Amputation after trauma

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Surgical amputation following an injury is rare, and consequently few surgeons perform them frequently in this context. Overall, only around 5-15% of lower limb amputations are performed following injury, with the majority being due to vascular disease[1,2]. Reference texts and the literature mainly focus on dysvascular limb loss patients who are typically older, sicker and with less potential for rehabilitation than the trauma patient, which limits their utility to the trauma surgeon.

The aim of this article is to provide the reader with an overview of the difficult decisions that have to be made when contemplating and planning lower limb amputation after trauma, and place them in the context of current literature and understanding.

Initial surgical treatment of severe limb injury

Severe limb injury frequently occurs in the context of poly-trauma. In these instances, initial treatment should be focused on the techniques of damage control resuscitation and surgery: haemorrhage control, tailored resuscitation with blood products and skeletal stabilisation.

Decision making around limb viability is extremely challenging in the context of surgery. Immediate completion of partial amputation is normally only necessary when the patient is in physiological extremis.

Surgeons may be tempted to rely on scoring systems such as MESS to aid decision making; at least six systems have previously been proposed to quantify limb injury and identify those which are potentially viable and those in which salvage attempts would likely be futile[3-8]. The studies presenting these scoring systems share similarities: they are cohort studies of limb-threatening trauma, the presumptive treatment was salvage, and regression analysis was used to determine predictive factors that form the basis of the scoring systems they propose. These scoring systems have been shown to be poor predictors of limb viability in both the civilian[9] and military context[10], and do not adapt as techniques and therapies improve.

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In the absence of an algorithmic basis for decision making, surgeons must rely on a subjective process based on their experience and unit capabilities. If possible, severely traumatised limbs should be carefully examined pre-operatively by senior orthopaedic and plastic surgeons, photographed, and imaged using CT angiography in accordance with NICE[11] and BOAST guidance[12]. Surgeons should postpone any absolute decisions about amputation until the limb has been fully assessed intra-operatively and crucially all non-viable or irredeemably contaminated tissue has been excised. This systematic excision or debridement may in fact involve a de-facto amputation.

Severely injured but perfused limbs should be stabilised with an external fixator and the wound dressed with a Topical Negative Pressure dressing (e.g. Wound VAC®). This temporary stabilisation and wound management provides time for surgeons to have a fully informed discussion with the patient about whether a severely injured limb should be amputated or whether attempts should be made at limb reconstruction.

Amputation versus reconstruction; could versus should

When deciding between amputation and reconstruction it is important to define what a successful outcome would look like. It is perhaps a natural tendency of the surgical character to push for reconstruction whenever possible. The surgeon's perception of 'success' would be united fractures, healed wounds and an absence of infection. In this situation, the surgeon is assessing whether reconstruction *could* be possible. However, a patient is more likely to define success by function, the absence of pain, walking distance and the avoidance of prolonged treatment. Here, the surgeon should not assess whether they *could* reconstruct the limb, but whether they *should*. Would surgical reconstruction give the patient the outcome they desired?

Surprisingly military patients who 'fail' reconstruction attempts and go on to have a delayed amputation have been found to have superior outcomes to patients who have retained their limbs after open tibia fractures[13] and severe hindfoot injuries[14-16]. It is important to note that this counter-intuitive finding might not extrapolate from a military cohort to a civilian one. This is also an extremely challenging area to quantify as superior outcomes following amputation may be limited to younger patients and a cross-over may occur when older patients with retained limbs eventually have superior function than similar, older amputees. Further confounders exist where the financial and social implications of limb loss versus retention typically favour the former, distorting quality of life metrics.

If the clinical situation permits, decisions about amputation or reconstruction should be discussed at length with the patient and their family. These should involve the Orthopaedic Trauma and Plastic & Reconstructive Surgeons, Prosthetist and members of the rehabilitation team. Realistic information should be given to the patient regarding the relative likelihood of them walking without a limp or pain and even running with the two treatment strategies. It is worth acknowledging that initial reconstruction does retain the option for later amputation.

Amputation level

Deciding the level at which an amputation should be performed presents its own challenges. The two broad treatment strategies are whether to perform the amputation proximal to the injury, or within the zone of injury. Terminalising a limb proximal to the zone of injury permits a robust stump to be formed in healthy tissue potentially requiring fewer surgical episodes. An amputation from within the zone of injury, often using plastic reconstructive surgery techniques to close or cover the stump, maximises residual limb length but often at the cost of a greater number of surgical procedures (serial excision and staged reconstruction) and a less robust stump.

Burgess' description of a below knee amputation with a posterior flap[17] has been adopted as the basis of trans-tibial amputation. He described a level 9-13cm below the joint. Given the huge functional advantage of retaining the knee joint, a trans-tibial level should be contemplated whenever the tibial tuberosity and extensor mechanism can be retained. There have been case reports of using distraction osteogenesis to lengthen short residual tibias that have been amputated just distal to the tibial tuberosity[18,19]. >>

If it is not possible to perform a transtibial amputation, then the preferred level is a knee disarticulation. This is a controversial area; the LEAP team found that the very small number of knee disarticulation patients in their study reported poorer outcomes than trans-femoral amputees. However, a larger meta-analysis reported superior overall quality of life and greater walking distances in patients following knee-disarticulation compared to trans-femoral amputation[20].

While the transected end of a femur or tibia do not allow end weight bearing, in a knee disarticulation the distal femur does allow direct end-weight bearing. However, surgeons should be aware that prosthetists have few options with prosthetic knee joints designed specifically for knee disarticulations. Since these have to be as compact as possible to minimise joint level discrepancy they are typically less sophisticated and have a reduced maximum weight compared to joints designed for transfemoral amputees.

The issue that normally dictates residual limb length is soft tissue coverage, not residual bone length. All bony prominences require coverage with muscle tissue to allow painless prosthesis use. Consideration should be given to using free-tissue transfer (flaps) for coverage, especially if this permits the retention of the knee joint. Gracilis and antero-lateral thigh flaps are associated with little functional deficit. Latissimus dorsi and rectus muscles have an important functional role after lower limb injury during the rehabilitation phase, and their use as donor tissue will incur a functional impairment.

Surgical principles

The function of muscles should be balanced either by suturing to their antagonists (myoplasty) or to bone (myodesis). If the amputation is performed within the zone of injury then tight sutures should be avoided to prevent strangulation in the event of further swelling and to permit some drainage. However, if the soft tissue envelope is left mobile and bulbous, then socket fitting will be challenging and forces will not easily be transmitted through the socket-stump interface.

In order to reduce potential contamination, the final bony resection should be performed at the time of final soft tissue coverage or closure.

Amputations performed through the femur have the advantage of a thick, well perfused, soft tissue envelope. However, muscle balancing can be challenging; the adductors are de-functioned when the femur is transected proximal to the adductor tubercle. Unless myodesis of the adductors to the distal femur is performed then the hip abductors will be unopposed leading to a widened, difficult gait.

Summary

Few Orthopaedic Trauma surgeons regularly perform amputations and much of the available literature on the subject is written from the perspective of vascular surgeons. The decision to reconstruct or amputate is challenging as surgeons must balance technical potential for limb reconstruction with likely functional recovery which, on occasion, will favour amputation.

When amputation is necessary this should be regarded as surgery to enable maximum rehabilitation and functional recovery. The knee joint should be preserved wherever possible, and when it is not, consideration should be given to a knee disarticulation. Muscle groups should be balanced and stump length maintained, especially above the knee. If these principles are followed, patients with severe limb injuries will have the best opportunity for maximal functional recovery.

Further reading

1. Atlas of Amputations & Limb Deficiencies, 4th Ed. 2018. Wolters-Kluwer. Editors: Krajbich JI, Pinzur MS, Potter BK, Stevens PM.

This is the definitive 3-volume textbook on this subject written on behalf of the American Association of Orthopaedic Surgeons. Pairs of chapters cover each amputation level, both the surgery and prosthetics/rehabilitation. Lots of useful technical information and good quality diagrams.

2. Traumatic and Trauma-Related Amputations Part I: General Principles and Lower-Extremity Amputations. Tintle SM, Keeling JJ, Shawen SB, Forsberg JA, Potter BK. JBJS. 2010; 92(17): 2852-2868.

3. Traumatic and Trauma-Related Amputations Part II: Upper Extremity and Future Directions. Tintle SM, Baechler MF, Nanos GP, Forsberg JA, Potter BK. JBJS. 2010;92 (18) 2934-2945

These are two large and relatively modern articles in the JBJS' Current Concept Review series. They have useful clinical photographs and plenty of surgical technical detail. Although aimed for a general audience, these papers are written from the perspective of military surgeons dealing with combat injuries

4. Ch 20, Vol 2 of Rockwood and Green's Fractures in Adults 9th Ed. Penn-Barwell JG, McVie J, Kendrew JK.

Chapter in Rockwood and Green's on lower limb amputation providing a step-by-step guide with diagrams to performing an amputation at transtibial, knee disarticulation and transfemoral levels. ■

References

References can be found online at www.boa.ac.uk/publications/JTO.