LOWER LIMB TRAUMA: LIMB SALVAGE OR AN EARLY AMPUTATION?

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Trauma is the leading cause of death and disability in the first four decades of life all over the world (1). This causes serious social and economic costs (1, 2).

The ultimate goal of the trauma care is to return the patient to an independent and productive life as soon as possible. Trauma surgeon’s role is critical in establishing a better quality of care, because he or she are responsible for taking the patient through all phases of the “trauma disease”, from resuscitation, into the reconstruction and rehabilitation phase (3). Unfortunately, recovery following injury is a complex problem. Combined arterial and skeletal extremity injuries associated with higher risk of the limb loss are the best example of this.

This article provides a general overview on the challenges related to the management of the lower limb trauma and specifically looks at the issues surrounding the damage control orthopaedics, limb salvage and early amputation.

Damage Control Surgery

The Damage Control Surgery (DCS) concept is applicable to any of the major body compartments, including the neck, chest, abdomen, pelvis and limbs. The objectives of DCS are the same. The aim is to stop the haemorrhage, correct coagulopathy, limit contamination, inflammatory response and enclose the viscera (4). Therefore, the concept of DCS is an essential component of Damage Control Resuscitation. It is a temporary measure enabling the salvage of critically ill trauma patients with exhausted physiology (5). DCS breaks the lethal triad (hypothermia, coagulopathy, and acidosis) which facilitates aggressive resuscitation of patients on the Intensive Care Unit (ICU) with subsequent definitive repairs (6).

Most commonly DCS is utilised in the form of Damage Control Laparotomy (DCL) and Damage Control Orthopaedics (DCO). During DCL, haemorrhage control is achieved by either ligation or intraluminal shunt for the arterial bleeding (5). Venous bleeding is managed largely by packing. This is then followed by limitation of gastrointestinal contamination by limited resection with stapling of the segments which are the source of contamination (7). Pancreatic and biliary injuries are managed by exteriorisation; bleeding spleen or kidney should be removed. Temporary closure of the abdomen excluding fascia helps to avoid Abdominal Compartment Syndrome (ACS).

Similarly, DCO is based on the principle of delayed definitive fixation of long bone fractures. Pape et al randomised patients into two groups, one with the primary intramedullary nailing and the other group treated by DCO (8). Both those groups of patients were treated within 24 hours of injury. He found significantly increased Interleukin 6 (IL-6) levels in the fracture nailing group with a peak at 24 hours after the injury. In contrast the DCO group had no increase in the IL-6 levels following surgery. These findings support the use of DCO in severely injured patients with high risk of Multi Organ Dysfunction Syndrome (MODS).
However, the lack of difference between the groups regarding the IL-6 levels and similar complications rate could be due to the small sample size of this study (only 35 patients recruited). Another limitation of this study was the exclusion of patients with severe injuries, which benefit most from DCO.

Intensive Care Unit

Subsequently, following the implementation of the DCO, the patient is transferred to Intensive Care Unit where the main goal is to restore severely abnormal physiology of the patient by aggressively addressing all three components of the lethal triad: hypothermia, acidosis and coagulopathy (7, 9). This ultimately enables definitive surgery without compromising the patient’s physiological status and exacerbating the inflammation cascade. On restoration of normal physiology, the patient returns to theatre for a definitive procedure, which usually takes place within 48 hours of injury.

On the other hand, there is a group of critically ill patients who are not fit for any definitive procedures beyond 48 hours. Lee and Peitzman showed that patients who return to theatre after more than 72 hours post injury have a greater mortality (5). If the temporary external-fixator has been applied following a femoral shaft fracture and a conversion to intramedullary nail is delayed, the risk of local pin site infection becomes greater. Also substantial evidence shows that delayed long bones fractures stabilisation is associated with MODS and Respiratory Complications (RC) including, Adult Respiratory Dysfunction Syndrome (ARDS), Hospital Acquired Pneumonia (HAP) and fat embolism (10, 11, 12).

Early fracture stabilisation

Johnson et al favours immediate fracture stabilisation following injury. His argument is based on the fact that patients immediately following injury are in “the best nutritional condition” and that early definitive fracture stabilisation lowers the morbidity and mortality (11). He showed that delay (more than 24 hours post injury) in a fracture stabilisation leads to a five-fold increase in ARDS incidence. But the small sample size of this retrospective study and the fact that authors included HAP in the ARDS group makes difficult to accept such conclusions. Reynolds et al replicated the above findings of the early femoral fixation (within 24 hours) regarding reduced respiratory complications (RC) and mortality in his study (13). However, when looking closer at the results it is clear that patient with Injury Severity Score (ISS) >18 had significantly increased rate of the respiratory complications. This finding indicates that the RC was primarily related to the severity of injury overall rather than the timing of fracture fixation.

This becomes particularly relevant in patients with associated head injuries (HI) when early definitive fixation of fractures can add to secondary brain injury by prolonging hypotension and hypoxia (12). In contrast some authors suggest that fracture fixation within 24 hours of injury improves outcomes in patients with associated head injuries, but some of those studies did not even provide the Glasgow Coma Scale (GCS) score on admission (12). Therefore this is a significant potential bias.

After concentrating on the larger picture of the damage control strategy for trauma patients it is essential to focus on local damage control techniques when dealing with lower limb trauma.

General principles

Severe lower limb injuries require an experienced and dedicated team of surgeons across multiple specialties (orthopaedic, plastic and vascular surgeons). Following primary survey, several general principles should be followed, including manual control of haemorrhage, general wound inspection, repeated neuro-vascular examination, limb alignment, antibiotic with Tetanus cover, photograph and sealing of the wound and X-ray of the injured limb (14). Naiques et al showed that debridement after 6 hours is not associated with an increased rate of infection in grade IIIB open Tibial fractures (15). However, small sample size could be responsible for the lack of a statistical difference between the time of the debridement and infection rate. Current guidelines state that wound debridement should be performed in theatre within 24 hours of injury by experienced Orthopaedic and Plastic sur-
geons (14). Therefore, previous dogma of the debridement (within 6hrs of the injury) is limited to few clinical scenarios, including soil/marine contamination, or limb ischaemia with/without compartment syndrome (14).

Debridement and lavage

In theatre, adequate debridement and lavage are crucial, because if performed inappropriately they will impact on the patient’s subsequent treatment options. Irrespective of the wound size careful assessment from superficial to deep tissues is essential and all non viable tissues have to be excised. Controversy surrounds the type and method of a lavage. Several animal models suggested that antibiotic irrigation reduces infection rate when compared with Normal Saline solution (16, 17). In contrast another animal model showed no benefit of antibiotic irrigation in rats (18). Anglen in his Randomised Control Trial (RCT) compared antibiotic versus soap as the irrigation solution in lower limb open fractures (19). He found that patients with antibiotic irrigation had more wound healing problems (9.5%) and higher infection rate (18%) when compared to the soap group (wound healing problems = 4% and 13% infection rate). Although this finding failed to reach statistical significance, there were few limitations which could potentially explain the differences. The group with soap irrigation included older patients and the main mechanisms of injury were falls. In contrast the antibiotic group had significantly higher energy injuries and this group also had a longer follow up. Another bias in the study was the lack of a control group with warm Normal Saline which is regarded as the solution of choice in lavage (20). Several studies proved that high pressure lavage significantly reduces the bacterial load, but at the same time is associated with significant bone damage (20). Therefore, low pressure lavage should be used which is safe and effective in reducing the infection rate (21).

Antibiotics

Interpretation of the literature regarding antibiotic use in the trauma patients is particularly challenging. There are numerous studies available, dealing with different drugs, different doses and duration of treatment. There is no doubt that broad spectrum antibiotics should be administered as soon as possible in the A/E department, because they are the most significant factor in decreasing the infection rates (14).

Soft tissue envelope

Extensive evidence supports the early use of soft tissue cover for the injured area, because it is associated with an increased rate of fracture synthesis and decreased deep infection rates, flap failures and length of hospital stay (22, 23). Gopal et al, described an innovative approach to Gustilo IIIB or IIIC fractures, which includes radical debridement and soft tissue cover with muscle flap within 72 hours (24). He recommended the preferential use of internal fixation due to a significant number of pin track infections (37%). However, this retrospective study had followed up patients up to one year only. Also this “fix and flap” approach seem to be useful in large hospitals with appropriate facilities and is not achievable in smaller centres without 24 hour dedicated teams. In cases when temporary wound cover is required, vacuum assisted closure dressing or antibiotic beads pouch (as part of the dressing), allow Plastic surgeon to plan for a definite bone cover (14). Depending on the extent of the soft tissue damage, skin grafts, local flaps or free flaps can be used. Soft tissue cover can only take place when appropriate skeletal stabilisation is achieved. External fixation is part of Damage Control Orthopaedics and is preferred when rapid stabilisation is required in open comminuted fractures, presence of severe soft tissue damage or vascular disruption. Conversion to internal fixation ideally should be achieved within 72 hours of primary debridement, but the surgeon is the one who is best placed to understand the best window of opportunity for the trauma patient to return to theatre for definitive surgery (14).

Limb salvage versus amputation

The most challenging injuries are Gustilo grade IIIC injuries, because immediate restoration of perfusion within 6 hours of ischaemia by definite or temporary shunting is essential
if optimal limb salvage is to be achieved. These complex lower limb injuries pose many deliberations.

Busse et al showed that aggressive limb reconstruction efforts may harm patients leading to prolonged hospitalisation, rehabilitation, greater costs, as well as increased sepsis (25). However, his meta-analysis is based on the results from small size studies with relatively short follow up and patients simply may have not recovered fully from these complex limb injuries. In contrast some authors support lower limb salvage procedures. For example, Dagum et al found that short form 36 (SF-36) scores favour limb salvage (26). Also Lange et al showed that patients with salvaged limb achieved greater median walking distance (27). Interestingly, MacKenzie et al found the same poor functional outcomes at 7 years from injury in both groups of patients: primary amputees' and patients with salvaged limbs (28). However, one could question the validity of such result due to the fact that scores (at 7 years) were collected over the phone only, with no clinical examination performed.

Management of the complex extremity injuries requires careful consideration as to whether and when amputation is indicated. A number of scoring systems have been developed to make an objective decision and to guide management regarding limb salvage versus primary amputation. The Gustilo classification is the most commonly used, but best applied post debridement of the wound (14). Also, inter-observer reliability of approximately 60% (ranging from 42 to 92%) has been reported (29). Other classification systems have been introduced, including Mangled Extremity Severity score (MESS), AO system and NISSA (nerve injury, ischaemia, soft tissue, skeletal injury, shock, age) and Limb Salvage Index (LSI). All these scoring systems emphasize factors which correlate with the outcome, but they all have their limitations. The most comprehensive seem to be the Ganaga Hospital Open injury score, because it addresses not only extent of concerning injury (skin/fasia, bone/joints, muskulotendinous/nerve units) but also incorporates co-morbidities and the secondary injuries (26). A score of 14 was found to be as a threshold for amputation, but the decision to amputate cannot be based solely on the scoring system. The decision must be a matter of clinical judgement based on each case, and it must always involve a consensus of the entire health care team, including the trauma, orthopaedic, vascular and plastic surgeons, rehabilitation specialist, psychologist, nurses, and most importantly the patient and family.

Swiontkowski et al looked at Gustilo grade IIIB and IIIC and found that for orthopaedics surgeons a lack of plantar sensation was the most significant factor regarding the decision to amputate, while one third of general surgeons rated an overall Injury Severity Score (ISS) as the most important factor (30). These differences could be explained by the fact that general surgeons in the long term have no follow up with such patients from the functional outcome limb point of view, whereas orthopaedics surgeons see such patients on a regular basis, which gives them a different perspective. Unfortunately, a RCT would not be possible due to obvious ethical issues- amputation versus limb salvage.

Bosse et al, proved that the absence of plantar sensation should not be an element in decision making process regarding an amputation, because more than half of the patients treated by salvage with insensate foot regained sensation at 2 years and did not report worse outcomes (31). These findings seem to be “confirmed” in day to day practice of vascular patients with insensate feet who can function exceptionally well for many years.

There is no doubt that an early amputation allows quicker recovery, shorter hospitalisation and lower costs and morbidity (25). Daugherty showed that after 28 years post injury with isolated Below Knee Amputation patients can return to normal life (32). But one could argue whether such an outcome is possible in a civilian setting at all. Firstly, because this exceptional group of patients (young and fit) participated in early walking programme and were looked after by dedicated multidisciplinary teams. These factors probably had an enormous impact on the patient’s acceptance and positive attitude to limb loss.

In contrast it’s tiring being an amputee, because the energy costs needed in walking increases with the proximal level of amputation, with bilateral limb loss and age (32,33). Older adults with above knee amputations become wheelchair dependant to some degree (28). Also many factors such as smoking, ethnicity, poor socioeconomic status impact on
poor outcomes in amputees (25, 28). Therefore, rehabilitation, educational programmes, a dedicated team of surgeons, physiotherapists and prosthetists play a crucial role in recovery and in helping amputees to re-integrate into society (33). Similarly vascular patients benefit from Artificial Limb Appliances Centre (ALAC) receiving comprehensive care.

CONCLUSIONS

Few would argue with the benefits of fracture stabilisation, but there is enough evidence to show that poorly planned and timed definitive surgery can be fatal for patients. Complex and prolonged surgery cause “second hit”, which further exacerbates an already disturbed physiology and immune system (11, 12). Trauma victims are representing critically ill group of patients and an extensive clinical network is required to provide a continuum to all phases of care. It ranges from the prehospital and in patient phases to outpatient rehabilitation and reintegration of the patient into an independent individual. It is not only physical injuries but also psychological/emotional harm that requires addressing in order to facilitate the best possible recovery. Involvement of therapists, psychologists and rehabilitation team should be incorporated into all stages of treatment even if the patient sustained an isolated lower limb injury only.

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