Chapter

28 Anaesthesia for Plastic Surgery in Children

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Introduction

Plastic surgeons treat a range of congenital and acquired conditions in children from birth to adolescence, and paediatric work makes a significant contribution to the plastic surgery caseload. Procedures are classified as 'reconstruction' or 'cosmetic', but this distinction is often blurred in children, as many abnormalities are both unsightly and impair physical function.

Common procedures such as correction of anomalies of the ears, hands and feet will be described in this chapter. Repair of cleft lip and palate is covered in Chapter 23. Urological surgeons undertake hypospadias repair in some centres, and this topic is covered in Chapter 34.

Several skin conditions are amenable to treatment with targeted laser surgery. Modern lasers have allowed many lesions to be treated in childhood, with less scarring, better cosmetic outcomes and reduced need for treatment in later life. Anaesthetists need to understand the principles of lasers, the attendant risks and the precautions required for safe use.

Preoperative Assessment

Most children undergoing plastic surgical procedures are ASA 1 or ASA 2 and require minimal investigation prior to surgery. Most children can be managed on a day-case basis. A routine plastic surgery list may include infants and adolescents, and key anaesthetic requirements are adaptability and close attention to detail. A friendly and supportive environment is vital, as many children will attend repeated visits, and bad experiences will lead to future anxiety. Time and effort spent building rapport with the parent and child will pay dividends.

General Principles

Distraction techniques in the anaesthetic room are helpful, and premedication is rarely required. Induction technique depends on the individual anaesthetist's preference, taking the age of the patient into consideration. Success with venous access in small infants is related to skin temperature, and it helps if the child is kept both warm and hydrated. Allowing clear fluids up to an hour prior to anaesthesia is now widely accepted as safe practice, and this in turn facilitates success in cannulation. Pain on injection may be reduced by using 0.5% propofol or by adding 1 ml of 1% lidocaine per 100 mg propofol. A strong light source for transillumination or ultrasound may be used to find hidden veins after inhalational induction.

A supraglottic airway device (SAD) may be used in most plastic surgical procedures. Care should be taken to avoid displacement in infants during surgery involving the face or in cases where the head is likely to be moved, such as during a pinnaplasty procedure. A reinforced SAD may be more stable, but there should be a low threshold to using a tracheal tube in these patients. Care should be taken to protect vulnerable areas such as the eyes and in the application of tourniquets.

Surgical procedures on the limbs are usually performed using a tourniquet to provide a clear surgical field and reduce blood loss. Relative hypotension may be helpful in some procedures; blood pressure of no more than 20% below baseline appears to be safe in healthy older children. It is safer to aim for normotension in infants, as adverse cardiovascular events are more common in this age group (bradycardia, myocardial depression from deep volatile anaesthesia). A combination of remifentanil and sevoflurane allows for good control of blood pressure. Great care must be taken to flush infusion lines at the end of surgery to avoid inadvertent boluses of drugs such as remifentanil.

Pain Management

Effective pain control is essential for plastic surgery. Apart from humanitarian concerns,

inadequate analgesia during surgery leads to labile blood pressure, poor operating conditions, the increased use diathermy and consequent inflammatory pain and further risk of rebound bleeding after surgery. Wound infection is more common if there is a postoperative haematoma. It is important to have a good understanding of the surgery, as surgical stimulation can vary enormously during a plastic surgical procedure.

Multimodal analgesia is especially relevant to paediatric plastic surgery. General anaesthesia should be combined with regional anaesthesia, local block or field infiltration where possible. It is helpful to inject local anaesthetic prior to incision, as this reduces hypnotic and analgesic requirements and improves recovery. If the surgeon is planning a complex procedure, local infiltration may have to be delayed until the end of the procedure to prevent interference with mapping of incisions or finding the right 'plane' in the surgical field. It is also important to anticipate analgesic requirements when the block wears off.

Remifentanil is ideal intraoperatively, as it blocks virtually all surgical stimulation, provides excellent cardiovascular stability, reduces hypnotic dosage and is simple to use in children of all ages. We commonly use a remifentanil infusion in our unit for procedures expected to take an hour or more. An initial bolus of 1 mcg kg^{-1} IV is followed by an infusion, normally at 0.1–0.2 mcg kg^{-1} min^{-1}. Morphine 50–100 mcg kg^{-1} IV should be given to provide analgesia postoperatively, particularly where remifentanil is used, and is best given early in the operation. Intravenous paracetamol provides a useful contribution to analgesia. Postoperatively, a combination of ibuprofen and paracetamol should be prescribed regularly, with morphine 200 mcg kg^{-1} orally (80 mcg kg^{-1} in infants) every three to four hours as required.

Congenital Limb Deformities and Hand Surgery

There is an enormous variety of congenital limb deformities, with most corrective surgery in the upper limb undertaken by plastic surgeons, particularly hand surgery. The aims of surgery are primarily to improve function and secondly to improve appearance. Manual dexterity develops at an early age, so surgery is often undertaken within the first two years, which allows for improved function. There are over 100 recognised syndromes with associated hand abnormalities, but this still only represents a small fraction of congenital hand abnormalities. A classification of upper limb abnormalities proposed by Swanson has been adopted internationally (see Table 28.1):

- Failure of formation
- Failure of differentiation
- Duplication
- Overgrowth
- Undergrowth
- Constriction band syndromes
- Generalised skeletal abnormalities

Correction of many congenital limb deformities involves some form of skin cover, either as a full thickness graft from an area such as the groin or as a split skin graft from the thigh or medial arch of the sole of the foot. This needs to be discussed with the surgeon in advance to allow appropriate preparation and to anticipate analgesia requirements both during and after skin grafting. The child may become cold during long operations if multiple sites are exposed. Standard warming measures should be used with careful monitoring of skin temperature. Be aware that modern convective warming devices can easily lead to overheating of a small child or infant, so always start on a gentle setting and reassess.

Most hand and foot surgery is carried out using a tourniquet to minimise blood loss and to provide a bloodless surgical field. Poor application will make dissection of tissue planes and identification of individual nerves very difficult, so it is vital to check that the tourniquet is the correct size, is functional and has been properly positioned with appropriate padding before draping.

Tourniquets may be used for up to two hours, but long tourniquet times are associated with increased postoperative oedema. In infants, the tourniquet becomes less effective after two hours owing to excellent collateral blood supply via bones, which cannot be occluded. Blood loss should be anticipated when the tourniquet is released if there has been extensive dissection. It is good practice to release the tourniquet briefly and reinflate to allow the surgeon to identify any major bleeding points. After the tourniquet is deflated, it is best to remove it fully to prevent venous congestion.

Regional blockade is ideal for limb surgery and has the added advantage of sympathetic block and vasodilation. This is useful for procedures

Table 28.1 International classification of upper limb congenital abnormalities

Type	Example	Notes
Type I – failure of formation	Hypoplasia of thumb	Failure of formation may be in: • Transverse axis (any level from shoulder to thumb) • Longitudinal axis (pre-axial (radial), central or post-axial (ulnar)
Type II – failure of differentiation of parts	• Soft tissue – syndactyly, camptodactyly, trigger finger • Skeletal – clinodactyly • Vascular/neurological	• Two or more digits fused together • Complex syndactyly as part of a syndrome (e.g. Apert)
Type III – duplication	• Polydactyly	• Extra digits • May occur as part of syndrome • Pre-axial (thumb) • Central (ring, middle and index) • Post-axial (little finger) most common • 2 in every 1,000 live births
Type IV – overgrowth	• Macrodactyly	Localised gigantism,
Type V – undergrowth	• Radial hypoplasia • Brachydactyly • Brachysyndactyly	e.g. radial club hand, thumb hypoplasia • Shortness of fingers and toes • Short and fused digits
Type VI –constriction band syndromes	• Amniotic band syndrome	• Entrapment of fetal parts (usually a limb or digits) in fibrous amniotic bands whilst in utero
Type VII – generalised anomalies	• Atypical cleft hands	

Source: Swanson, AB, Swanson, GD, Tada, K. A classification for congenital limb malformation. *Journal of Hand Surgery American* 1983; 8:693–702.

involving microscopic anastomosis of vessels, such as toe-to-hand digit transfers. Axillary brachial plexus block can be performed using a single injection placed under ultrasound guidance (see Chapter 15).

Digit Relocation and Transplantation

With a hypoplastic or missing thumb but normal fingers, the usual treatment is pollicisation of the index finger, which involves shortening and rotating the index finger on its neurovascular supply to occupy the position of the thumb. With congenitally short (brachydactyly) or absent digits, microsurgical techniques now allow reconstruction of digits by using one or more toes.

The principal aims of reconstruction are focused on improvement in function. Surgery has the greatest impact when the missing digit is a thumb or where there are several digits missing. The second toe is the most common digit transplanted, as it is relatively long, has a reliable blood supply and has the ability to grow. Removing the second toe does not appear to have a great impact on the function or appearance of the foot. The big toe is rarely used to reconstruct digits, but a partial flap called a 'wrap-around flap' may be created from the pulp and nail of the big toe, with the donor site being covered with a skin graft.

Digit transfer operations take two to three hours. Careful planning is required to make sure all equipment is available and the child is appropriately positioned for microsurgical access. A vacuum bean mattress can be very helpful to reduce the risk of pressure-related injury. Antibiotics should be given five minutes prior to inflation of the tourniquet to allow for good tissue penetration. A peripheral block at the donor site and an axillary plexus block are ideal.

Syndactyly and Polydactyly

Syndactyly (fusion of digits) and polydactyly (accessory digits) are the two most common congenital abnormalities of the hand. Syndactyly tends to affect the ring and little finger but can affect all fingers. It may vary in severity from a single slightly displaced web to a full fusion up to the tips of the nails affecting many digits with bony abnormalities included. With increasing complexity of syndactyly, there is the additional risk of complex neurovascular arrangements, especially when associated with osseous abnormalities (see Figure 28.1).

With the increased detail provided by modern ultrasound machines, traditional peripheral nerve blocks have effectively been superseded by reliable and anatomically easy to identify blocks performed in the forearm or elbow. For the median nerve, a position midway along the forearm is best, as the nerve is easily identified centrally being away from most of the tendons but also not too deep in the muscle layers. For the radial nerve, placing the probe in the crease of the elbow on the lateral side allows easy access to the nerve. An in-plane technique using a 22G short bevel needle is ideal to judge both the depth and trajectory. The aim is simply to gently float the nerve in a few milliliters of plain local anaesthetic to ensure the needle remains clear of the nerve. The ulnar nerve is generally not so easy to locate using ultrasound but can easily be blocked by inserting 2 ml of plain local anaesthetic under the flexor carpi ulnaris muscle just proximal to the pisiform bone at the wrist.

Ear Surgery

Correction of Prominent Ears

This condition is associated with loss of the antehelical fold of cartilage. Surgery aims to correct this to allow the pinna to lie parallel to the head.

Pinnaplasty is usually delayed until the age of four to five years, when the ear cartilage is more rigid. This operation has traditionally been associated with a high risk of postoperative nausea and vomiting (PONV). The use of propofol infusion combined with local anaesthetic infiltration and minimal opioid helps to reduce this risk. Careful attention must be given to bandaging postoperatively to reduce the risk of haematoma, at the same time avoiding excessive pressure on the cartilage of the pinna, which may also increase PONV. A flexible SAD is often used so that the head can be turned easily during the procedure. It is important to ensure the head is not rotated more than 65° from the midline to avoid neck injury, including atlantoaxial dislocation.

Ear Reconstruction

Approximately one in 6,000 infants are born with microtia. This can be corrected by a two-stage reconstruction using costal cartilage. A tracheal tube should be used for the first stage as it takes several hours, involves rib harvest and has the potential for pneumothorax. After the first stage, a continuous infusion of levobupivacaine using a fine catheter in the costal wound provides good postoperative analgesia for 24 hours. As with

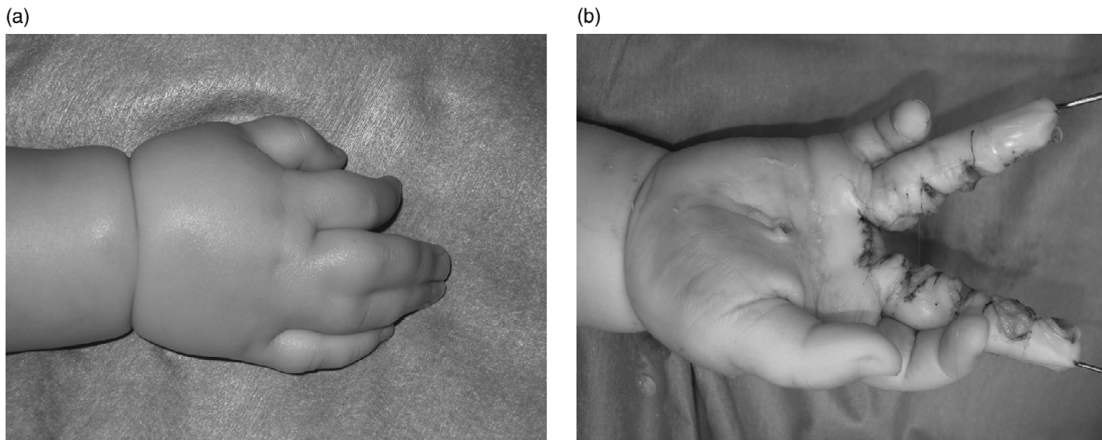

Figure 28.1 Syndactyly release in a one-year-old infant.

pinnaplasty, attention must be paid to the bandaging of the ears to minimise the risks of graft ischaemia. Mini-vacuum-suction drains are usually inserted to avoid haematoma. The second stage is a shorter procedure but incorporates a skin graft, usually from the thigh.

Accessory Auricles

Accessory auricles are abnormal segments of ear tissue commonly in the pre-auricular region but sometimes on the cheek and neck. They may contain cartilaginous remnants and require adequate exposure and removal. Surgery is generally performed when the infant is three to six months old.

Dermoid Cysts

These commonly occur at the outer border of the eyebrow (external angular dermoid cyst). In this location, they are generally superficial and are removed via a small incision adjacent to the eyebrow. Dermoid cysts also occur in the midline of the nose. The problem here is that there may be a sinus with an epithelial lined track extending deeply into the nasal septum and possibly to the base of the skull. Always consider the possibility for the need for deep exploratory surgery and choose a secure airway technique.

Tongue Tie

Tongue tie release to free up mobility of the tongue is a short procedure commonly performed in infants. A flexible SAD may be used, with a carefully positioned throat pack and local infiltration of the area.

Poland Syndrome

Poland syndrome comprises congenital breast hypoplasia associated with unilateral absence of pectoralis major muscle and an ipsilateral hand deformity. The aim is to achieve a natural shaped breast and chest wall symmetry. Surgery using tissue expanders and implants is normally carried out in late adolescence.

Gynaecomastia

Gynaecomastia is excessive breast formation in boys and usually occurs because of oestrogen and testosterone imbalance at puberty. Surgery is undertaken either by liposuction or direct excision via the areolar margin of the breast tissue. Surgical excision is associated with increased postoperative bleeding and haematoma. It is important that the blood pressure is normal prior to closure of the wound so that good haemostasis can be obtained, especially if local anaesthetic with adrenaline has been used. The adrenaline in the infiltration solution will wear off after two hours, which may increase the risk of bleeding and haematoma formation.

Laser Surgery

Lasers are used to treat a range of congenital and acquired skin conditions, most of which respond well to treatment. The use of lasers presents a variety of challenges in children. Vascular and pigmented lesions such as port wine stains change in their pigmentation as the child gets older, making the lesion more resistant to laser intervention. Lesions are now treated at an earlier age so that fewer treatment sessions are required, with fewer complications as a result.

Principles of Laser Surgery

Chromophores are pigmented targets that selectively absorb certain wavelengths of light. Laser light is intense monochromatic light, the wavelength of which is determined by the medium (gas, liquid or solid) through which the light passes. Laser irradiation can be used to selectively target chromophores (water, haemoglobin or melanin) in the skin by selecting an appropriate wavelength along with an appropriate pulse and energy setting. The net result is intense localised production of heat in the chromophore resulting in vaporisation in the target tissue. To target specific tissues precisely, it is necessary to consider the thermal relaxation time of the chromophore. This is defined as the time necessary for the target chromophore to cool to half its peak temperature after irradiation. The pulse time of the laser must be equal to or less than this to prevent damage to surrounding tissues and allow time for appropriate cooling and dissipation of energy.

Early laser technology used continuous-wave mode for treating vascular skin lesions and was associated with a high degree of scarring because of uncontrolled heating effects. This led to the development of pulsed dye lasers (PDL), with wavelengths of 585 nm or 595 nm, which have become the mainstay for treatment of vascular

lesions in terms of efficacy and low risk of adverse scarring. The PDL emits a laser beam with wavelength close to one of the maximum absorption peaks of oxyhaemoglobin. Transient bruising lasting several days is common after use of PDL lasers. Recent advances include dynamic surface cooling, which increases the efficacy of the laser (e.g. Candela laser) and very short pulse duration, which improves the clinical result and helps minimise adverse effects.

Laser Surgery and Anaesthesia

The choice of laser and laser settings needs to be adjusted to take account of the smaller vessels in children and the unpredictable nature of scarring. The laser is applied in multiple 'dots' to cover the birthmark and to produce a controlled burn. Wound aftercare is a vital part of the treatment process, and aloe vera is commonly used for cooling the skin. If the treatment results in an open wound, a topical antiseptic such as mupirocin ointment is usually applied.

Each shot of the laser feels like being flicked with an elastic band, so many children will require general anaesthesia. The aim is to keep the patient immobile, warm and well perfused so the surgeon can visualise the vessels at the site of surgery clearly. The airway can generally be managed with a SAD, and it is helpful to avoid tapes to secure the SAD if lasering around the mouth. Analgesia such as fentanyl, paracetamol and ibuprofen should be given, and cool face packs help to reduce discomfort. A stat dose of dexamethasone reduces facial swelling after treatment. Some children will be able to undergo laser treatment with just a topical anaesthetic cream applied an hour before surgery. Whichever method is undertaken, efforts should be made to ensure the experience for the child is pleasant, as four to six treatments may be required at intervals of every six months. Children should avoid sun exposure before, during and after laser treatment as it may decrease the efficacy of the procedure or contribute to postoperative pigmentation changes.

Laser Safety

Universal safety precautions are mandatory:

- Wet swabs should be used to protect the child's eyes, and staff should wear protective goggles appropriate to the specific laser used.
- The theatre doors should be locked or alarmed and notices displayed to indicate laser treatment in progress.
- The CO_2 laser is particularly associated with fires, and stringent fire precautions must be taken.
- Risks include burning holes in drapes or ignition of flammable substances such as tincture of benzoin. It is sensible to reduce the inspired oxygen as low as possible when lasering in the region of the airway. A fire extinguisher must be immediately on hand and wet swabs used to cover potential ignition points.
- Scavenging systems need to be in place, and face masks should be worn when lasers are used to remove viral warts, as an aerosol of vaporised tissue is produced with the potential risk of viral DNA being inhaled.
- There is a potential for electrical injury or an accident from tripping over cables when several lasers are used in the same theatre, and extra vigilance is required.
- Forgetting to change goggles when switching lasers is another potential risk.

Lesions amenable to treatment by laser surgery

Vascular birthmarks are relatively common in infants and can be separated into two distinct categories:

- Vascular tumours otherwise known as haemangiomas
- Vascular malformations such as port wine stains

It is important to identify the type of lesion correctly as they have quite different natural histories and treatments. Most infantile haemangiomas are uncomplicated and do not require any intervention, as they will naturally involute with time. Some haemangiomas undergo rapid proliferation and may threaten vital structures or have the potential to cause major disfigurement. Lasers can be used to target symptomatic superficial haemangiomas, with specific indications being bleeding, rapid proliferation and ulceration.

The most used laser for this is the PDL (585 nm or 595 nm) targeting oxygenated haemoglobin. For more deeply embedded haemangiomas, the 755 nm alexandrite or the 1064 nm Nd:

YAG laser may be used for higher penetration (see Figure 28.2). A course of treatments over several weeks is often necessary, and residual telangiectasias may require further treatment, again with the PDL laser. Laser therapy for such lesions will invariably involve general anaesthesia for patients in this age group.

Vascular malformations such as port wine stains are less common than infantile haemangiomas and do not undergo rapid growth followed by involution. They tend to grow with the child and become prominent during puberty. Several unusual conditions may be associated with port wine stain

- Glaucoma (port wine stain around the eye)
- Sturge–Weber syndrome (malformation affects superficial vessels of the brain, associated with developmental delay, hemiplegia and seizures)
- Klippel–Trenaunay syndrome (vascular malformation affecting arm or leg, associated with hypertrophy and venous and lymphatic malformations)
- Proteus syndrome (associated with hemihypertrophy, lymphangioma, lipoma and macrocephaly).

The underlying pathology is associated with an increased number of ectactic vessels in the papillary and reticular dermis. They can also be treated by targeting oxygenated haemoglobin in the vascular compartment with the PDL laser. This is effective in reducing the visual impact of lesions by around 80%.

The response to treatment is hugely variable and will depend on the depth of the lesion, with deeper structures being more difficult to treat. Timing of treatment is controversial, but earlier intervention during childhood is generally felt to be helpful, as the laser has more effective penetration in thinner skin and reduces the need for intervention at a later stage. When planning a course of laser treatment, it is helpful to undertake a test patch to show the parents the effect and demonstrate the postoperative bruising associated with the procedure.

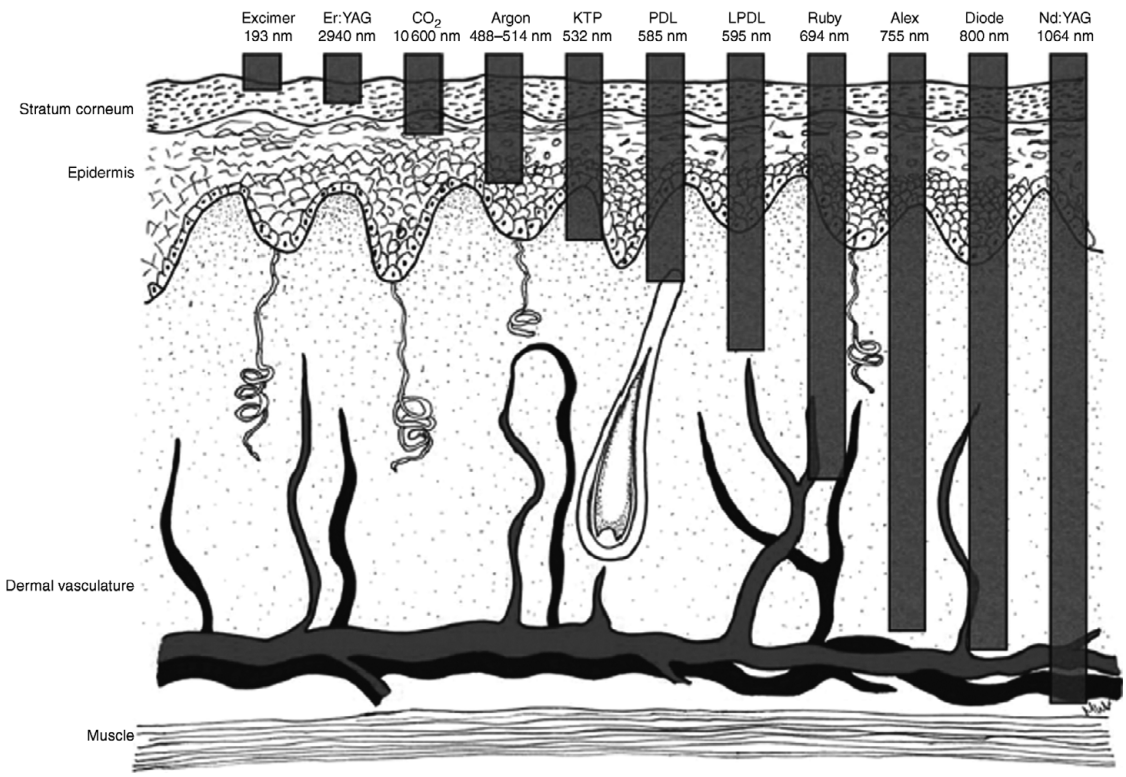

Figure 28.2 Depth of penetration of different lasers and site of damage in the skin. Er- and Nd-YAG, erbium- and neodymium-doped yttrium aluminium garnet; KTP potassium titanyl phosphate; PDL, pulsed dye laser; LPDL, long-pulse dye laser; Alex, Alexandrite laser.
Source: Adapted from figure 1.13 of Dover JS, Arndt KA, Geronemus RG. *Illustrated Cutaneous and Aesthetic Laser Surgery,* 2nd ed. McGraw-Hill. 1999.

Childhood pigmented lesions are amenable to treatment with Q-switched lasers, which have a very short pulse duration but very high peak power. They produce largely non-thermal mechanical damage with shock waves, vaporisation of tissue and destruction of melanin pigment. Ruby (694 nm) and alexandrite (755 nm) laser light are well absorbed by melanin but not haemoglobin. They are effective in the treatment of epidermal lesions such as sebaceous naevus and naevus of Ota and can be used in non-pulsed mode for the removal of hair. If the density of pigment is relatively low, laser surgery is often combined with local anaesthesia infiltration, but if used for depilatory action, then application of ice is usually adequate for pain relief.

Key Points

- Multimodal analgesia techniques are key to success in paediatric plastic surgery.
- Being skilled in simple peripheral and regional blockage is invaluable to aiding smooth recovery.
- Time invested in preparation to enable a calm cooperative child who is both warm and hydrated pays dividends.
- Use local anaesthesia field infiltration, local blocks or regional blockade where possible.
- Administer long-acting opioids early.
- Good communication between the anaesthetist and surgeon is vital.
- Safety is paramount when undertaking anaesthesia for laser surgery.