and other congenital limb deformities, achondroplasia, bone cysts
- Infections: Osteomyelitis (acute, untreated, chronic), TB, poliomyelitis
- Developmental abnormalities: Developmental dysplasias of the hip (congenital dislocation of the hip (CDH)), Perthes disease, slipped upper femoral epiphysis (SUFE), idiopathic scoliosis
- Neuromuscular conditions: Muscular dystrophies, progressive muscular atrophy, poliomyelitis, scoliosis

- Neurological conditions: Cerebral palsy, spina bifida
- Auto-immune conditions: Juvenile idiopathic arthritis (JIA)
- Tumours: Sarcomas, osteochondromas
- Rare congenital conditions: Osteogenesis imperfecta, neurofibromatosis, mucopolysaccharidosis (Hunter's, Hurler's), arthrogyrosis multiplex.

### COMMON ORTHOPAEDIC CONDITIONS IN LMIC

#### Trauma

Acute fractures and burns are common in children in LMIC and can be associated with high morbidity. A high proportion of fractures are treated non-surgically with traction or simple casting, with fracture manipulation under anaesthesia one of the most common paediatric orthopaedic procedures undertaken. Paediatric musculoskeletal impairment (MSI) has a prevalence of 2.6-4.8% in children under 12 years; angular limb deformity and fracture non/mal-union are seen in a significant proportion of children presenting for elective surgery.<sup>1,2</sup> Polytrauma and burns (acute and reconstructive procedures) are challenging problems associated with high mortality, which are considered elsewhere in this edition of *Update* [page 199 and 204].

#### Congenital talipes equinovarus (clubfoot)

Congenital talipes equinovarus (clubfoot) seems to have a higher prevalence in developing countries compared to elsewhere - for example, the incidence of clubfoot in Malawi is 2 per 1000 children, twice that of North America and Europe.<sup>3,4</sup> Although clubfoot programmes

### SUMMARY

Paediatric orthopaedic procedures range from fixing simple fractures in otherwise healthy children to more complex procedures in patients with major co-morbidities. Anaesthetic management is generally dependent on the complexity of the procedure as well as the child's general health. Pain relief is a particular challenge. Regional anaesthesia plays a very important role in managing intra- and postoperative pain. Availability of resources, training and safety are a major determinant of anaesthesia technique in LMICs.

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with Ponseti serial casting are widespread in LMIC, disability associated with untreated or partially treated clubfoot remains high.<sup>5,6</sup>

### CASE SELECTION

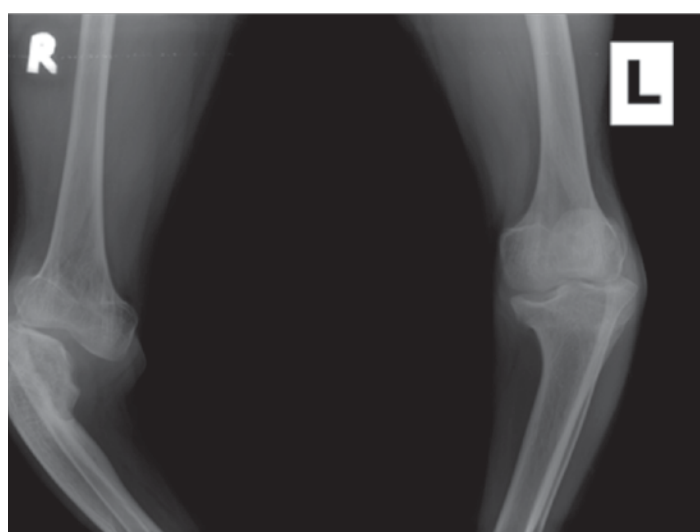
The success of orthopaedic programmes in LMICs depends on case selection and choice of surgical procedure. In general, interventions that have a good outcome are those that require little or no follow up, are cheap to perform with minimal instrumentation and implanted material, and do not require specialised surgical skills. The majority of children with cerebral palsy are best treated with prolonged physiotherapy; operative intervention and prolonged multidisciplinary follow-up are time consuming and expensive.

Five common orthopaedic conditions that benefit from operative intervention and where operative treatment is financially and practically feasible are:



**Figure 1.** *Recurrent club foot*

- Neglected or recurrent talipes (club foot): postero-medial release, posterior release, wedge tarsotomy or triple arthrodesis (see Figure 1)
- Chronic osteomyelitis: sequestrectomy and debridement. Some cases occur secondary to overlying soft tissue injury but many cases are caused by blood borne infection. If the osteomyelitis is adjacent to a joint there should be a high index of suspicion for intra-articular spread with septic arthritis. Systemic infections prevalent in the developing world include tuberculosis and Human Immunodeficiency Virus (HIV). Thanks to a successful global polio vaccination programme, the prevalence of this disease is now very low but it has yet to be eradicated.
- Angular limb deformities: Malnutrition with vitamin D deficiency and rickets, and developmental disorders such



**Figure 2.** *Blounts Disease (Bow legs) showing angular deformities around the knee, more severe on the right leg*

as Blounts disease cause angular limb deformities, especially around the knee (see Figure 2). An open osteotomy is required to re-align the limb and the reduction is usually maintained by casting rather than metalwork.

- Burns contractures. Releases and skin grafting are common procedures undertaken by orthopaedic surgeons, particularly when involving the hands
- Open fracture requiring wash out and debridement

## **ANAESTHETIC MANAGEMENT OF CHILDREN PRESENTING FOR ORTHOPAEDIC SURGERY**

### **Pre-operative assessment and preparation**

All children should be seen pre-operatively, preferably with a parent present, and a full history and appropriate examination taken as routine (see p XX this *Update*). Pay particular attention to co-existing conditions, particularly for children with cerebral palsy or cardiorespiratory disease. Previous experience of anaesthesia can be a useful pointer as many of these children may have had other procedures, with positive or negative experiences. Review of previous anaesthetic charts is useful when available. A particular challenge is the small malnourished child presenting for the first time with a long history of an untreated fracture or osteomyelitis to a facility with minimal facilities for pre-operative investigation, but much can be gained from the patient history and examination.

Pain management is often a special concern for children and parents, and pain management plans should be discussed before surgery. For fractures, this is usually best provided by a cast, sling or traction, supplemented with oral analgesia. IV morphine may be required if pain is severe, or a regional block may be of benefit (e.g. femoral nerve block). Consent should be obtained if rectal analgesics are to be used.

**Starvation:** This should be as standard, but children with acute fractures or complex co-morbidities may well have delayed gastric emptying. Extra caution is required.

**Pre-medication:** This is not usually required, but those with learning difficulties or previous difficult experiences may benefit from sedative pre-medication. For a child undergoing multiple procedures, a calm, smooth induction of anaesthesia can help enormously with subsequent anaesthesia.

Simple oral analgesics such as paracetamol 20mg.kg<sup>-1</sup> PO or ibuprofen 5-10mg.kg<sup>-1</sup> PO can be given as a premed. This is easy to do, well-tolerated, inexpensive, may reduce opioid requirements, and improves postoperative pain management.

**Examination:** This should be a focused physical examination relevant to the history and practical aspects of anaesthesia, for instance, intravenous access, airway management and positioning.

**Investigations:** Children who are fit, healthy and having minor procedures do not require laboratory investigations. Those undergoing major surgery will need a haematocrit or full blood count with group and screen as a minimum. Investigation of cardio-respiratory disease is best done in consultation with a paediatrician. Screening with pulse oximetry, particularly an overnight assessment of SpO<sub>2</sub> may be useful if there is a concern about cardiorespiratory disease.

The anaesthetic plan should be explained to the parents and the child if possible, and consent obtained.

### **Anaesthetic technique**

The surgery and available resources will determine the choice of technique. Some procedures such as tendon release in the Ponseti procedure are routinely performed under local anaesthesia. Many cases are safely anaesthetised with either IM or IV ketamine; regional anaesthesia may be used for older children. For peripheral surgery, a standard GA technique is appropriate for most cases, with spontaneous breathing with inhalational anaesthesia, ideally supplemented by regional block or local infiltration. Consider tracheal intubation if there is delayed gastric emptying, expected poor respiratory effort under anaesthesia (e.g. neurologically impaired), or a very long procedure.

Intravenous access is best practice for all cases. Short simple cases such as application of hip spicas and other plaster applications may be safely anaesthetised without IV access; infants, however, should have secure IV access even for these cases. Though simple and often quick, fracture manipulation can be very stimulating and an IV is useful for quickly deepening anaesthesia. Ketamine anaesthesia or regional blocks awake are safest with IV access in place.

Analgesia is best provided with a multi-modal technique (ketamine, oral analgesics, a regional block or local anaesthetic infiltration, +/- opioids if required). Postoperatively, use regular simple analgesics supplemented by stronger opioid drugs if required (given by agreed protocol), guided by age-appropriate pain assessment tools (e.g. FACES, FLACC) (see pain management page 72 this *Update*)

It is good practice to give intravenous fluids to rehydrate following a period of fasting and to replace intra-operative losses. Postoperative nausea and vomiting can be reduced with good hydration, and this is less expensive and more readily available than anti-emetic drugs.

Open procedures will require prophylactic antibiotics, which should be given before 'knife to skin'.

### **Regional anaesthesia in paediatric orthopaedic surgery**

Regional anaesthesia can provide excellent perioperative analgesia and anaesthesia, but requires special training and equipment; regional anaesthesia is discussed elsewhere in this *Update*. (See article page 99).

Specific considerations for orthopaedic surgery are as below:

- **Choice of block:** Discuss with surgeons and ward nurses

when deciding which block will be the most useful (location and longevity required). The child and parents' previous experience of regional anaesthesia may guide decisions. Catheters can also be used in regional techniques to prolong analgesia.

- **Lower extremity surgery:** The simplest block to perform is caudal block, as this covers many lower limb procedures, and is safe and efficacious in all paediatric age groups.<sup>7,8,9</sup> Unilateral limb blocks provide good quality analgesia; the most common and easy to perform being femoral/3:1 or popliteal sciatic blocks. Any procedure below the knee can be covered with popliteal blocks, supplemented locally or by infiltration of the saphenous nerve for lateral surgery at the ankle or foot. Ankle blocks are straightforward and can provide good pain relief for foot procedures.
- **Surgery at the hip:** This requires a higher block usually an epidural, as a one shot or catheter technique. This provides excellent prolonged analgesia for most lower limb surgery. Lumbar epidurals can only be safely performed in children under general anaesthesia.
- **Spinal anaesthesia:** This can be used in older children as an alternative to a GA. It is safe and cost effective in experienced hands and if the appropriate equipment is available, particularly when working with a fast surgeon. Consent is clearly an important issue.
- **Upper extremity surgery:** Brachial plexus block at the axilla provides excellent analgesia for wrist and hand surgery in children, and may be supplemented by local infiltration or ketamine IV or IM if required to provide anaesthesia for surgery. In expert hands, supraclavicular block or interscalene block may be used to provide anaesthesia or analgesia.<sup>10</sup>

## BLOOD LOSS AND BLOOD CONSERVATION

It is important to develop good blood conservation practices during orthopaedic surgery in LMIC as chronic anaemia is common in children, access to safe blood transfusion is limited and costly, and this type of surgery has the potential for large blood loss.

Blood conservation is greatly aided by the use of tourniquets where possible, but much can be achieved by simple changes in anaesthetic technique, without the use of induced hypotension or expensive drugs.

The following techniques help to reduce the requirement for blood transfusion:

- In elective surgery, optimise preoperative haemoglobin: consider de-worming and iron supplements in at-risk populations
- A stable anaesthetic with good analgesia, with control of heart rate and blood pressure in the low normal range. Use sedative premedication if the child is anxious. If available, TIVA with propofol and remifentanyl is useful as anaesthetic depth can be varied easily according to the level of surgical stimulation
- Maintain normothermia to prevent cooling and hence coagulation problems; limit patient exposure from induction of anaesthesia onwards
- Position the child carefully to reduce venous congestion, avoid hypercarbia and avoid the child coughing. This will help to reduce bleeding from the surgical site
- Tranexamic acid 10-20mg.kg<sup>-1</sup> bolus IV at induction, repeat dose 10mg.kg<sup>-1</sup> IV at 4 hours. This is a safe drug and has been shown to reduce blood loss in trauma patients and should be increasingly available

**Table 1.** Different types of cerebral palsy

Description:	Spastic CP	Ataxic CP	Athetoid/dyskinetic CP	Mixed type
<b>Incidence (% cases)</b>	<b>70%</b>	<b>10%</b>	<b>10%</b>	<b>10%</b>
<b>Clinical features:</b>	Hemiplegic CP - one side of the body is affected.  Diplegic CP - both legs are usually more affected than both arms  Tetraplegic CP - all four limbs are involved	Intention tremor  Head tremor  Poor sense of balance with falls and stumbles	Dystonic - maintained twisting position of torso and extremities  Athetosis - slow, purposeless, distal movements  Chorea - quick, jerky, proximal	Spastic athetoid

- Use clearly defined transfusion protocols, in particular the trigger for transfusion. Healthy children can tolerate an acute drop in haemoglobin to 7g.dl<sup>-1</sup> with no adverse effects. A low haemoglobin threshold for transfusion is a cost free way of avoiding transfusion
- If available, intra- and post-operative cell salvage is very useful
- Temporomandibular joint dysfunction, increased incidence of malocclusion; possible difficult intubation
- Autonomic neuropathy; poor control of temperature and blood pressure. Intraoperative hypothermia is common, compounded by lack of fat and muscle in the malnourished child
- Difficult venous access due to spasticity or dystonia

If major blood loss occurs (i.e. more than half circulating blood volume), use whole blood to correct coagulopathy, or “reconstituted whole blood”, using FFP and platelets with each red cell transfusion.

## **SPECIFIC CONDITIONS REQUIRING ORTHOPAEDIC SURGERY**

### **Cerebral palsy**

Most children with cerebral palsy (CP) presenting for surgery in LMIC will have mild deficits affecting one or two limbs, but without the major complications associated with CP. These children will often be otherwise well, but with decreased mobility or limb deformity requiring correction. Rarely, children with severe comorbidity may also present (see Table 1).

Intellectual disability and epilepsy are common in children with spastic quadriplegic CP. Bulbar muscles are involved to a varying degree, resulting in poor control of the mouth, tongue and pharynx. Aspiration pneumonia is most likely in this group. Dyskinetic CP may be associated with deafness, dysarthria and drooling.<sup>11</sup>

### *Anaesthetic implications of CP:*<sup>11, 12</sup>

- Cognitive, communication and behavioural disorders
- Epilepsy (30% of children)
- Gastro-oesophageal reflux is common; may cause recurrent respiratory problems
- Drooling of saliva may be related to pseudobulbar palsy with impaired swallowing or tongue thrusting
- Poor nutritional status, with potential for electrolyte imbalance or anaemia
- Respiratory problems; poor respiratory reserve, sub-clinical pulmonary aspiration from reflux, recurrent respiratory tract infections, and chronic lung disease
- Poor dentition; dental caries and loose teeth are common. The potential for bacteraemia during airway instrumentation has important implications for children receiving metal implants

Ideally, children with CP undergoing major surgery should be assessed by a paediatrician prior to surgery, to make sure that they are as fit as possible for the proposed surgery. Anticonvulsant therapy should be continued perioperatively and restarted as soon as possible postoperatively. These patients may also require physiotherapy, bronchodilators and antibiotics preoperatively. Several readings of the blood pressure should be taken to check the baseline. Keep the child warm and avoid exposure whenever possible.

### *Orthopaedic procedures in children with CP*

Soft tissue releases to relieve contractures are commonly performed in these children. Repeat procedures are common. Recent trends are for single event multilevel surgery involving tenotomies and/or osteotomies at different levels on one or both limbs.

### *Conduct of anaesthesia*

It is important to have a good rapport with these children and engage them in the discussions. Communication may be difficult and the child may be anxious, so it is useful to have their carer available at induction and in the recovery room. Sedative premedication can be considered but these patients can have an unpredictable response to them. Antacids, prokinetics and drugs to reduce secretions may be useful. Thiopentone is a useful IV induction agent in children with epilepsy. Intubation should be considered in children with reflux. The child should be positioned carefully to prevent pressure sores, nerve or muscle damage. Children with severe CP may have reduced volatile anaesthetic requirements and may take a long time to wake after surgery.

Muscle spasms are a particular problem in children with spastic CP, and for this reason, regional techniques are strongly recommended for intra-operative and postoperative analgesia, also to reduce opioid requirements. In children having extensive lower limb surgery, epidural analgesia is beneficial.<sup>11</sup> Pain assessment can be challenging, but should not prevent the anaesthetist seeking to provide good analgesia.

Postoperatively, drooling can present problems, and frequent suctioning may be necessary. Aspiration of gastric contents

**Table 2.** Classification of neuromuscular disorders

	Inherited	Acquired
<b>Prejunctional</b>	Peripheral neuropathies <ul style="list-style-type: none"> <li>• Charcot-Marie Tooth</li> <li>• Friedreich's ataxia</li> </ul>	Motor neurone disease Multiple sclerosis Guillain-Barré syndrome Peripheral neuropathies
<b>Junctional</b>		Myasthenia Gravis Eaton-Lambert Syndrome
<b>Post-junctional</b>	Dystrophies <ul style="list-style-type: none"> <li>• Duchenne (DMD)</li> <li>• Becker's</li> </ul> Myotonias <ul style="list-style-type: none"> <li>• Myotonic dystrophy</li> <li>• Myotonia congenital</li> <li>• Other myopathies</li> <li>• Hyper/hypokalaemic periodic paralysis</li> </ul> Metabolic/mitochondrial disorders	Inflammatory myopathies Critical illness polyneuropathy and myopathy

may occur in children with pseudobulbar palsy. Children with CP are commonly irritable on emergence, but it may be difficult to elicit the cause.

## Neuromuscular disorders

### Pre-operative assessment

Children with significant neuromuscular conditions presenting for orthopaedic surgery usually have a clear diagnosis (see table 2). If there is limited information, it is important to ask how long the child has been weak, whether the weakness is stable or progressive, if the muscle weakness is associated with fatigability and what limits activity. All major cases should be discussed with a neurologist or paediatrician before surgery. All medication should be continued preoperatively, and restarted as soon as possible after surgery.

Anaesthetic assessment should include current status, airway, cardio-respiratory and any other system disorders. The principal anaesthetic risks relate to the airway, respiratory impairment, poor myocardial function, gastro-oesophageal reflux, abnormal drug reactions (principally MH), and excess bleeding in certain myopathies (e.g. Duchenne muscular dystrophy, DMD). Investigations are best undertaken in consultation with respiratory paediatricians and/or paediatric cardiologists if available. The family should be counselled to make sure that they are aware of the prognosis of the specific

condition, also that they are realistic as to their expectations about surgery.

Assessing functional capacity during exercise is very useful, as it will help identify to significant cardio- respiratory or airway compromise. However, if the child is inactive this may mask the severity of both respiratory and cardiac disease. Formal sleep studies are often used to indicate the need for non-invasive respiratory support postoperatively; overnight oxygen saturation monitoring can also reveal useful clinical information. Children already established on non-invasive ventilatory support can be safely anaesthetised; familiarity with the particular device and current settings is essential preoperatively (the parents are often expert). The device must be available for immediate use as the child wakes after surgery.

Progressive degeneration of cardiac muscle fibres, resulting in conduction defects and cardiomyopathy occurs in DMD; this occurs in later adolescence and is managed in the early phase with ACE inhibitors. Friedrich's ataxia is also associated with cardiomyopathy.

Dysphagia and decreased gastric motility are common.

Review of previous anaesthetics is useful but does not mean subsequent anaesthetics will be problem-free, for instance, relating to airway or respiratory events. Previous uneventful

use of suxamethonium or volatile agent does not guarantee that they can subsequently be used safely.<sup>13</sup>

### *Perioperative management*

There should be full discussion with the family before surgery to discuss potential risks and benefits of surgery. Sedative pre-medication should be used with caution if at all, as it may cause respiratory depression or reduced respiratory muscle tone. However, anxiety can be high in these patients.

Spontaneous ventilation techniques are often not well tolerated in children with neuromuscular disease. TIVA with propofol and remifentanyl is effective and safe for these patients, provided cardiac function is not severely impaired.

Choice of anaesthetic technique can be very difficult in some children, but must be made on an individual basis. For instance, a child may have a history of difficult intubation, or severe respiratory impairment, but refuses surgery under regional anaesthesia. The child may be willing to undergo a regional anaesthetic block, but these techniques are often technically more challenging in children with neuromuscular disease. It is sensible to avoid large doses of opioids perioperatively, particularly where ventilatory support postoperatively is limited or unavailable.

All cases should be closely monitored, including core body temperature, as these children are prone to both hypo- and hyperthermia. Hyperthermia may occur due to increased muscle activity seen in myotonias, iatrogenic causes or malignant hyperthermia. Monitoring must be continued postoperatively, ideally in a high dependency area. Intensive care, ideally with ventilatory support, should be available for high-risk cases and/or those undergoing major surgery.

Children with neuromuscular diseases have increased sensitivity to non-depolarizing neuromuscular blocking drugs. The use of a nerve stimulator and short acting neuromuscular blocking agents is recommended. Suxamethonium must NOT be used. In the channelopathies, there may be a dramatic rise in serum potassium in response to suxamethonium.<sup>14</sup> Malignant hyperpyrexia (MH) and anaesthesia-induced rhabdomyolysis (AIR) may also be precipitated. The only conditions shown to have a definite link to MH are King-Denborough syndrome, central core disease and Evans myopathy. Patients with other neuromuscular conditions have shown MH-like symptoms under general anaesthesia but the link with true MH remains unclear.<sup>15</sup>

Children presenting for muscle biopsy have a 10-20% chance of a positive finding and around half of these have a diagnosis of muscular dystrophy. In these circumstances, avoid volatile agents and use total intravenous anaesthesia (TIVA) or spinal anaesthesia with sedation in preference.

## **SPECIFIC ORTHOPAEDIC PROCEDURES**

### **Surgery for osteomyelitis and septic arthritis**

Antibiotics have a limited role in the treatment of septic arthritis and established osteomyelitis. Infection within a joint is an orthopaedic emergency and requires urgent open or arthroscopic wash out.

Infected bone needs thorough debridement of the connecting sinus tracts and ample curettage of the bone segment to remove dead bone (sequestrum), one of the major causes of recurrence of osteomyelitis. Extensive infection may require one side of the bone to be removed to allow adequate drainage, a process known as decortication. Soft tissues are allowed to heal by secondary intention and regular dressing changes are essential for healing. These children may be chronically unwell, anaemic, with poor nutrition, and they may also have impaired clotting.

### **Ponseti procedure**

This technique involves manipulation and casting to correct congenital clubfoot without surgery (see Figure 3). The ligaments, joint capsules and tendons are stretched under gentle manipulations and a plaster cast is applied after each manipulation. The displaced bones are gradually brought into correct alignment and remodel. The initial phases of this procedure do not require anaesthesia. One stage requires a percutaneous tenotomy, which can be done under local infiltration with lignocaine and/or topical anaesthesia. In 10-30% of cases, a tibialis anterior tendon transfer to the lateral cuneiform may be required when the child is about 3 years old and this will require general anaesthesia with or without regional analgesia.

### **Application of hip spica casts**

Spica casts create stability and immobilise femoral fractures and hip abnormalities. Anaesthesia is usually required to apply



**Figure 3.** Ponseti casts in a hospital in Nepal

a hip spica. In small children, hip spicas are applied with the child on an elevated narrow table that provides very little head support.

During cast placement, the goals of anaesthesia include haemodynamic stability, appropriate anaesthesia and safe patient positioning. The patient's health status and any pre-existing disease dictate the choice of anaesthetic technique. It is important to remain vigilant when the child is placed on the spica table to ensure that the airway is secure and to prevent nerve damage. Consider intubation in children who weigh <10kg, particularly as the abdomen may be compressed during the application.

### **Pelvic osteotomies for congenital dislocation of the hip (CDH)**

These are used to correct developmental dysplasia of the hip joint to stabilise the hip, allow corrective remodelling and prevent early osteoarthritis. The choice of osteotomy will depend on the severity of the acetabular dysplasia, the presence or absence of congruent hip reduction and the age of the child.

Both general and regional anaesthesia can be used if no contraindications exist. These procedures can be long and can be associated with considerable blood loss. General anaesthesia combined with spinal or epidural analgesia can provide good surgical conditions as well as effective postoperative pain control. Postoperatively, oral pain medication can be given, including paracetamol PO, opioids PO and non-steroidal anti-inflammatory drugs (give NSAIDs short-term to reduce any interference with bone healing).

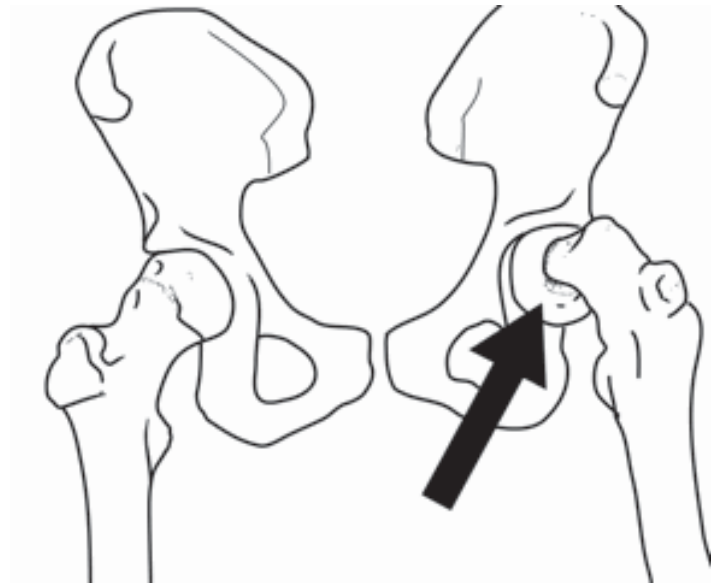
### **Slipped upper femoral epiphysis**

Slipped upper femoral epiphysis (SUFE) is a condition seen in children who are growing rapidly, and usually presents between the ages of 8 and 15. It is due to weakness in the growth plate that results in slippage of the femoral head from the rest of the femur. The child will often complain of knee or hip pain and may present with a limp.

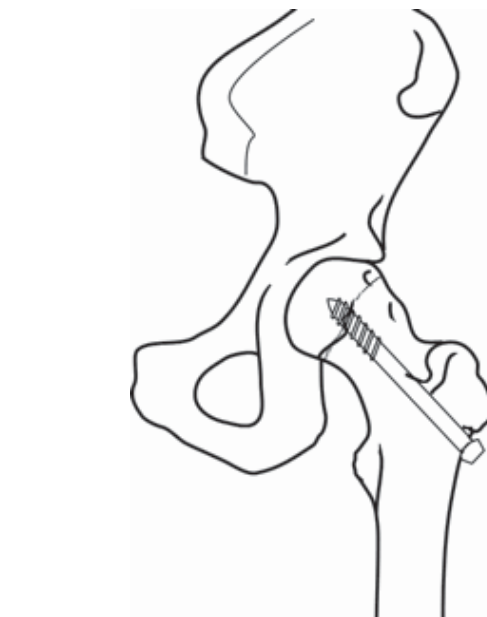
SUFE is an orthopaedic emergency if the child presents acutely, as further slippage may result in occlusion of blood supply to the femoral head resulting in avascular necrosis. Surgery involves the placement of one or two percutaneous cannulated screws into the femoral head to prevent further slippage. In 20-40% of cases the opposite hip may become affected and therefore the other side is also fixed. (See Figures 4 and 5)

There is a high association of obesity with SUFE. Other associations include endocrine abnormalities especially hypothyroidism and treatment with growth hormone. A high incidence of renal osteodystrophy is also found in this group of patients. Preoperative investigations should therefore include full blood count, urea and electrolytes, thyroid screen and a group and screen for blood.

**Figure 4.** *Slipped Upper Femoral Epiphysis (SUFE)*



**Figure 5.** *Insertion of femoral screw for slipped upper femoral epiphysis*



Intraoperatively, the patient may be positioned supine or lateral. Take care to avoid nerve compression or injuries. General anaesthesia, in conjunction with regional anaesthesia, can be used if there are no contraindications to regional anaesthesia. A single shot caudal or epidural can be helpful.

### **Treatment of limb deformity and leg length inequality**

There are many different conditions in childhood that can lead to deformity of a limb or differences in leg length. Treatment depends on the age of patient (how much growth is to be expected) and the pathology causing the limb length inequality.



## Epiphysiodesis

This is surgery that slows down the growth of the longer leg over a period of time or corrects angular knee deformities and is only performed in growing children. Small incisions are made around the knee near the femoral and/or tibial growth plates. The growth plates are prevented from growing by the use of small screws and plates called 8 plates. If the desired effect has been achieved and there is still some limb growth left the 8 plates are removed and bone growth resumes.

## Application of external fixator

The Taylor spatial frame is an example of an external fixator used to treat complex fractures and limb deformities. Anaesthesia techniques for this type of surgery will depend on the patient's general health and co-morbidities. General anaesthesia and regional analgesic techniques are usually employed. However in patients having an external fixator for acute fractures, use of a regional block must be discussed with the surgeon as it may mask signs of compartment syndrome postoperatively.

## Scoliosis/spinal deformity surgery

Specialist orthopaedic teams perform scoliosis surgery. Surgery is generally for cosmetic reasons, particularly in teenagers with idiopathic scoliosis, but in children with cerebral palsy or muscular problems, surgery may improve sitting balance, pain or even prolong life if the deformity is severe. Most cases are idiopathic in origin, and the children are otherwise completely healthy; they may only be underweight or occasionally anaemic. Children with severe scoliosis due to neuromuscular disorders are much higher risk due to impaired cardiorespiratory function.

A posterior approach is the most common technique, with spinal fixation in older children or to insert a growing rod system in pre-pubertal children. A thoracotomy may occasionally also be required which will require lung collapse to optimise access to the spine. The repair is usually done as a single-staged rather than as a two-staged procedure.

Scoliosis surgery is historically an operation associated with major blood loss and significant risk of cord injury. The use of comprehensive blood conservation techniques may allow allogenic blood transfusion to be avoided. Modern techniques, including spinal cord monitoring during surgery by trained electrophysiologists, can minimise risks. Propofol and remifentanyl TIVA provide optimal anaesthesia for spinal cord monitoring and a smooth recovery (volatile anaesthetic anaesthetics can interfere with the spinal cord monitoring). Good postoperative analgesia can be provided with an epidural (if there is no contraindication or concern about cord function post-operatively), or with balanced intravenous analgesia with morphine supplemented with ketamine and oral medications.

## Acknowledgements

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