Chapter 12

Damage Control Surgery

Introduction

The traditional approach to combat injury care is surgical exploration with definitive repair of all injuries. This approach is successful when there are a limited number of injuries. Prolonged operative times and persistent bleeding lead to the lethal triad of coagulopathy, acidosis, and hypothermia, resulting in a mortality of 90%.

> **Damage control is defined as the rapid initial control of hemorrhage and contamination, temporary closure, resuscitation to normal physiology in the ICU, and subsequent re-exploration and definitive repair. This approach reduces mortality to 50% in some civilian settings.**

- What might increase the life and limb salvage rate in troops in the field setting is the application of the damage control concepts described above in patients with favorable physiology.
- Tactical Abbreviated Surgical Control (TASC).
  - o Damage control techniques in a tactical environment.
  - o Abbreviated, focused operative interventions for peripheral vascular injuries, extensive bone and soft tissue injuries, and thoracoabdominal penetrations in patients expected to survive, instead of definitive surgery for every casualty.
  - o This may conserve precious resources, such as time, operating table space, and blood.
- This TASC philosophy relies on further definitive surgical care at the next echelon of care.

Damage control techniques should be considered in all multi-system casualties at the onset of surgical therapy. When initially rejected, reconsideration should occur when unexpected findings are discovered or natural breaks in the surgical therapy occur, following an initial decision to perform a definitive repair.

The goal of damage control is to restore normal physiology rather than normal anatomy. It is used for the multiple injured casualty with combinations of abdominal, vascular, genitourinary, neurologic, orthopedic, and/or thoracic injury in **three separate and distinct phases**:

1. **Primary Operation and Hemorrhage Control** – surgical control of hemorrhage and removal of contamination; laparotomy terminated, abdomen packed and temporary closure; definitive repair is deferred.
2. **Critical Care Considerations** – normal physiology restored in ICU by core rewarming, correction of coagulopathy, and hemodynamic normalization.
3. **Planned Reoperation** – re-exploration to complete the definitive surgical management or evacuation.

General Considerations

- Philosophy of damage control is "a live patient above all else."
  - o Avoid hypothermia.
  - o Rapidly achieve hemostasis.
  - o Perform only essential bowel resections.
  - o Close or divert all hollow viscus injuries, only performing reconstruction at the second operation after the patient has stabilized and can tolerate a prolonged operation.
- **When to employ damage control.**
  - o Use damage control in patients who are present with or at risk for developing:
    - ♦ Multiple life-threatening injuries.
    - ♦ Acidosis (pH < 7.2).
    - ♦ Hypothermia (temp < 34°C).
    - ♦ Hypotension and shock on presentation.
    - ♦ Combined hollow viscus and vascular or vascularized organ injury.
    - ♦ Coagulopathy (PT > 19 sec and/or PTT > 60 sec).

    - ♦ Mass casualty situation.
  - o Take into account ability to control hemorrhage, severity of liver injury, and associated injuries.
  - o Pack **before** massive blood loss (10–15 units of pRBCs) has occurred.
  - o Injuries that typically require damage control techniques.
    - ♦ Upper abdominal injuries that are not isolated spleen injuries (duodenal, large liver injuries, pancreas, and so forth).
    - ♦ Major penetrating pelvic trauma of more than one system.
    - ♦ Any retroperitoneal vascular injury.

To reiterate, damage control is practiced in three phases:

1. Primary operation and hemorrhage control.
2. Critical care resuscitation.
3. Planned reoperation.

Phase 1: Primary Operation and Hemorrhage Control

Phase 1 of damage control includes 5 distinct steps:

1. Control of hemorrhage.
2. Exploration to determine extent of injury.
3. Control of contamination.
4. Therapeutic packing.
5. Abdominal closure.

- Control of hemorrhage/Vascular injury repair.
  - o Control of hemorrhage is best done with ligation, shunting, or repair of injured vessels as they are encountered.
  - o The primary goal is hemorrhage control, not maintenance of blood flow.
  - o For the patient in extremis, clamping or shunting of major vessels is recommended over repair.
    - ♦ THINK: ligate/shunt ⇒ fasciotomy.
  - o Additional methods of hemorrhage control include balloon catheter tamponade of vascular or solid viscus injuries.
- Exploration to determine extent of injury.
  - o Damage control laparotomy.
    - ♦ Rapidly achieve hemostasis.

- Perform only essential resections or pack solid organs to diminish blood loss.
- Close or divert all hollow viscus injuries.
- Rapidly terminate the procedure to correct hypovolemia, hypothermia, and acidosis to prevent coagulopathy.
- Perform definitive reconstruction only after the patient has stabilized and can tolerate a prolonged operation.

- Control of Contamination.
  - Contamination control also proceeds as injuries are encountered, utilizing clamps, primary repair or resection without reanastomosis.
  - With multiple enterotomies, if the area of injury represents less than 50% of the length of the small bowel, a single resection can be undertaken.
  - At this stage of the operation, the surgeon must decide whether or not to proceed with definitive repair of the identified and controlled injuries. Careful communication with the anesthesiologist is critical to this decision.
    - If aggressive resuscitation has been successful in maintaining normal temperature, coagulation, and acid base status, then definitive repair may proceed.
    - If any of these interrelated factors are abnormal, the procedure should be terminated (contamination controlled without reanastomosis) and the patient taken to the ICU for further resuscitation.
    - The presence and status of extra-abdominal injuries needs to be taken into consideration when deciding how much physiologic reserve the patient has left.
- Therapeutic Packing.
  - Resuscitative vs Therapeutic Packing.
    - Resuscitative packing is manual compression of the bleeding site as an initial measure in controlling or minimizing blood loss.
    - Therapeutic packing provides long-term tamponade of liver, pelvic, and retroperitoneal bleeding.
  - Do not use the "pack and peek" technique wherein the liver is packed and the patient resuscitated; the packs are removed to identify the source of bleeding, but rebleeding

occurs before the site can be identified; the liver is packed again; the patient is resuscitated again; and the entire cycle is repeated.
  - Definitive therapeutic packing is based on three basic principles.
    - Pressure stops bleeding.
    - Pressure vectors should recreate tissue planes (attempt to recreate the pressure vectors created by the capsule of a solid organ or fill the space of that organ, not random pack placement).
    - Tissue viability must be preserved.
  - 6–12 laparotomy pads are the best commonly available packing material.
  - An intervening layer, such as a bowel bag, sterile drape, absorbable mesh, or omentum, can be placed between packs and the tissue to aid in easy pack removal at relaparotomy.
- Abdominal Closure.
  - Leave the fascia open.
  - Vacuum pack (preferred technique — easy, keeps patient dry, allows for expansion).
    - With fascia open, place fully plastic-covered (bowel bag, X-ray cassette bag, Ioban drape) sterile operating room (OR) towel circumferentially under the fascia to cover the viscera. Place a small number of central perforations to allow fluid to egress to the drains.
    - Place closed-suction drains (Jackson-Pratt, modified Foley, small chest tube) above the plastic at the level of the subcutaneous tissue brought out through separate stab wounds or the inferior portion of the wound.
    - Place lap sponges to fill in the wound.
    - Cover the entire wound with a large Ioban drape.
    - Place drains on low suction and secure to the skin.
  - A silastic sheet or 3-liter IV bag, sewn to the skin or fascia, can accomplish abdominal closure in virtually every instance.
  - Skin closure is not recommended, but may be quickly accomplished with skin staples, towel clips (reliably stronger), or running monofilament suture.

Skin closure may lead to abdominal compartment syndrome.

Thoracic injuries

- **The goal of abbreviated thoracotomy is to stop the bleeding and restore a survivable physiology; contamination is usually not a problem.**
- In the exsanguinating patient, formal lung resection gives way to using large staplers in a nonanatomic wedge resection to rapidly achieve hemostasis and control of air leaks.
- In pulmonary tractotomy, the lung bridging the wound tract is opened between long clamps or with a linear stapler. The tract can thus be directly inspected, bleeding points selectively ligated, and air leaks controlled.
- Vascular injuries can be treated with intraluminal shunts or Fogarty balloons to achieve distal control in inaccessible areas.
- Tracheal injury can be treated with airway control placed through the site of injury.
- Extensive bronchial repairs are not feasible in the patient in extremis; therefore, rapid resection of the affected lobe or lung would be best.
- When dealing with esophageal injury, diversion, and wide drainage, not definitive repair, is the best course of action.
- A single en masse suture closure of the chest wall is best because wound closure of skin with towel clips may result in significant blood loss from the musculature.

Phase 2: Critical Care Considerations

- Physiologic support in the post-op TASC patient is paramount to survival.
  - **Core rewarming**: warmed resuscitative fluids, blankets, ventilator air, and environment, or commercially available products such as Bair Hugger, Chill Buster.
  - **Reversal of acidosis**: appropriate/aggressive resuscitation with crystalloid, colloid, and blood products.
  - **Reversal of coagulopathy**: at many locations, only ultra-fresh whole blood is available to correct coagulopathy.
- Abdominal compartment syndrome.

- Abdominal compartment syndrome is a condition in which **increased intra-abdominal pressure adversely affects the circulation and threatens the function and viability of the viscera**.
- Measurement is performed using urinary bladder pressure (normal = zero).
  - Several methods are available for performing bladder pressure.
    - Place 100–150 cc of sterile saline in the bladder and clamp the foley.
    - Access the needle port on the catheter and attach to a pressure monitor (central venous pressure transducer).
    - Access the needle port and create a column of water via plain IV tubing held vertically or use of the pressure gauge from a lumbar puncture kit.
    - If there is no needle port, clamp the foley proximal and the distal end of regular IV tubing in the usual drainage end of the catheter until firmly in place.
  - Measurement of bladder pressure is a good variable to test and follow; however, intervention for abdominal compartment syndrome (ACS) should occur when suspected or clinically indicated.
- Occurs in abdominal trauma accompanied by visceral swelling, hematoma, or abdominal pack use.
- Physiology of abdominal compartment syndrome.
  - Cardiac output and venous return are decreased.
  - Reduction in blood flow to liver, intestines, and kidneys can result in anuria.
  - The two hemidiaphragms push upward, decreasing thoracic volume, and compliance leading to elevated peak airway pressures.
  - Central venous, pulmonary capillary wedge, and right atrial pressures increase with intra-abdominal pressure (can lead to false PA catheter pressures).
  - PO_2 is decreased due to increases in airway pressures and ventilation/perfusion abnormalities that worsen with positive end-expiratory pressure (PEEP).

Abdominal Pressure	Degree of Elevation	Clinical Effect
10–20 mm Hg	Mild	Insignificant
20–40 mm Hg	Moderate	Oliguria and organ dysfunction
>40 mm Hg	Severe	Requires immediate attention

Phase 3: Planned Reoperation

- Packs should be left in place until the patient's hemodynamics are stable and all major sites of hemorrhage have had time to clot.
- Reoperation should be scheduled when the probability of achieving definitive organ repair and complete fascial closure are highest.
- Timing must coincide with reversal of hypotension, acidosis, hypothermia, and coagulopathy. Typically occurs 24–48 hours following the primary insult when brisk diuresis, negative fluid balance, diminishing abdominal girth, and decreasing peripheral edema indicate reduction in visceral and parietal edema.
- **This surgery may occur at the next echelon of care.**
  - Stratevac should be weighed carefully because transit operative care is minimal. Surgical expertise is generally not available and transit times are often greater than 24 hours.
- Timing can, however, be dictated by other pressing clinical concerns such as abdominal compartment syndrome, limb ischemia, and suboptimal control of spillage at primary operation.
- In cases of a packed and drained duodenum, pancreas, kidney or bladder, or liver injuries with gross bowel contamination, packs should be retrieved within 36–48 hours.
- It is sometimes necessary to perform this type of operation at the bedside, as the patient's cardiopulmonary status does not allow a trip to the OR.

Conduct of Relaparotomy

- It is to be presumed that injuries were missed.
- **A complete laparotomy must be performed in search of missed injury.**

- The surgeon must exercise caution and sound judgment before performing full reconstruction of the GI tract because the patient is typically still critically ill and catabolic, making the patient less likely to heal anastomoses and even less likely to tolerate a leak or uncontrolled fistula.
- Feeding tube placement, either transabdominal or naso-enteric, should be placed at this time.
- Repacking may be re-employed if other measures fail to control hemorrhage.
- An abdominal film should be obtained to insure all packs have been removed from the abdomen. Sponge counts should be considered unreliable in this situation.

- **Unplanned Reexploration.**
  - Emergent, unplanned reexploration should be performed in any:
    - Normothermic patient with unabated bleeding (> 2 units of PRBCs/h).
    - Patient who develops severe intra-abdominal compartment syndrome.
    - Patient requiring postoperative transfusion of > 10 units of PRBCs.
    - Patient with persistent lactic acidosis.

Austere Field and Military Surgical Considerations

- Due to severe physiological insult, the typical civilian damage control patient requires 2 surgeons and 1 nurse, at a minimum, at the bedside for the first 6 hours. An example of the magnitude of the ICU problem that may be encountered is a casualty who requires a pulmonary artery catheter, 3 operations, 33 units of PRBCs, and an ICU stay of 23 days. In mass casualty scenarios, this patient would likely be triaged as expectant.

Tactical Abbreviated Surgical Control philosophy allows the surgeon to apply damage control techniques when the limitations of reserve exist outside the patient, in the tactical environment, not just to patients about to exhaust their physiological reserve (classic damage control scenario).

Summary Points

- Damage control is not a procedure of last resort. The consideration of damage control techniques should be made at the initiation of operative intervention in any multitrauma casualty and reconsidered during any case where extensive injuries are involved.
- Consider damage control in patients with severe liver injury, combined vascular and hollow viscus injuries, multiple sites of hemorrhage, diminished physiological reserve, and combinations of severe injury involving multiple organ systems (eg, CNS, orthopedic, vascular, or thoracoabdominal).
- Consider damage control early, ISS > 35, pH < 7.2, temperature < 34°C, shock, or coagulopathy.
- Avoid: hypothermia, 'pack and peek', tight abdominal closure, abdominal compartment syndrome, delayed relaparotomy for surgical bleeding, and getting stuck in a conventional thinking mode.
- Think: vascular shunts/fasciotomy, abdominal packing, external fixators, angiographic embolization (when available), temporary closure, nonanatomic resections, and missed injury.
- Plan sequence of operation in stable patients to allow for use of damage control if instability develops.