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Chapter

Damage Control in Liver Surgery

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Abstract

Damage control surgery is an old type of surgery practiced for many years to save the lives of badly injured patients. Damage control was first practiced in the American navy where a damaged vessel would receive minimal repair to keep it afloat. This translates to the field of medicine where minimal surgery is performed to save the life of a patient, and minimal action is taken to avoid major ailments, including hypothermia, acidosis, and coagulation defects during major trauma. Before World War II damage control surgery was popular, but later this type of surgery was abandoned. However, with a better understanding of the physiology of trauma and a revision of the outcome of badly injured patients, surgeons have reverted to damage control surgery, for example the packing of bleeding organs such as the liver and the controlling of sepsis, rather than taking patients to intensive care for further assessment. Damage control surgery has many benefits for badly injured patients and improves their chances of survival.

Keywords: liver trauma, perihepatic packing, acidosis, hypothermia, hypercoagulability

1. Definition of damage control

Damage control is defined as measures that are taken to minimize damage whether physical or non-physical. In emergency surgery it is the immediate action taken to stop bleeding and/or minimize sepsis, rather than taking the patient to intensive care for assessment. Damage control was first practiced in the American navy where a damaged vessel would receive minimal repair to keep it afloat.

2. History of damage control surgery

In ancient times, Greek and Roman physicians tried to use different modalities available at the time to save the lives of patients bleeding to death due to traumatic and non-traumatic causes. Millions of patients die around the world from bleeding each year. The liver packing technique, a highly effective technique to control bleeding, has been used in surgery for more than 100 years, where gauze packing is placed inside the liver wound to control the bleeding. Organ packing was used before World War II to control bleeding from liver wounds. Perihepatic packing goes back to 1908 when James Hogarth Pringle was the first surgeon to perform packing to stop massive bleeding from damaged liver at the Royal Glasgow Infirmary [1–3]. In 1913, Halstead used a rubber sheet between the gauze packs and the damaged liver tissue. After World War II, liver packing for a massively bleeding liver fell

into decline. During the war the number of trauma patients with liver injury had intrahepatic packing to stop the bleeding. Trauma surgeons reported complications due to packing such as bleeding and abscesses, and since the war packing has been banned. From 1955 onwards, Madding, Lucas, and Ledgerwood performed liver packing on their patients and achieved good results. In 1981, David Felaciano performed liver packing on his patient [3], which gave potential results. In 1983, Harlan Stone was the first surgeon to follow damage control surgery by minimizing emergency surgery on exsanguinating patients from bleeding trauma due to a coagulation system defect [4], and performed periorgan packing, terminating the surgery on those unwell patients [5–7]. With the development of surgery and a better understanding of the physiology and pathology of trauma with different multicenter studies on the outcome of hepatic trauma, trauma surgeons reverted to the practice of ancient surgeons and used packing for bleeding organs. The decision to undertake damage control surgery should be decided as early as possible before the patient succumbs to the lethal triangle of acidosis, hypercoagulability, and hypothermia. By using damage control, 5 to 65% of patients may be controlled by packing. In 1970, no patients with uncontrolled massive liver injury were being treated with packing. In 1993, Rotondo and Schwab used the term damage control for the packing of bleeding organs [8–10]. Peitzman reported good results with damage control for major liver injury. Packing followed by angioembolization has produced excellent results [11]. Asensio had excellent experience with damage control surgery and produced excellent work in this regard. From 1990 to 2000, damage control was successfully applied in the management of severe abdominal trauma.

3. Stages of damage control surgery

Damage control surgery for patients with trauma or other non-traumatic surgery goes in danger of life if complete surgery. There are indications for damage control surgery, for example absolute indications and relative indications; however, it is better not to wait for indications.

Absolute indications include the following:

1. Acidosis, where the pH is less than 7.2.

2. Deranged clotting, where the patient bleeds, prolonged prothrombin time, and activated partial thromboplastin time.

3. Hypothermia, where the patient's temperature is less than 34°C.

These indications should be prevented [12].

Relative indications

1. Major intra-abdominal bleeding, which is very difficult to control.

2. Low blood pressure, where the carotid artery is weak or not palpable, systolic blood pressure is less than 70 mmHg, and tachycardia is evident.

3. Prolongation of time to control the bleeding is over 90 min.

4. Association with extra-abdominal injury.

5. Transfusion with more than 10 units of blood.

Stage I of damage control surgery is where the patient is taken to the operating theater and undergoes minimal and necessary surgical operations [13–15]. The above three usual causes following injury are leading causes of death in patients.

Massive transfusion, acidosis, and hypothermia have been considered as significant contributors to deranged clotting and coagulation manifestations. Hypothermia is caused by keeping the abdomen open for a long time, cold intravenous fluid, and blood. Acidosis happens due to low cardiac output. Tissue hypoxia techniques may include:

1. Removing a bleeding spleen or kidney.

2. Resection of devitalized bowel injury without performing anastomosis.

3. Packing a bleeding liver/packing a bleeding area.

4. Inserting vascular shunts.

5. Leaving the abdomen opened to prevent abdominal compartment syndrome

Stage II of damage control consists of:

- Admitting the patient to the intensive care unit, where the patient should be kept on a ventilator with complete relaxation and analgesia.

- Correcting for acidosis.

- Correcting for clotting by giving fresh frozen plasma and fresh blood.

- Correcting for hypothermia by warming both the patient and the fluid.

- Preventing complications such as infection, deep vein thrombosis, and adult respiratory distress syndrome (ARDS), which may happen in the intensive care unit.

Stage III of damage control ensures that once the patient is hemodynamically stable, he or she should be taken to the operating theater again within 24–72 h where the following procedures can be performed: removal of abdominal packs, removal of devitalized tissue, anastomosis of bowel, removal of shunts and performing vascular anastomosis, performing feeding jejunostomy, and closure of the abdominal wound.

4. Complications of damage control surgery

Intra-abdominal hypertension and abdominal compartment syndrome are the main and most serious complications of abdominal damage control surgery where intra-abdominal pressure rises above the normal level, which is 12 mmHg, and where the intra-abdominal pressure rises above 20 mmHg, which will affect the arterial perfusion pressure and result in organ dysfunction or failure; the condition will be labeled as abdominal compartmental syndrome. The following vital organs will be affected: kidneys, heart, lungs, liver, and gastrointestinal system. Its incidence ranges from 14% in patients with severe abdominal trauma to 50% in

patients with severe trauma where the intra-abdominal pressure is above 12 mmHg. Perfusion of the vital organs is affected by intra-abdominal pressure (organ perfusion pressure = mean arterial pressure – intra-abdominal pressure). Once the intra-abdominal pressure is raised, perfusion to the vital organs will be decreased. The increase in intra-abdominal pressure is due to tissue edema; this edema could be bowel wall edema or edema of any intra-abdominal tissue, fluid overload by resuscitation, or capillary leakage because of inflammatory mediators released during trauma/sepsis.

5. Physiological effects of abdominal compartment syndrome

1. **Renal function**: because of the increase in intra-abdominal pressure, organ perfusion pressure will be reduced and renal blood flow will be reduced; glomerular filtration rate is reduced and urine output will decrease; the patient will suffer renal failure.

2. **Cardiac function**: increased intra-abdominal pressure will compress the vena cava and will result in reduced venous return; cardiac output will be reduced.

3. **Lungs function**: increased intra-abdominal pressure will result in reduced diaphragmatic movement, and will cause hypoventilation, increased airway pressure, and reduced lung compliance. All will end with hypoxia and hypercapnia, and because of sepsis and fluid overload will cause acute lung injury (ARDS). Prolonged lying down in the intensive care unit will be accompanied by deep vein thrombosis and can be followed by pulmonary embolism.

4. **Liver function**: hepatic blood flow will be reduced, impaired metabolism of glucose, lactate.

5. **Gastrointestinal function**: because of increased intra-abdominal pressure, bowel perfusion is reduced, and there will be bacterial translocation.

6. **Central nervous system function**: increased intra-abdominal pressure will cause a rise in intrathoracic pressure and increased central venous pressure will cause increased intracranial pressure and reduced cerebral perfusion pressure.

Forms of intra-abdominal pressure can be measured as follows:

1. Urinary bladder pressure, which is best measured by Foley's catheter.

2. Gastric pressure measured by nasogastric tube.

3. Trans-peritoneal needle connected to a monitor or manometer will detect intra-abdominal pressure.

4. Colonic pressure. Intra-abdominal hypertension is measured in grades:
   Grade I when the pressure is 12–15 mmHg.
   Grade II when the pressure is 16–20 mmHg.

Grade III when the pressure is from 21 to 25 mmHg.
Grade IV when the pressure is above 25 mmHg.
The incidence of abdominal compartment syndrome among severe trauma patients ranges from 1 to 14%.

Clinical presentation:

1. Pale-looking body color and hypotension.

2. Oliguria.

3. Breathlessness.

4. Abdominal distension.

5. Raised jugular venous pressure.

6. Peripheral edema.

Investigations:

No specific investigations, only clinical suspicion, measuring the abdominal pressure, and X-ray of the abdomen will show distension of bowel loops; a CT scan will show bowel wall edema.

Treatment of abdominal compartment syndrome:
It is better prevented than treated.

1. Urgent release of abdominal compartment tension by celiotomy.

2. Ventilator support.

3. Analgesia.

When applying damage control surgery in trauma patients, it is advisable to leave the abdomen open.

Management of open abdominal wound in cases of damage control surgery:

1. To avoid onset of compartment syndrome the abdominal wall should be left completely open or there should be partial approximation of the wound edges or skin only. If the abdomen is left completely open, the patient should be kept on a ventilator and completely paralyzed to avoid eviceration of the bowel outside the abdomen [16]. A plastic bag can be fixed to the edges of the abdomen wall with continuous stitches or skin clips like a sterile urine bag; towel clips, zipper sheath, and surgical mesh can also be used. This type of dressing allows the clinician to inspect the viscera, does not lead to increased intra-abdominal pressure, will not adhere to the bowel, and will be easier to remove. Once the patient improves and abdominal pressure is back to normal the abdominal wound can be closed. The patient may develop an incisional hernia, which can be dealt with later.

2. Intra-abdominal sepsis, because of the presence of gauzes inside the abdomen, will cause bacterial overgrowth. Major trauma may also be associated with bowel injury and contamination. Prolonged manipulation surgery and blood transfusion will also enhance bacterial overgrowth.

3. Missed organ injury like bowel injury if not recognized will result in a fistula between the bowel and the abdominal wall.

4. Bowel obstruction may be because of major surgery and gauzes left for some time. The bowel will stick at the inflammatory site and will result in bowel obstruction.

5. Hernia (abdominal wall hernia) may develop because of multiple surgeries and the abdomen being left open, resulting in weakness of the abdominal wall.

6. A longer stay in hospital or the intensive care unit may be inevitable.

7. Bile leak, collection of bile, and hemobilia may occur.

8. Vascular complications include hemorrhage, arteriovenous fistula, pseudoaneurysm and occur in 20–45% of patients with grade III to IV injury.

9. Bed sores can result from prolonged stays in the intensive care unit.

Figures 1–3 show a patient who had damage control laparotomy for intra-abdominal bleeding, where the abdomen was not closed.



Figure 1.
Patient after major abdominal trauma, where the abdomen is left open.



Figure 2.
Patient after major abdominal trauma, where the abdomen is closed with the use of a sterile plastic sheath, where we used sterile urine bag.



Figure 3.
The wound is approximated and not closed completely.

6. Benefits of damage control surgery

Damage control surgery is self-explanatory and it shows a big change in emergency surgery management. It has benefits for patient management:

1. Patients with massive uncontrolled hemorrhage can be saved from death by following the stages of damage control surgery, and the three biggest risks to patients are acidosis, hypothermia, and coagulopathy.
2. Mortality and morbidity can both be reduced.
3. A massively bleeding organ can be packed and the patient can be booked for another session of surgery where correction of acidosis, hypothermia, and coagulopathy can be performed, where the patient can be shifted to a tertiary center for surgery by a more qualified team [8].
4. Surgery can be deferred until an experienced surgeon is available, for example in places of combat.

7. Zliten Teaching Hospital's experience with damage control surgery

Zliten is a busy teaching hospital and provides medical and surgical treatment and nursing care for general and injured patients. It was heavily workloaded with injured people during the Libyan war in 2011 and is still receiving patients associated with weapon injury, in addition to other traumas such as road traffic accidents. In 1991, an 18 years-old Libyan, the first patient who had received perihepatic packing after severe liver injury grade IV, developed renal impairment, liver impairment, pleural effusion, and intestinal obstruction. He survived with major multiorgan insult and now is a medical doctor. The operative mortality of damage control is approximately 12% in Zliten hospital (**Figures 4–6**).

8. Experience of Zliten Teaching Hospital with damage control surgery

This experience was gained over a period of 27 years from 1991 to 2018. The number of patients with liver trauma is 324, with a female to male ratio of 26:298.

Most of the patients are between 20 and 40 years of age. Patient statistics are as follows:

Over 27 years, before the war, during the war, and after the war the number of patients with major liver trauma: 324.

Number of patients with perihepatic packing: 96.

Patients who survived after packing: 88.

Patients who died during packing and after packing: 8.

Patients who had the packs removed after 72 h: 76.

Patients who had repacking after 24 h: 4.

Patients who had packing removed at 48 h: 8.

Packing for non-trauma intra-abdominal bleeding: 5 patients.

Packing bleeding after hydatid liver surgery: 1 patient.

Massive bleeding postcholecystectomy with retrohepatic varices: 1 patient.

Massive bleeding after hepatic artery injury during postcholecystectomy: 1 patient.

Intragastric packing for gastropathy: 1 patient.

Intraurinary bladder packing for bleeding from prostatic tumor: 1 patient.

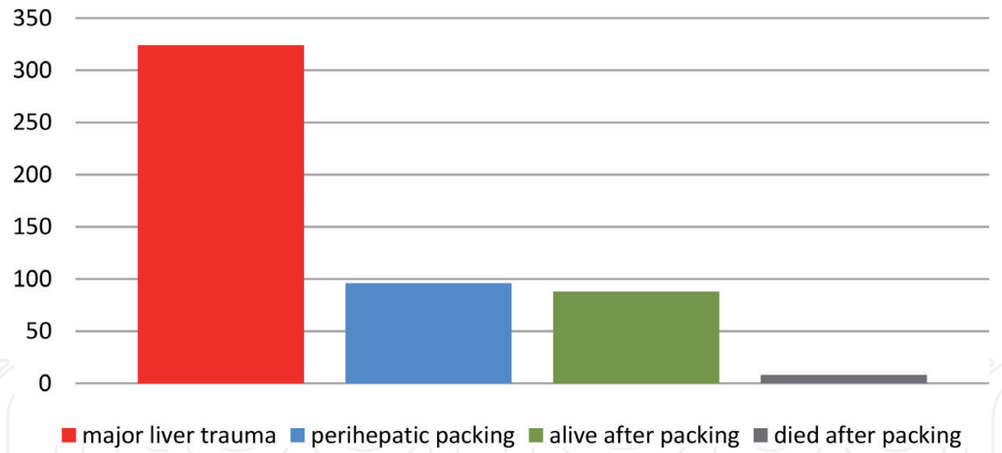


Figure 4.
Diagram showing major liver trauma at Zliten Teaching Hospital over a period of 27 years.

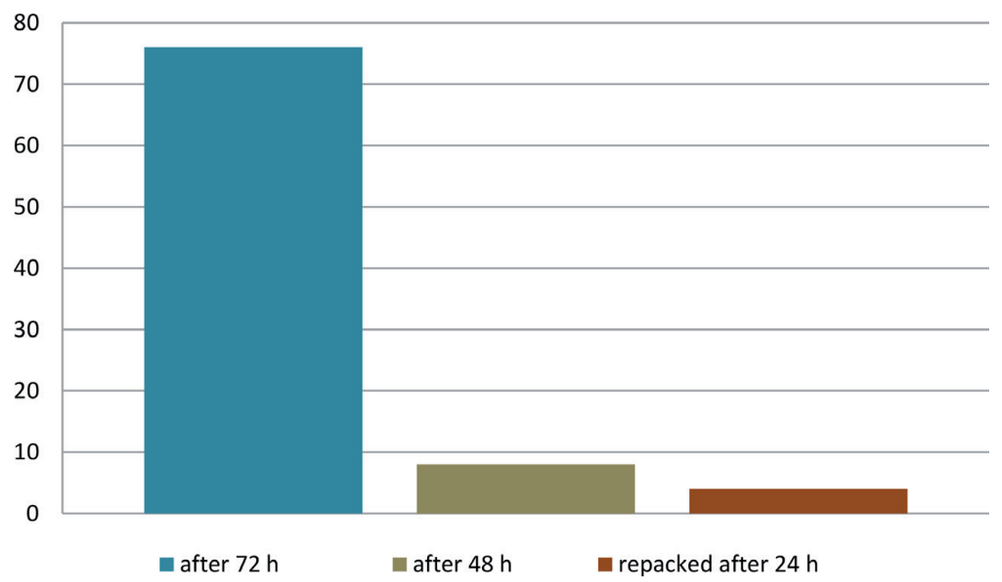


Figure 5.
Removal of the packs.

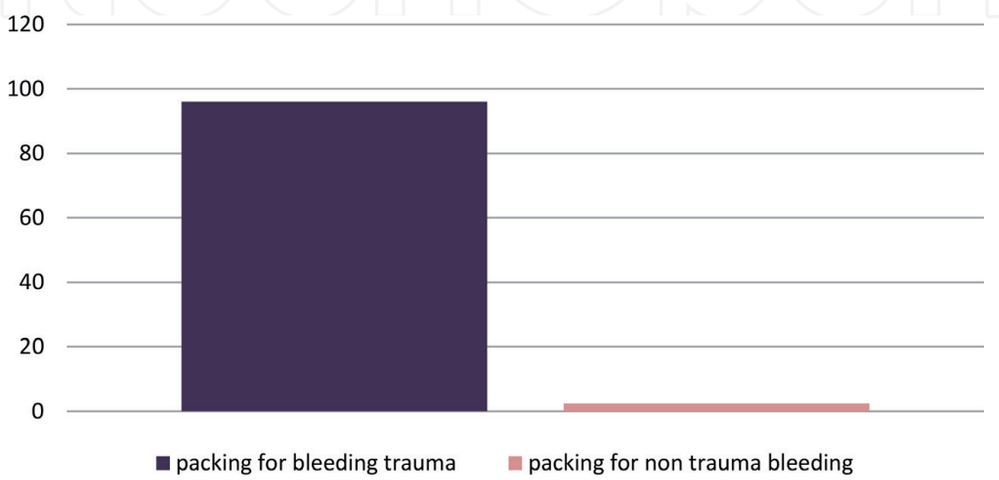


Figure 6.
Packing for trauma and non trauma intra-abdominal bleeding.

Complications after damage control surgery noticed among patients:

1. Bile leak: 4 patients stopped by themselves.
2. Wound dehiscence: 3 patients.
3. Bowel obstruction: 2 patients.
4. Postoperative jaundice: 3 patients due to massive transfusion.
5. Renal impairment: 1 patient.
6. Intra-abdominal abscess: 1 patient.
7. Intra-abdominal compartment syndrome: 4 patients.

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