Damage Control Orthopaedics 2013

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Introduction

Damage control orthopaedics is an approach to musculoskeletal injury treatment and timing that recognizes the potential of surgical intervention to interfere with recovery, as well as to enhance recovery. Damage control attempts to optimize trauma outcome by matching the patient's tolerance to surgical intervention with the extent and aggressiveness of the approach. The timing and treatment of orthopaedically injured patients with long bone fractures generally consists of early total care which means operative fixation within 24 hours. It improves their outcome and decreases the complication rate. However, this approach is not always the best and actually might be harmful for patients. After injury, patients develop a hyper-inflammatory reaction which is followed by hypo-inflammatory phase. Any additional surgical insult can create additional inflammatory response. This additional insult in single injured patient generally does not lead to any additional consequences. However, in the case of a multiply injured patient, extensive surgical insults can lead to severe inflammatory changes called systemic inflammatory reaction syndrome, which ultimately leads to multiple organ failure and increased risk of death. Damage control orthopaedics emphasizes stabilization and control of injuries, along with preventing the progression of injuries.[1]

History

Before 1970, treatment for multiply injured patients consisted of observation with immobilization of fractures with splints, traction, etc., and if patients survived, then definitive fixation.[1] In the 1980s, Bone et al.[2] and Border[3] demonstrated that immediate or early fixation of fractures in multiply injured patients led to a decrease in pulmonary complications and improvement of skeletal outcomes. This brought the era of immediate total care (definitive long bone fixation within 4-6 hours) and later on, early total care (definitive fixation within 24 hours).[2] The term "damage control" came into use at first by general surgeons when they did immediate, abbreviated procedures, primarily in the abdomen, to control and prevent further progression of damage and then at a later date, definitive repair of the injuries and closure of the abdomen.[4] In the late 1990s, studies showed that in severely injured patients, an injury severity score greater than 25 was associated with higher inflammatory burden, acute lung injury, and increased mortality rate.[5] It was recognized that there are some patients who are so severely injured that they cannot tolerate long operations, blood loss, and especially medullary canal manipulation, without a significant life threatening deterioration of pulmonary function and overall homeostasis. Temporary external fixation, which is the hallmark of damage control orthopaedics, was not associated with inflammatory changes. The studies also showed that it was easy to convert external fixation to definitive fixation later on when the patient's overall condition had stabilized to the point where definitive fixation procedures could be tolerated.[5,6]

Physiology

Systemic inflammatory response, also called "first hit," after polytrauma is followed by counter inflammatory response (host defense response), which is a hypo-inflammatory reaction to counter severe inflammation.[7] Any further insult, such as extensive surgical insult, can lead to "second hit," ending with multiple organ failure and death.[7] Various parameters, such as body temperature, heart rate, white blood cell count, respiratory rate, serum lactate level at admission and lactate clearance, can help to identify whether a patient is in severe inflammatory reaction or not.[7] Damage control orthopaedics concentrates on prevention of this severe inflammatory reaction, or second hit, while simultaneously stabilizing fractures to prevent further damage.

Patient selection

Inter-service communication is an integral part of damage control orthopaedics. The trauma team in the United States consists of an anesthesiologist, an intensivist, a trauma surgeon and an orthopaedic surgeon who, with the trauma surgeon, provides major input. For long bone fractures, the trauma surgery service, with the help of the orthopaedic service, makes the decision as to whether the patient is fit to undergo definitive orthopaedic intervention or requires damage control with staged skeletal stabilization.[1]

Patients with multiple injuries can be divided into stable, unstable, or borderline patients.[8,9] Early total care is suitable for stable patients, while unstable patients benefit from damage control orthopaedics.[8,9] Patients identified as borderline by the criteria given by Pape can undergo immediate interventions, such as hemorrhage control and decompression of body cavities. If they become stable after these interventions then early total care becomes beneficial for them; otherwise, damage control should be applied.[8]

Strategies and methods for damage control orthopaedics

External fixation is a mainstay for damage control orthopaedics, as it rapidly stabilizes the fracture with minimal blood loss, minimal additional soft tissue damage, and minimal disruption of the medullary contents, leading to minimal pulmonary and systemic inflammatory reaction. It restores alignment and stability to the fractured skeleton, which allows soft tissue to rest and prevents soft tissue shortening, beneficial both immediately and subsequently at the time of definitive surgical repair. Generally, fixator pins are placed away from the zone of injury with a simple frame, providing temporary fixation which can be converted easily to definitive fixation. Procedures that reduce physiologic burdens on the trauma patient without causing increasing catabolic demands, such as debriding open wounds and treating compartment syndrome, if present, with fasciotomy, are priorities in damage control. Other methods used in damage control orthopaedics are long bone fixation with unreamed or unlocked intramedullary nails and retrograde femoral intramedullary nail fixation to achieve long bone stabilization while reducing the extensive physiological stress of standard nailing and the application of splints to more minor fractures, allowing soft tissue to rest (Tables 1 and 2) .

Inflammatory markers, elevated after injury, generally stabilize in 3 to 5 days, after which definitive surgical fixation could be considered with significant decreased risk of second hit.[10] Temporarily placed external fixators are converted to definitive fixation within 5 to 14 days. The fracture fragments can still be manipulated 14 to 21 days after injury so as to provide optimal fracture reduction.[11]

The concepts of damage control are applicable locally as well as generally. The previous comments have dealt with the patient's general condition and risk of death and treatments which impact the overall patient. Focal damage control is the recognition that the immediate condition of the local tissue may not tolerate immediate definitive operative intervention. Focal damage control suggests a staged treatment approach with immediate treatment that minimizes additional local injury and more aggressive, more definitive treatment several weeks later when the local soft tissue condition allows. One great example is the treatment of distal tibial plafond fractures where very high rates of soft tissue slough and infection often occurs after immediate plating. These commonly require free flap coverage or other extensive soft tissue reconstructions and even then a relative high rate of amputation is reported. The complications of operative treatment (amputations) are far worse than the natural history of the injury (ankle arthritis).[12]

Focal damage control principles have gained acceptance with staged treatment. On the day of injury a spanning external fixator is placed which restores length and stability to the limb without causing much additional soft tissue injury. The local soft tissue is given time to stabilize and definitive reduction and fixation is performed when swelling has resolved and the soft tissue envelope is more tolerant of surgical dissection. The same principles have been applied to calcaneus fractures, which are typically treated initially with a closed reduction and splint and a delayed open reduction internal fixation. Severe proximal tibia fractures associated with compartment syndrome, arterial injury, extensive comminution, diaphyseal extention, open wounds, or soft tissue injury are typically treated with a spanning

Table 1

Basic strategies for damage control orthopaedics

Interventions
Immediate and rapid stabilization of long bone fractures, typically with external fixation
Release of tight soft tissue compartments (compartment syndrome)
Reductions of dislocations
Surgical debridement of open wounds
Amputation, in cases of unsalvageable extremities

Table 2

Injuries in which damage control orthopaedic principles are beneficial

Injury	Comments
Bilateral femoral fractures	Early total care is associated with a high rate of adult respiratory distress syndrome (ARDS).[14]
Femur fracture in the presence of chest injury	Early total care is associated with a high rate of ARDS.[14]
Polytrauma with chest injury	Early total care is associated with a high rate of ARDS.[14]
Polytrauma with head injury	Early total care leads to secondary brain injury by decreasing mean arterial pressure and increasing intracranial pressure.[15,16]
Pelvic ring disruptions associated with potentially lethal hemorrhage	Damage control orthopaedic principles include resuscitation, application of pelvic binder or pelvic external fixation, along with angiographic embolization.[10]
Mangled extremities	Mangled extremity severity score is useful. In patients with score above 7 amputation should be considered.[13]

external fixation and delayed plating when the soft tissue envelope has recovered. In patients with fractures that are associated with a high rate of soft tissue complication, application of damage control orthopaedic principles allows the soft tissues to rest while maintaining soft tissue and bony length.[12,13]

Summary

Damage control orthopaedics is an accepted approach to musculoskeletal injury treatment and timing that recognizes the potential of surgical intervention to interfere with recovery as well as to enhance recovery. There are two types of damage control: general and local. General damage control orthopaedics avoids the early second hit phenomena and prevents worsening of systemic inflammation which can contribute to increased mortality rates in severely traumatized patients. It simultaneously stabilizes the fractures sufficiently to prevent further tissue damage without pushing patients beyond physiological tolerance limits. Focal damage control applies the same principle to local injury, typically using immediate temporary external fixation with delayed staged plating when the soft tissue envelope will tolerate an extensive surgical dissection.

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