General Surgery Approach to DC: Decision Making and Indications

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11.1 Introduction

The process by which to select the appropriate patients to undergo damage control surgery is the fundamental beginning to decision making. Classically, the indications to truncate an operation rather than proceed with primary definitive surgical care are acidosis, hypothermia, and coagulopathy (the so-called lethal triad) [1]. Rotondo and colleagues coined the term "damage control" laparotomy for exsanguinating penetrating injuries (with transfusion of greater than 10 units packed red blood cells) where a survival benefit was noted for a subset of maximally injured patients, those with major vascular and two or more visceral injuries [2]. The process of damage control surgery is divided into phases. The surgeon must maneuver the patient through these phases and constantly reevaluate the overall status.

11.2 Indications

In the severely injured patient, time is of the essence, and the primary goals of damage control are to control hemorrhage and stop contamination. This is followed by a period of time for resuscitation and restoring physiologic reserve. Patient selection comes from recognizing the severity of the mechanism of injury, the complexity of the injury pattern, and/or the presence of physiologic derangements in light of recognized patient comorbidities. It is usually a combination of multiple factors that end up necessitating the use of damage control surgery. The surgeon's attention to subtle clinical findings at the index operation may be the first sign a patient would benefit from the damage control approach. Noting that the patient feels cold, that there is no presence of clot in the surgical field, or that the bowels are becoming boggy and edematous are key intraoperative findings.

It should be noted that overuse of damage control exposes patients to the risks of multiple operations, open abdomen management, and prolonged intensive care stay thereby negating the potential benefit of the concept [3]. It is estimated that fewer than 30% of civilian trauma laparotomies benefit from the damage control approach [3]. Its overuse has been demonstrated to cause potential harm and can result in long-term morbidity [4]. The most frequent complications following an open abdomen include gastrointestinal fistulas, intra-abdominal abscesses, and ventral hernias [5]. Careful identification of the appropriate patient and refraining from the overuse of damage control surgery can avoid unnecessary complication.

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11.3 Patient Factors

Early recognition of the patient's existing comorbidities, prior surgical history, and whether they are taking any anticoagulants or antiplatelet function medications can allow for early selection of patients for damage control surgery. In addition, some patients may have low functional reserve and benefit from a truncated operation and ushering to the ICU.

11.4 Mechanism/Injury Pattern

The type of mechanism of injury can be crucial to selection of patients for damage control, and those selected will typically have blunt polytrauma, multiple penetrating torso trauma, severe contamination, and major bleeding sources in other regions. These warrant consideration for damage control surgery as they require prioritization of injuries and the severity of injury is likely to result in the lethal triad.

Early into the operative case, it is possible to identify patients who are more likely to benefit from damage control due to the degree of the injuries. Patients who require packing of complex liver injury are best served by damage control. These patients will potentially require angio-embolization prior to their next operation. Patients with multiple bowel injuries such as combined small bowel and colon injuries with segmental resection will require "planned second look." These patients may require additional bowel resection with multiple anastomoses. Similarly, patients with multiple combined and complex injuries within the abdomen such as gastric and renal or pancreas and spleen will need a damage control laparotomy. Abbreviated control of multiple complex injuries with packing or stapling and adequate drainage can be utilized to control the abdominal injuries and facilitate stabilization in order to be able to address other areas of injury.

When considering the mechanism of injury in a patient with multiple cavity or extremity injuries, it is important to keep in mind the possibility of involving multiple surgical teams to treat injuries simultaneously. Examples may include one team performing a laparotomy and packing the liver and resecting bowel, while another team obtains vascular control with a shunt in an extremity or places multiple extremity external fixation devices for complex crush injury associated with fractures. Not only considering that the patient require a damage control surgery for management of their general surgical injuries, but placing these in context with the other injuries allows for efficient management and expedited transition to the ICU for ongoing resuscitation. In these challenging cases, it is critical for the surgeon to triage the critical procedures and involve the appropriate teams.

11.5 Physiologic Derangements

Patients are actively resuscitated upon arrival, and the process extends into the operating room and intensive care unit with the goal of avoiding the lethal triad prior to its start to avoid failure of correction. Early recognition of any of the following should indicate the potential need for damage control surgery [6].

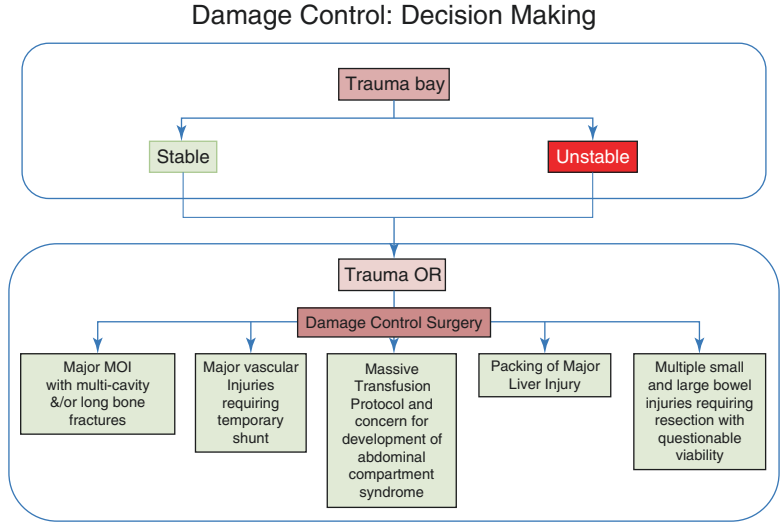
Significant bleeding requiring >10 units PRBC
Severe metabolic acidosis pH <7.20
Hypothermia temp <35.0 °C
Operative time >90 min
Coagulopathy as seen by either laboratory result or "nonsurgical" bleeding
Lactate >5 mmol/L

11.5.1 Decision Making: Considerations at the Index Operation

Trauma patients undergoing laparotomy for truncal injuries should be prepped from the chin to both thigh and bilateral posterior axillary lines to have full access to all body regions and maximize efficiency of the operation.

"Time is of the essence." Once the decision has been made to proceed with damage control surgery, the surgeon's goal should be to complete

the initial procedures within 90 min or less. The clear objectives are (1) to control hemorrhage and (2) stop or control contamination. The abdomen should be left open and a temporary abdominal closure barrier placed. These patients undergoing damage control surgery typically require a massive transfusion and are at risk for abdominal compartment syndrome. In addition, rapid return into the abdomen is occasionally required.



In addition, it is not uncommon to start a trauma laparotomy and find oneself in the midst of a very unexpected injury pattern which quickly goes from bad to worse. What may have started out as a semi-elective laparotomy turns into a fight for the patient's survival. Once must be able to quickly shift gears and move to a "damage control" mode.

11.6 Hemorrhage Control

The first step in the trauma laparotomy is performing a generous midline incision as it provides exposure to all four quadrants in the abdomen. The next step is deciding on exposure, commonly a self-retaining surgical retractor should be ready to place and retract the abdominal wall.

Hemorrhage control initially starts by exposing the bleeding. This is best done by efficiently packing the abdomen with laparotomy pads. This has the dual effect of "mopping up" and tamponading the bleeding. This maneuver allows the anesthesia team time to begin to catch up with their resuscitation. The importance of packing cannot be underestimated, as it allows for time for both the surgical team and the anesthesia team to strategize and determine if this is a patient who can now have their injuries formally addressed or dealt with in a damage control manner.

While the initial maneuver of hemorrhage control is packing, pattern recognition will guide the surgeon to the potential source of bleeding. If the patient remains profoundly hypotensive following packing, a significant source of arterial hemorrhage is likely. A well-packed liver injury that continues to bleed may have a retrocaval injury. If bleeding is coming from the mid abdomen after packing of the gutters, bleeding may be coming from the root of the mesentery. If an enlarging retroperitoneal hematoma is identified in any of the zones, a surgical bleeding is likely to be encountered. Suspicion of this type of injury may require temporary aortic occlusion with either a cross-clamp or intra-aortic balloon both of which require additional areas to be prepped and additional equipment.

Major vascular injuries should be initially controlled with Allis clamps for lateral injuries or

cross-clamps for transections. For major arterial or venous injuries, initial management may be either vessel ligation or the placement of temporary intravascular shunts in critical arteries [7]. In the context of uncontrolled hemorrhage, the subclavian vein, iliac vein, and inferior vena cava can all be ligated at the risk of development of severe limb edema. The external carotid can be ligated without consequence and the internal carotid with the risk of neurologic deficit. Ligation of the femoral artery can result in critical limb ischemia, slightly higher than the risk of ligating the subclavian artery, however both can be shunted [8].

For patients with severe liver injuries, the initial goal should be control of bleeding, as it is the uncontrollable hemorrhage which is the cause of early death and the related requirement of massive transfusion which contributes to late fatal complications [9]. A complex liver injury can be managed with a Pringle maneuver followed by supra and infrahepatic packing. The falciform ligament should be divided as not to injure the liver during packing. Pattern recognition should continue to be appreciated when the packed liver packing does not stop bleeding and appears. An arterial injury should be suspected and suture ligated must be performed if possible. A necessary consideration is the role of angiography as an adjunct for therapeutic intervention. While another option is going to angio-embolization after packing of a major liver injury, when planning on taking a patient with significant abdominal trauma for operation, placing the patient on a radiographically compatible table or in a hybrid suite can facilitate performing angiography for control of visceral or pelvic hemorrhage after the abdomen has been packed or externally fixated.

11.7 Contamination

In some circumstances the mechanism of the diffuse extent of injury can require a "second look" in order to evaluate the evolution of injuries. In high-energy injuries the extent of bowel wall injury is often not apparent at the initial operation, and a second evaluation is crucial as these injuries can result in delayed ischemia or perforation, which can threaten anastomoses and stomas. Knowing the patient will require a "second look" based on the injuries allows a switch to proceeding with damage control and foregoing a longer more definitive operation. Those necessitating "second look" consist of boggy or edematous bowel, dusky with poor perfusion without frank ischemia, and in areas of mesenteric hematomas without bowel compromise.

After resecting affected sections of bowel, the next decision point is when to perform the anastomosis and in what fashion. With regard to deciding between stapled versus handsewn, numerous studies have attempted to evaluate if one is superior to another and have yet to identify a striking difference [10]; however in difficult cases with edematous bowel, many surgeons will tend toward performing a handsewn anastomosis. A potential reason to perform a handsewn anastomosis is when there is bowel edema. There are comments in the literature stating that there still may be a difference in outcomes between the two, which has simply failed to be demonstrated by existing literature. It has been reported that handsewn anastomoses do consume significantly more time and this should be taken into account [11].

For colonic injuries, these can be primarily repaired or resected and placed back into continuity with an anastomosis. The average leak rate is 16% and from the largest study 18%. There is the suggestion that repair and anastomosis is preferable in a patient in whom there is an open abdomen. The rationale is such that while this is a "high-risk" anastomosis, with the abdomen open, the bowel can be inspected for potential complications prior to abdominal closure, and this eliminates the potential morbidity of an ostomy [12]. Another suggestion is to wait to decide whether to perform an anastomosis versus ostomy at the second operation after determining whether the patient is able to be closed [13]. The reasoning is that there is an increase in complications including anastomotic leaks when patients are not closed within 5 days. All of these factors address thinking of damage control surgery with care of bowel in isolation. This should be taken in

the context of potential confounding factors such as suspicion of tenuous blood supply or other associated injuries, such as pancreatic injury, which may place a repair or anastomosis at additional risk.

11.8 Management of the Open Abdomen

After patients have undergone correction of their physiologic derangements, they should return to surgery for definitive repair. Ideally, this first trip back to the operating room should occur within 36 h. This return to the operating room can be done in either an on-demand or scheduled fashion; however, on-demand laparotomy is associated with a reduction in re-laparotomies and negative laparotomies and may result in cost savings. In a normothermic patient, they should undergo re-laparotomy for ongoing transfusion requirement of 2 units of RBC/hour [14]. There is the potential that during this first return to the operating room, they may not be able to achieve definitive repair of their injuries or the edema is such that it is not possible to close the abdomen. Significant risk of development of abdominal compartment syndrome is a contraindication to abdominal closure, as is recurrence of physiologic derangement or ongoing contamination.

The concept remains that there must be a continual reevaluation of the status of the patient and their injuries in order to determine whether or not the patient is ready to undergo their definitive surgical therapy. When evaluating which patients were unlikely to achieve primary fascial closure during their initial hospitalization, it is patients who had higher numbers of explorations and developed intra-abdominal abscess/sepsis and blood stream infections and those who develop acute renal failure or enteric fistulas and ISS >15 [15].

As soon as physiologically possible, patients do better with abdominal closure. In keeping this in mind, it is possible to reduce the morbidity associated with damage control laparotomy. For patients closed at first take back, the overall complication rate was reduced to 47%, significantly lower than the reported 63% for all patients managed with damage control with an average of 1.66 complications per patient [16]. In addition, patients closed within 7 days of their index operation were found to have less daily pain, higher rate of return to work after injury, and higher quality of life [17].

Conclusions

When considering damage control management, it is important to continually reassess the patient's clinical status and prioritize this along with their injuries to perform focused operative interventions with the main goal of resuscitation. At each point one must ask whether the patient has ongoing physiologic derangements or are they able to move on to the next phase. It is important to recognize that this is a dynamic process, and at each branch point, the patient can return to a state of dysfunction and require ongoing damage control management.

One approach to conflicting priorities is to involve multiple teams simultaneously with each addressing a separate injury/region in order to minimize operative time/stress and more quickly address hemorrhage and contamination.

Careful consideration of the long-term outcomes aids in operative management in order to give critically injured patients the highest chance of the best possible outcome given their particular circumstance and injuries. The goal is to do what is vitally necessary up front, move to the ICU for resuscitation, then stage the definitive repairs. Minimizing the number of patients selected for damage control to only those necessary and then minimizing the number of interventions, time to anastomosis, and time to closure have improved outcomes.

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