Amputation and rehabilitation

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Abstract

Most lower limb amputations in the UK are performed in order to treat peripheral arterial disease and its complications. Amputations are usually classified as minor (toe and partial foot amputations) or major (when most of the limb is removed). Principles of selecting amputation level are considered and the importance of optimization of the patient's medical status is stressed. Most patients requiring amputations have significant comorbidities and amputation carries an appreciable anaesthetic risk. Minor amputations include toe and ray amputations, transmetatarsal and mid-foot amputations. Ankle-level amputations, such as Syme's amputation, are rarely indicated and it is difficult to fit prostheses to these stumps. Below-knee and above-knee amputations are the most commonly performed major amputations. Below-knee amputations may be carried out using either a long posterior flap or skewed flaps. Skewed flaps may be preferred when the posterior skin is of poor quality, and produce a cylindrical stump well-suited to limb fitting. Through-knee and hip disarticulations are also described. Successful amputation surgery, with good outcomes for the patient, requires attention to detail and careful coordination with physiotherapy and rehabilitation departments. The aim is to produce a well-healed, pain-free stump suitable for limb fitting.

Keywords Amputation; critical ischaemia; peripheral arterial disease; prosthesis; rehabilitation

Epidemiology and aetiology

Amputation is one of the procedures performed most commonly by surgeons. Most amputations (80%) are carried out to treat complications of peripheral vascular disease and the vast majority involve the lower limb. Forty per cent of these are performed in diabetic patients. Other indications for amputation include trauma, aggressive infection (necrotizing fasciitis), malignant tumours, congenital deformity, chronic pain or a 'useless' limb (usually due to neurological injury). In the UK, around 5000 patients a year will require a major lower limb amputation.

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Types of amputation

Amputations are often referred to as major, where the majority of the limb is removed, or minor. A detailed discussion of upper limb amputations is beyond the scope of this article, which will concentrate on amputations of the lower limb.

Preoperative assessment of the patient

Preoperative assessment of the patient involves a multidisciplinary approach with input from the surgical and anaesthetic team, prosthetic specialist, nursing staff, physiotherapists, occupational therapists, specialist diabetes team, psychologists, and should include nutritional assessment.

Consideration of the level of amputation should take into account the likely ability of the patient to undergo successful rehabilitation. Walking with a prosthesis compared to normal ambulation requires an additional energy expenditure of 25–40% for a below-knee prosthesis and 65–100% for an above-knee prosthesis. This may severely limit mobility of patients with co-existing ischaemic heart disease. In contrast, wheelchair use demands energy expenditure only 8% greater than normal walking. An above-knee or through-knee amputation is the best option for a patient who is only ever likely to be mobile in a wheelchair. A below-knee stump is more liable to decubitus ulceration and is contraindicated in the bedbound patient. Flexion contracture at the knee of greater than 15 degrees also precludes below-knee amputation.

For the surgeon, assessment of the level of amputation should take into account the severity and pattern of vascular disease, the degree of tissue loss and the viability of tissues in the vicinity of the proposed flaps, as well as the presence of infection. The use of adjunctive tests such as laser Doppler studies, transcutaneous pO_2 measurement or isotope measurements of skin blood flow are unproven and most surgeons rely on clinical judgement.

Major amputation is high-risk surgery and therefore optimization of comorbid disease is crucial to limit perioperative complications. The most common comorbidities encountered in those undergoing major amputation are hypertension, diabetes and ischaemic heart disease.

Preoperative preparation should include deep vein thrombosis (DVT) prophylaxis and prescription of broad-spectrum antibiotic prophylaxis including activity against anaerobes. For major amputations a urinary catheter is useful for postoperative monitoring of urine output and for ease of micturition, whilst the patient is bedbound. A careful history and examination is required to detect the presence of previous orthopaedic prostheses or vascular bypass grafts that may be encountered during surgery.

Lower limb amputation

Toe amputation

Toe amputation is the most common amputation performed in the lower limb. It is essential to evaluate the arterial circulation prior to considering toe amputation. The presence of palpable foot pulses is associated with a healing rate of 98%, reducing to 75% with absent foot pulses. Toe amputation may be carried out using fish-mouth, racquet or circular incisions. Amputation must never be performed through a joint as this exposes avascular

cartilage, which will not heal. Therefore toe amputation is usually performed through the proximal phalanx.

Ray amputation

A ray amputation refers to excision of the toe through the metatarsal bone. A tennis racquet-shaped incision is used to expose the metatarsal head, which is excised at the neck.

Dissection should remain close to bone to avoid devitalization of flaps or adjacent toes. Tendon remnants are excised as far proximally as possible. In the presence of infection the wound should be left open. Ray amputation usually allows normal ambulation although ray excision of the hallux may cause ulceration of the plantar skin due to abnormal weight distribution.

Transmetatarsal amputation

Transmetatarsal amputation is indicated for gangrene or infection affecting several toes. It is essential that the plantar skin is healthy as the incision uses a total plantar flap. The metatarsals are divided at the mid-shaft level. A well-healed transmetatarsal amputation provides excellent function.

Mid-foot amputation

A mid-foot amputation may be carried out when more proximal forefoot disease precludes amputation at the transmetatarsal level. This amputation should only be considered in the patient with absent or correctable ischaemia. The Lisfranc amputation is a disarticulation between the metatarsal and tarsal bones and the Chopart amputation is a disarticulation of the talo-navicular and calcaneo-cuboid joints. The main disadvantages of these procedures are the unpredictable healing rates and development of equinus deformity, which may limit ambulation.

Ankle-level amputation

The Syme and Pirogoff amputations at the ankle level are rarely indicated in vascular surgical practice. It is difficult to fit prostheses to these stumps and in most cases below-knee amputation is preferable, to allow successful healing and ambulation.

Below-knee amputation (BKA)

There are two basic techniques commonly used for BKA. The long posterior flap technique was introduced by Burgess and Romano in 1967 and is the most commonly used method. The Skew flap technique was described by Robinson in 1982. A randomized trial comparing the two techniques demonstrated equivalence in terms of healing, need for revision and successful walking.

Burgess long posterior flap: The usual elective site for below-knee amputation is 14 cm below the knee joint or 10—12 cm below the tibial tuberosity. The absolute minimum level permitted for successful limb-fitting is 7 cm below the joint line. The skin incision is placed 1 cm distally to the proposed level of tibial transection. Skin flaps may be accurately marked using a length of suture material and a skin marker using a rule of thirds (Figure 1).

The initial incision is made through skin and subcutaneous fat with a scalpel and continued through the muscles of the anterior and peroneal compartments with a diathermy blade. The vessels are identified prior to division and ligated with absorbable suture material. The tibial nerve should be divided under gentle traction with a scalpel blade taking care to identify and diathermy the vasa nervorum, which will otherwise cause troublesome bleeding in the depths of the wound. A perineural catheter can be inserted intraoperatively and used to provide postoperative analgesia.

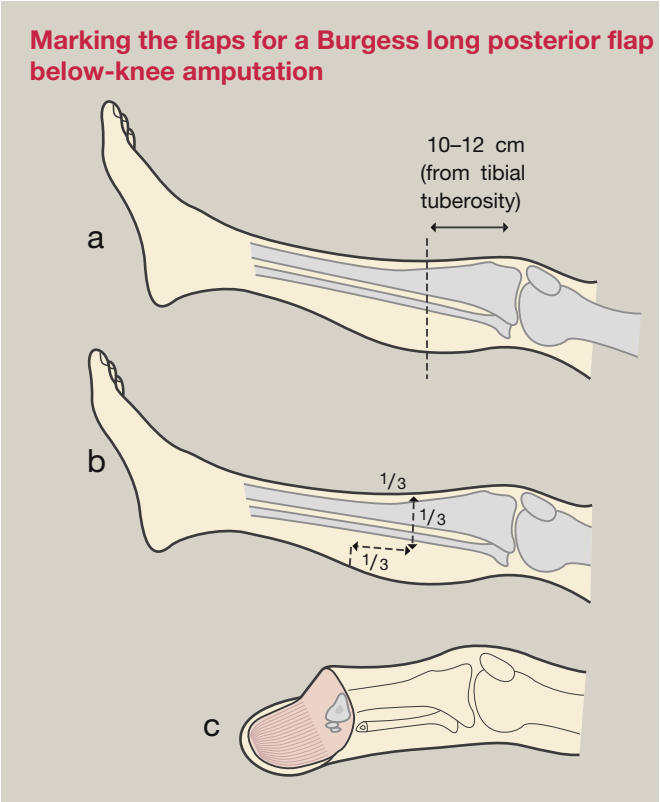

Figure 1

The fibula is stripped of periosteum up to 2 cm above the skin incision, divided and filed smooth. The tibia is also stripped of periosteum to the level of planned division and divided with a hand or oscillating saw. In order to prevent a prominent bony protruberance the tibia is bevelled and filed smooth. Soleus should be excluded from the posterior flap and cut level with the bone section. The gastrocnemius muscle is suitably thinned to provide coverage for the tibial bone end. Excessive bulk in the posterior flap may hinder subsequent limb-fitting: aim for a cylindrical stump. Before closure meticulous attention should be paid to haemostasis and a drain inserted. The fascia is brought together with interrupted sutures and the skin closed.

Skew flap technique: This technique is useful when a long posterior flap would be compromised by ulceration or gangrene extending proximally onto the site of the proposed posterior flap. The skew flap amputation naturally gives a more cylindrical stump shape than the posterior flap technique. This potentially avoids the need for lengthy postoperative stump moulding prior to prosthetic fitting.

Skin flaps are marked on the limb using as a basis the circumference of the leg at the proposed site of tibial division

which is located 10–12 cm from the joint line at the tibial plateau (Figure 2). The anterior junction between the flaps must lie more than 2 cm from the tibial crest. Medial and lateral myoplastic flaps are fashioned with division of the bones carried out as described above.

Through-knee amputation

A through-knee amputation may occasionally be indicated when infection or gangrene precludes creation of the flaps normally used for successful healing of a BKA. It is useful when above-knee amputation (AKA) would be hampered by the presence of orthopaedic metalware in the femur.

A through-knee amputation results in an end-bearing stump for prosthetic attachment. In the non-ambulatory patient the stump provides a long lever arm for better mobility and balance in bed.

A through-knee amputation is fashioned by creation of anterior and posterior flaps or sagittal flaps. Transection of the femoral condyles allows easier skin flap closure and better prosthesis fitting. In the Gritti-Stokes amputation the patella is fixed to the underside of the transected femoral condyles. The main disadvantage of through-knee amputation is the unpredictable healing of the skin flaps.

Above-knee amputation

For ambulation following AKA the ideal level of transfemoral amputation aims to achieve a stump long enough to act as a lever arm for locomotion while allowing adequate clearance of the knee for jointed prostheses. A bone section 15 cm above the tibial plateau or 25 cm below the greater trochanter is optimal. Removal of less than 10 cm of femur will result in difficulty attaching a jointed prosthesis. The shortest stump recommended is measured as 15 cm from the greater trochanter to the level of femoral section. If this is not achievable hip disarticulation is preferable.

The flaps for AKA are based on equal myoplastic flaps fashioned as a fishmouth marked out using a quarter of the leg circumference as a guide (Figure 3). The general principles follow that outlined for BKA.

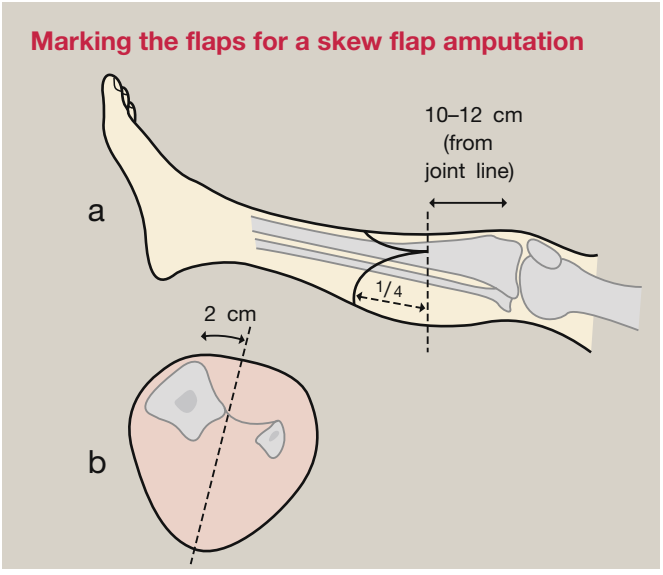

Figure 2

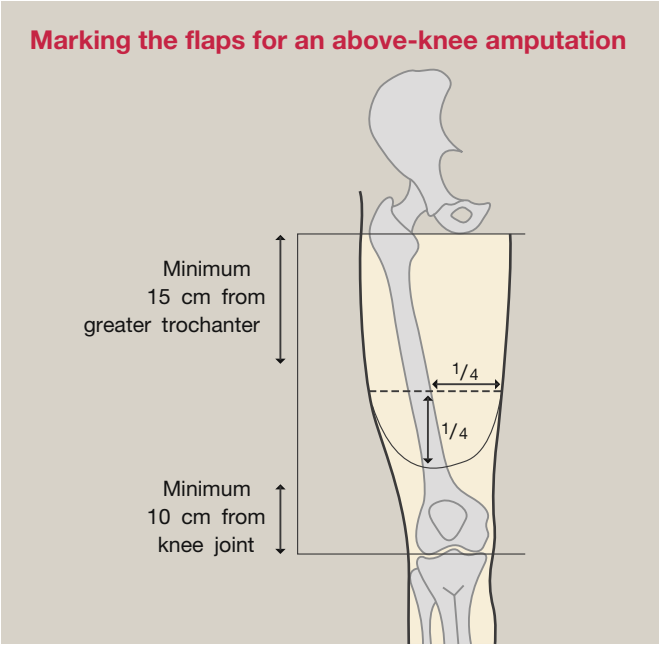

Figure 3

Hip disarticulation and hindquarter amputation

The main indications for these operations are malignant disease, extensive trauma, infection or gangrene, or a non-healing high above-knee amputation. There is a low incidence of successful ambulation in vascular patients following this type of surgery.

Postoperative complications

Complications specific to amputation surgery include local complications such as stump haematoma, flap necrosis or infection. Stump trauma from falls is common, often due to failure to remember the limb is missing. The pain management team are useful in helping with postoperative wound pain and phantom pain. The latter can often be successfully treated with a combination of amitryptiline and gabapentin or pregabalin as first-line pharmacotherapy. There is equivocal evidence that good preoperative analgesia can reduce phantom pain in the long term (pre-emptive analgesia). However early postoperative use of a nerve catheter, left insitu temporarily following surgery, allows direct infusion of local anaesthetic onto the sciatic or tibial nerves and may be valuable in reducing postoperative pain. Psychological problems and depression are common following amputation, as part of the emotional adaptation to limb loss. Late complications include neuroma formation, osteomyelitis, bony erosion, ulceration and ongoing ischaemia.

Outcome of surgery

Successful surgery will result in a well-adjusted, rehabilitated patient. Fifty per cent of patients undergoing major lower limb amputation for ischaemia will require amputation of the contralateral limb within 2 years. Survival following amputation in the patient with vascular disease is 31% at 5 years following

surgery, underlining the severe co-morbid diseases that coexist in these patients. Figures from the National Vascular Database and Hospital Episode Statistics in the UK suggest that perioperative mortality following major amputation may be as high as, with in-hospital mortality following AKA being twice that following BKA, 12.2% and 5.8%, respectively.

In response to these figures the Vascular Society of Great Britain and Ireland (VSGBI) have published a Quality Improvement Framework in order to improve outcomes following surgery with the aim of reducing and maintaining the 90-day mortality of major lower limb amputation to 10% or less nationally.

Timing of surgery is a key quality indicator: major amputations should be carried out in daylight hours wherever possible in accordance with the VSGBI Quality Improvement Pathway, and should be undertaken with consultant supervision by a surgeon practiced in amputation.

Rehabilitation

Physiotherapy should begin preoperatively and be continued postoperatively with an aim to prevent contractures, limit oedema and to aid general mobility in bed and on transfer. Once the wound has healed an elasticated stump-shrinker sock (e.g. Juzo^{TM}) is applied to provide stump moulding. Early ambulation is commenced with a variety of early walking aids such as the Pneumatic Post Amputation Mobility Aid (PPAM Aid) for BKA or the Femurette for AKA. Once the stump has moulded satisfactorily, a cast can be made for prosthesis fabrication. During this phase the amputee undergoes gait retraining and exercises designed to strengthen proximal muscles. Walking is gradually reintroduced initially with the assistance of gait aids.

Prosthetics

For BKA a patellar-tendon-bearing prosthesis is used. An inner-lining, elasticated stocking or silicone gel sleeve is used as an attachment for the plastic laminate prosthesis to the residual limb. A variety of foot and ankle design options are available. Dynamically responsive or energy-storing designs permit a greater range of physical activity. Multiaxial units provide movement in both the medial-lateral and dorsiflexion-plantarflexion directions allowing easier walking on uneven terrain. For AKA, the prosthesis is attached to the limb with an ischial containment socket held in place with suction or a total elastic suspension system. Sophisticated knee mechanisms now exist to provide a more natural gait. These include hydraulic, pneumatic or computerized systems. For elderly patients' safety, knees with an autolock are often provided to aid stability when standing. Prostheses designed for different activities are also now available (e.g. golf, athletics, swimming).

Summary of the principles of amputation surgery

- Avoid undermining or devitalizing skin flaps.
- Use a tourniquet to control haemorrhage
- Ligate vessels as they are encountered to minimize bleeding.
- Divide nerves cleanly and away from bone ends to avoid neuroma formation
- Presence of muscle that does not bleed or contract in response to diathermy stimulation indicates devitalization – select a higher level for amputation.
- Guillotine amputation of highly infected tissue with later stage completion of amputation is indicated for severe sepsis and may reduce revision rates.
- Avoid unnecessary bulk in the stump when closing.
- Use a suction drain(s) for major amputation.
- Avoid tight stump bandaging which can cause skin breakdown. ◆

FURTHER READING

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