Damage control for torso trauma

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In the late 1980s, high-powered weaponry and multiple trajectories became common causes of injury in urban American trauma centres. Definitive injury repair often took many hours. Although surgery was technically successful, these patients often died of a lethal triad of hypothermia, acidosis and coagulopathy.

American trauma surgeons developed a concept where only immediately life-threatening injuries were repaired at the time of initial operation. Other injuries were temporized and repaired definitively when the patient was more stable. A number of terms existed until 1993 when Rotondo et al coined the term 'damage control' (*Table 1*) (Talbert et al, 1992; Carrillo et al, 1993; Rotondo et al, 1993, Shaprio et al, 2000).

The principles of damage control are depicted in *Table 2*. Damage control can be divided into five phases. A rapid initial resuscitation and evaluation should be followed by immediate transfer to the operating room. These patients present with multi-cavitary injury and are in extremis. Rapid airway control is essential. Chest tubes should be inserted for clinical indications. Large bore intravenous access is essential and blood transfusion should be started. Hypothermia must be anticipated and avoided.

TABLE 1.
Damage control

Abbreviated laparotomy
Staged laparotomy
Planned re-laparotomy for trauma
Bail-out surgery

TABLE 2.
Principles of damage control

Only blood loss kills early
Gastrointestinal injuries cause problems much later
Everything takes longer than you think
It is easy to miss an injury if you rush
Hypothermia, acidosis and coagulopathy only lead to more of the same
The best place for a sick person is in the intensive care unit

Radiographic evaluation should be kept to a minimum. In blunt trauma X-rays of the chest and pelvis suffice. In penetrating injury, anteroposterior films can identify missile trajectory. The abdomen should be rapidly evaluated with the use of directed ultrasound or percutaneous peritoneal lavage. This should take less than 15 minutes. Depth of shock can be estimated by an arterial blood gas, noting pH and base deficit. Initial base deficit correlates with transfusion and resource needs, as well as with hospital mortality (Rutherford et al, 1992; Davis et al, 1996).

The combination of injury anatomy and patient physiology allows for good patient selection. For instance, bi-cavitary injury (thorax and abdomen) and certain injury constellations (head of the pancreas, or major vascular injury and gastrointestinal injury) should prompt damage control. Patients who are physiologically unstable are good candidates for damage control. Finally, those with hypothermia, acidosis or non-mechanical bleeding should undergo damage control.

Full operative exposure is absolutely necessary to make wise decisions. Medial visceral rotation from the right, left or both sides most often provides the best exposure (Scalea and Rodriguez, 2001). During the initial damage control laparotomy, named vascular bleeding must be controlled. The rest should be packed. Gastrointestinal (GI) contamination should be controlled and attempts made to get the patient out of the operating room as quickly as possible. Adjunctive haemostasis with angioembolization can be helpful postoperatively.

One must anticipate the need for rapid infusion systems and/or the cell saver and have them set up when the patient reaches the operating room. If postoperative angiography is needed, the angiography team must be notified early. The need for component therapy (platelets and plasma) should be anticipated and available early.

Expendable solid organs (the spleen) should be resected. Essential organs (the liver) should be debrided. Mesenteric bleeding should be controlled and all other bleeding packed. GI injuries should be controlled by simple resection. GI continuity should not be restored.

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Major vascular injuries must be dealt with. Simple repair, if possible, is preferred. If not, ligation is an option if it will not produce critical ischaemia. Vessels that cannot be ligated often can be shunted. Size match is important: larger blood vessels (the aorta or iliac arteries) can be shunted using a chest tube of appropriate size, and small vessels (the superior mesenteric artery) can be shunted with a piece of intravenous tubing (Henry, 2002). The auto anticoagulation makes shunt thrombosis very unlikely. Retroperitoneal venous injury can be controlled using intestinal Allis clamps (*Figures 1–3*). This provides rapid haemostasis and allows decision making about whether repair or ligation will be wisest (Henry et al, 2001).

Control of bleeding at the junction of the splenic and superior mesenteric junction is often difficult. Dividing the pancreas with a stapler provides good access to that area. Pancreatic reconstruction can be accomplished later.

Mortality is increased if damage control is used after attempts at definitive care (Hirshberg et al, 1994; Henry et al, 2001); therefore it should be considered early. Mortality is also increased if emergency reoperation is necessary after attempts of damage control (Burch et al, 1992). Thus, adequate haemostasis must be established.

Skin closure with running suture and towel clip is rapid. The 'Bogota bag' can be constructed by splitting a 3-litre saline bag and using it as a fascial bridge. The authors' preference has been to use a layered vacuum closure constructed out of a plastic drape with holes cut in it, a damp towel, rolls of damp gauze, nasogastric tubes and an occlusive dressing (*Figure 4*). This is inexpensive, achieves rapid closure and the drainage is quantified.

In the intensive care unit, initial attempts should be made to achieve normothermia and correct coagulopathy. Resuscitation will often require placement of invasive monitors to determine invasively derived oxygen transport parameters. The goal is to clear lactate to normal levels (Abramson et al, 1993) (*Figure 5*).

Intra-abdominal hypertension is a devastating postoperative complication after primary fascial closure or closure with suture or towel clips (*Table 3*). Intra-abdominal pressure can be established by measuring bladder pressure. Pressures over 25 mmHg should prompt decompression.

When patients are stable, they may be returned to the operating room and unpacked. A careful search for missed injuries is important. The GI tract can be reconstructed and a stoma created if

Figure 1. Initial temporary venous control.

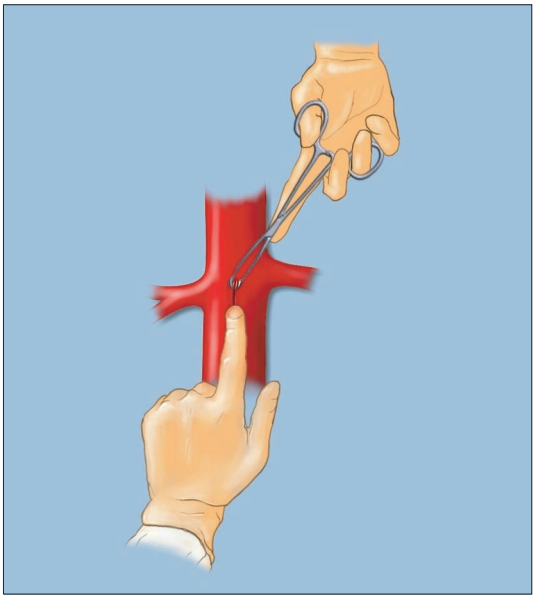


Figure 2. Temporary venous control.

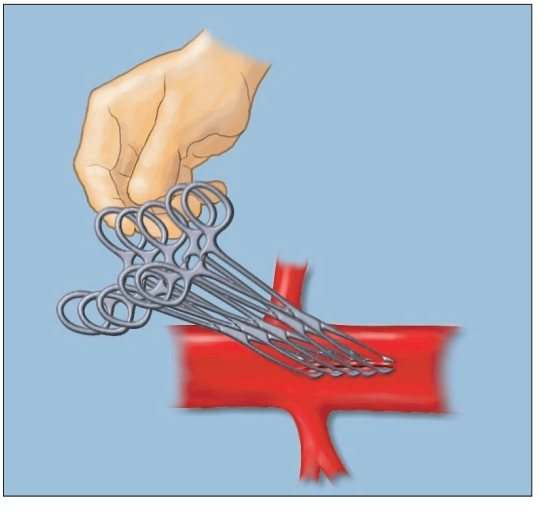
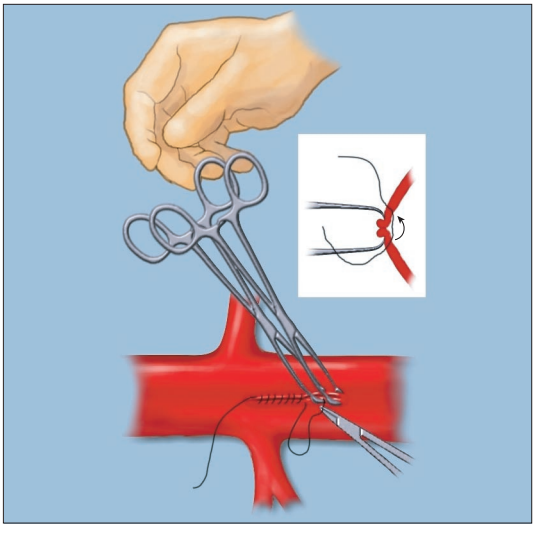


Figure 3. Completion of venous control.



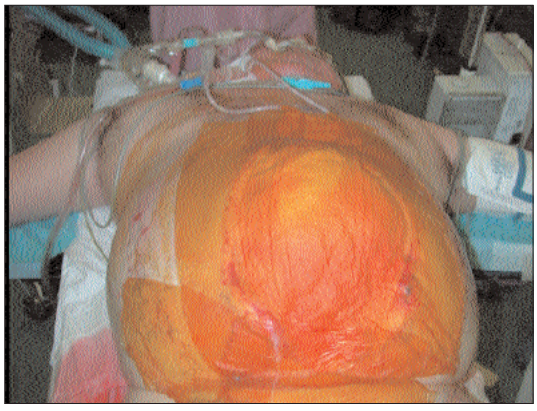


Figure 4. Temporary vacuum dressing.

necessary. Injuries to the liver and pancreas can be drained and a feeding tube placed. As counts are notoriously inaccurate, full imaging of the abdomen is important to assure all laparotomy packs have been removed. The numerous closure options are listed in *Table 3*. It is virtually never possible to close primarily. If complex acute reconstructive options fail, options will be limited later. The authors generally prefer Vicryl mesh and skin grafting.

TABLE 3. Closure options

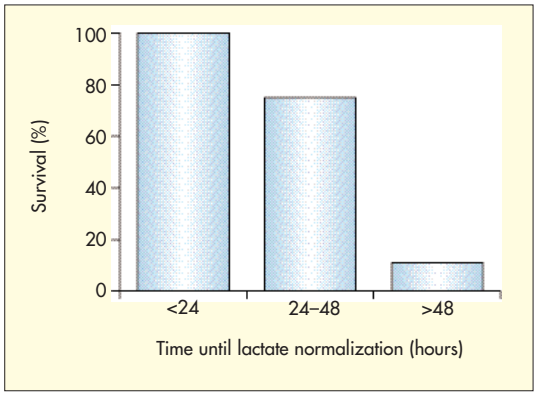
Close primarily
Close the skin
Acute lateral releases
Vicryl mesh to split thickness of skin graft
Gortex
Whittman patch

After 4–6 months, patients are good candidates for final abdominal wall reconstruction. Patients should be nutritionally competent (prealbumin above 15 g/litre. Virtually all patients are reconstructable by some combination of lateral component separation and/or prosthetic material. If GI reconstruction is needed, the authors' preference is to use Alloderm (Lifecell Corporation, Branchburg, NJ) as the fascial substitute.

These principles initially described for use in the abdomen are now used in a wide variety of clinical scenarios such as emergency general surgery, vascular or thoracic surgery. Several years ago their use was described in severe bony injury, coining the term 'damage control orthopedics' (Henry et al, 1997; Scalea et al, 2000).

Damage control is a philosophy of care that modifies the use of standard principals and techniques. Rapid evaluation is followed by control of major vascular injuries and contamination. Other bleeding is controlled with packing. Adjunctive haemostasis via angiographic embolization can be helpful followed by secondary resuscitation. Early reconstruction is followed by later reconstruction in approximately 6 months. HM

Figure 5. Survival vs lactate clearance.



KEY POINTS

- Damage control is applicable for the most critically injured patients.
- A combination of injury anatomy and patient physiology should be used to select patients for damage control.
- Emergency department evaluation should be geared only to identify the body region in which the patient is exsanguinating.
- The goal of damage control laparotomy is to arrest haemorrhage and to control contamination. Non-surgical bleeding should be controlled by packing.
- Secondary resuscitation is best performed in the intensive care unit with attention to reversing coagulation, achieving normothermia and tailoring resuscitation to specific endpoints.
- Ongoing bleeding or development of intra-abdominal hypertension requires immediate re-exploration.
- Early reconstruction can be accomplished when the patient is stable. Complex early reconstructive procedures should be avoided.
- Final reconstruction can be ideally accomplished at 4–6 months postinjury.

Conflict of interest: none

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