Abdominal Injury

- Patients who have suffered abdominal trauma can generally be classified into the following categories based on their physiological condition after initial resuscitation:
  - **haemodynamically 'normal'** – investigation can be completed before treatment is planned;
  - **haemodynamically 'stable'** – investigation is more limited. It is aimed at establishing whether the patient can be managed non-operatively, whether angioembolisation can be used or whether surgery is required;
  - **haemodynamically 'unstable'** – investigations need to be suspended as immediate surgical correction of the bleeding is required.

- A trauma laparotomy is the final step in the pathway to delineate intra-abdominal injury.
- The patient's physiology must be assessed at regular intervals and, if there is an indication that the patient is still actively bleeding, then the source must be identified, unless the patient is unstable, requiring immediate surgery.
- Examination in unstable patients should take place either in the ED or in the operating theatre if the patient is deteriorating rapidly.

Investigations

- Investigations are driven by the cardiovascular status of the patient.
- **Focused abdominal sonar for trauma (FAST)** is a technique whereby ultrasound (sonar) imaging is used to assess the torso for the presence of free fluid, either in the abdominal cavity, and is extended into the thoracic cavities and pericardium (eFAST).

- eFAST is accurate at detecting >100 mL of free blood; however, it is very operator dependent and, especially if the patient is very obese or the bowel is full of gas, it may be unreliable.
- Hollow viscus injury and solid organ injury are difficult to diagnose, even in experienced hands, as small amounts of gas or fluid are difficult to assess, and eFAST a low sensitivity (29–35%) for organ injury without haemoperitoneum.
- eFAST is also unreliable for excluding injury in penetrating trauma.
- If there is doubt, the eFAST examination can be repeated.

- **Diagnostic peritoneal lavage (DPL)** is a test used to assess the presence of blood or contaminants in the abdomen.
- DPL is especially useful in the hypotensive, unstable patient with multiple injuries as a means of excluding intra-abdominal bleeding.
- **CT** has become the 'gold standard' for the intra-abdominal diagnosis of injury in the stable patient.
- The scan can be performed using intravenous contrast.
- CT is sensitive for blood and individual organ injury, as well as for retroperitoneal injury.
- An entirely normal abdominal CT is usually sufficient to exclude intraperitoneal injury.

- The following points are important when performing CT:
  - it remains an inappropriate investigation for unstable patients;
  - if duodenal injury is suspected from the mechanism of injury, oral contrast may be helpful;
  - if rectal and distal colonic injury is suspected in the absence of blood on rectal examination, rectal contrast may be helpful.
- **Laparoscopy or thoracoscopy** may be a valuable screening investigation in stable patients with penetrating trauma, to detect or exclude peritoneal penetration and/or diaphragmatic injury.
- In most institutions, evidence of penetration requires a laparotomy to evaluate organ injury, as it is difficult to exclude all intra-abdominal injuries laparoscopically.
- When used in this role laparoscopy reduces the non-therapeutic laparotomy rate.

Individual Organ Injury

Liver

- Blunt liver trauma occurs as a result of direct injury.
- Penetrating trauma to the liver is relatively common.
- Not all penetrating wounds require operative management and may stop bleeding spontaneously.
- In the stable patient, CT is the investigation of choice. It provides information on the liver injury itself, as well as on injuries to the adjoining major vascular and biliary structures.

- Liver injury can be graded and managed using the American Association for the Surgery of Trauma (AAST) Organ Injury Scale (OIS).
- The operative management of liver injuries can be summarized as ‘the four Ps’:
  - push;
  - Pringle;
  - plug;
  - pack.
- At laparotomy the liver is reconstituted and bleeding is controlled by direct bimanual compression to achieve its normal architecture as best as possible (push).
- The inflow from the portal triad is controlled by a Pringle’s manoeuvre, with direct compression of the portal triad, either digitally or using a soft clamp.

- Any holes due to penetrating injury can be plugged directly using silicone tubing or a Sengstaken Blakemore tube, and, after controlling any arterial bleeding, the liver can then be packed.
- Bleeding points should be controlled locally when possible, and such patients if required, subsequently undergo subsequent angioembolisation.
- A closed suction drainage system must be left *in situ* following hepatic surgery.
- Finally, the liver can be definitively packed, restoring the anatomy as closely as possible.
- Placing omentum into cracks in the liver is not recommended.

Biliary injuries

- Isolated traumatic biliary injuries are rare and occur mainly from penetrating trauma, often in association with injuries to other structures that lie in close proximity.
- The common bile duct can be repaired over a T-tube or drained and referred to appropriate care as part of damage control, or even ligated.

Spleen

- Splenic injury occurs from direct blunt trauma.
- Most isolated splenic injuries, especially in children, can be managed non-operatively.
- However, in adults, especially in the presence of other injury or physiological instability, laparotomy should be considered.
- Splenectomy may be a safer option, especially in the unstable patient with multiple potential sites of bleeding.
- In certain situations, selective angioembolisation of the spleen can play a role.
- Following splenectomy the platelet and white count rise and may mimic sepsis.
- Innoculation against *Pneumococcus* is advisable within 2–3 weeks, by which time the patient's immune system has recovered.

Pancreas

- Most pancreatic injury occurs as a result of blunt trauma.
- The major problem is that of diagnosis, because the pancreas is a retroperitoneal organ.
- CT remains the mainstay of accurate diagnosis.
- In penetrating trauma, injury may only be detected during laparotomy.
- Classically the pancreas should be treated with conservative surgery and closed suction drainage.
- Injuries are treated according to the OIS system of the AAST.

Stomach

- Most stomach injuries are caused by penetrating trauma.
- Blood presence is diagnostic if found in the nasogastric tube, in the absence of bleeding from other sources.
- Surgical repair is required but great care must be taken to examine the stomach fully, as an injury to the front of the stomach can be expected to have an ‘exit’ wound elsewhere on the organ.

Duodenum

- Duodenal injury is frequently associated with injuries to the adjoining pancreas.
- Like the pancreas, the duodenum lies retroperitoneally and so injuries are hidden discovered late or at laparotomy performed for other reasons.
- CT is the diagnostic modality of choice.
- The only sign may be gas or a fluid collection in the periduodenal tissue, and leakage of oral contrast, administration of which may improve accuracy of diagnosis.
- Smaller injuries can be repaired primarily.
- Major trauma, especially if the head of the pancreas is simultaneously injured, should be treated as part of a damage control procedure and be referred for definitive care.

Small bowel

- The small bowel is frequently injured as a result of blunt trauma.
- The individual loops may be trapped, causing high-pressure rupture of a loop or tearing of the mesentery.
- Penetrating trauma is also a common cause of injury.
- Small bowel injuries need urgent repair.
- Haemorrhage control takes priority and these wounds can be temporarily controlled with simple sutures.

- In blunt trauma with mesenteric vessel damage, the bowel ischaemia that results will dictate the extent of a resection.
- Resections should be carefully planned to limit the loss of viable small bowel, but should be weighed against an excessive number of repairs or anastomoses.
- Haematomas in the small bowel mesenteric border need to be explored to rule out perforation.

Colon

- Injuries to the colon from blunt injury are relatively infrequent, and are more frequently a penetrating injury.
- If relatively little contamination is present and the viability is satisfactory, such wounds can be repaired primarily.
- If, however, there is extensive contamination, the patient is physiologically unstable or the bowel is of doubtful viability, then the bowel can be closed off (‘clip and drop’).
- A defunctioning colostomy can be formed later or the bowel reanastomosed once the patient is stable.

Rectum

- Only 5% of colon injuries involve the rectum.
- These are generally from a penetrating injury, although occasionally the rectum may be damaged following fracture of the pelvis.
- Digital rectal examination will reveal the presence of blood, which is evidence of intestinal or rectal injury.
- These injuries are often associated with bladder and proximal urethral injury.
- With intraperitoneal injuries, the rectum is managed as for colonic injuries.
- Full-thickness extraperitoneal rectal injuries should be managed with either a diverting end-colostomy and closure of the distal end (Hartmann's procedure) or a loop colostomy.
- Presacral drainage is no longer used.

Renal and urological tract injury

- In the stable patient, CT scanning with contrast is the investigation of choice.
- For assessment of bladder injury a cystogram should be performed.
- Generally, renal injury is managed non-operatively unless the patient is unstable.
- The kidney can be angioembolised if required.
- Ureteric injury is rare and is generally due to penetrating trauma.
- Most ureters can be repaired or diverted if necessary, or may even be ligated as part of Damage control procedures.

- Intraperitoneal rupture of the bladder, usually from direct blunt injury, will require surgical repair.
- Extraperitoneal rupture is usually associated with a fracture of the pelvis and will heal with adequate urine drainage via the transurethral route.
- Suprapubic drainage is reserved for when this is not possible.

Retroperitoneum

- Injury to the retroperitoneum is often difficult to diagnose, especially in the presence of other injury, when the signs may be masked.
- Diagnostic tests (such as ultrasound and DPL) may be negative.
- The best diagnostic modality is CT, but this requires a physiologically stable patient.
- In penetrating trauma, every injury should be explored for damage to structures along the wound track (e.g. ureter), unless preoperative investigation allows non-surgical management of the injury.tient.

- The retroperitoneum is divided into three zones for the purposes of intraoperative management: In blunt trauma:
  - Zone 1 (central): central haematomas should always be explored, once proximal and distal vascular control has been obtained.
  - Zone 2 (lateral): lateral haematomas should only be explored if they are expanding or pulsatile. They are usually renal in origin and can be managed non-operatively, though they may sometimes require angioembolisation.
  - Zone 3 (pelvic): as with zone 2, these should only be explored if they are expanding or pulsatile. Pelvic haematomas are exceptionally difficult to control and, whenever possible, should not be opened; they are best controlled with compression or extraperitonea packing, and if the bleeding is arterial in origin, with angioembolisation.