

# 55 Abdominal injury

## 55.1 Introduction & anatomy

The abdominal organs can be injured by penetration by a sharp object (e.g. knife or bullet), or a blow from a blunt instrument. As Hippocrates knew, the bowel can be ruptured, even if there is no visible mark on the abdominal wall.

Bleeding into the peritoneal cavity, especially from splenic or hepatic rupture, or leakage of intestinal content may be fatal.

Your main tasks will be: (1) to diagnose when a patient has a serious abdominal injury, (2) to stop the bleeding, and (3) to repair a bowel injury.

Your primary goal is not to make a clear-cut diagnosis pre-operatively, but rather to establish promptly whether serious abdominal injury is present. *Always have a very high index of suspicion.*

If your patient has one serious injury, he has a 50% chance of having at least another severe injury, which will need treatment too, perhaps simultaneously, so assume there is an abdominal injury until you are certain otherwise.

Blunt injuries are particularly difficult:

- (1) There may be no clear history of abdominal trauma, especially in a frightened child. The injury may initially be so mild that you have to take a very carefully history and make meticulous frequent examinations of the abdomen. The victim may even walk into hospital.
- (2) Other more obvious injuries, such as a fractured femur, may distract your attention.
- (3) The victim may be drunk, or unconscious from a head injury and unable to describe the symptoms. If you anaesthetize him to treat the other injuries, he cannot complain of increasing abdominal pain.
- (4) For the first few hrs after a blunt injury, the abdomen may be deceptively normal. Although a haemoperitoneum usually causes pain, tenderness, guarding, and absent bowel sounds, these symptoms and signs may be absent, especially early on, in children and the elderly.
- (5) Distinguishing between muscle pain and peritoneal irritation may be very hard.
- (6) Some injuries may not present for several days, especially a subcapsular splenic haematoma, or a retroperitoneal injury of the pancreas or duodenum.

Blunt abdominal injuries arise in road traffic crashes, falls from a height (especially in children), assaults, wild animal attacks, sports, farm or industrial accidents, natural disasters, and in blast injuries following explosions.

(Special features of penetrating injuries are specifically dealt with in 55.3)

For all these reasons, abdominal injuries need clinical judgment, care, and skill. So, be vigilant and suspicious. *You will need a watchful eye, a light touch, and a sympathetic ear. Don't let a patient go home if there is even a slight possibility that there might be an injury to the abdomen.* If you are in any doubt, observe carefully and use the special methods described below. They will be particularly useful if there is also a head injury, and may indeed be life-saving.

The decision to operate will be much more difficult if you have already administered an anaesthetic. If someone needs a laparotomy, *do it early.*

### A CLOSED ABDOMINAL INJURY CAN EXIST WITHOUT ANY EXTERNAL SIGNS

#### ANATOMICAL ZONES

To identify & localize an abdominal injury, you must get well acquainted with anatomical surface markings of the abdomen, as well as the internal spaces (10-3).

Divide the abdomen into 2 regions:

- (1) external - anterior abdomen, flanks and back,
- (2) internal - peritoneal cavity (upper and lower), retroperitoneal space and pelvis (55-1).

**(a) The anterior abdomen** extends from the trans-nipple line superiorly, inguinal ligaments and symphysis pubis inferiorly, & anterior axillary lines laterally.

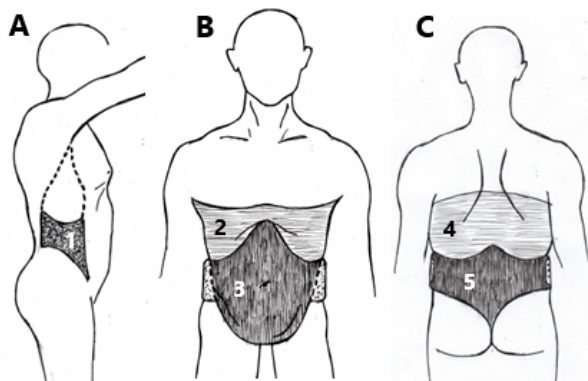
**(b) The flank** lies between anterior and posterior axillary lines, from the 6<sup>th</sup> intercostal space to the iliac crest.

**(c) The back** lies posterior to the posterior axillary lines, from the tip of the scapulae to the iliac crests.

*CAUTION! It is essential that your abdominal assessment should always include concealed areas such as flanks and back so that you don't miss potentially life-threatening injuries in these areas.*

**(d) The upper peritoneal cavity** (otherwise known as the intra-thoracic abdomen) is covered by the lower aspect of the bony thorax, & includes the diaphragm, liver, spleen, stomach, and transverse colon. *But note that a pathologically enlarged liver or spleen extends beyond the protection of the thoracic cage and is more prone to injury!*

## EXTERNAL ABDOMINAL ANATOMY



**Fig. 55-1 EXTERNAL ABDOMINAL ANATOMY:** A, flank (1). B, anterior thoraco-abdominal area (2) & anterior abdomen (3). C, posterior thoraco-abdominal area (4), back (5). After Legome E, Shockley LW. *Trauma: a comprehensive emergency medicine approach*, CUP 2011 with kind permission.

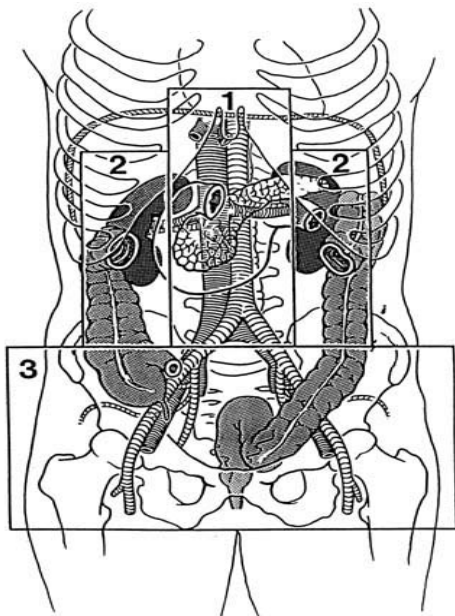
*N.B.* In full expiration, the diaphragm rises to the level to the 5<sup>th</sup> intercostal space, making the viscera susceptible to damage especially from an object which penetrates the chest and the diaphragm (i.e. a thoraco-abdominal injury).

*N.B.* If there are lower rib fractures, you must always suspect injury to the liver or spleen.

**(e) The lower peritoneal cavity** contains the small bowel, ascending and descending colon, and the female Fallopian tubes.

**(f) The pelvic cavity** contains the rectum, urinary bladder, male prostate, iliac vessels, and the female uterus & vagina.

## ZONES IN THE RETROPERITONEAL SPACE



**Fig. 55-2 THE RETROPERITONEAL SPACE**, divided into 3 zones: 1, Central zone I: explore all supracolic haematomas, but only infracolic haematomas in penetrating injury or if expanding in blunt injury. 2, Lateral zones: *don't explore*. 3, Pelvic zone III: *don't explore*. After Tomado de Sheldon GF, Blaisdell WF, Trunkey DD; *Abdominal trauma*, Thieme, New York, 1982 with kind permission.

**(g) The retroperitoneal space** contains the abdominal aorta, inferior vena cava, most of the duodenum, pancreas, kidneys, ureters, and posterior aspects of the ascending and descending colon.

*CAUTION!* Injuries to retroperitoneal viscera are difficult to recognize because of limited access by ultrasound, diagnostic peritoneal lavage (DPL) & even at laparotomy.

Divide the retroperitoneal space further when you have to consider exploring a haematoma subdivided into 3 imaginary zones (55-2).

MURAV ULAL (40) was a sailor who fell on to a crate. In the casualty department, no injuries were found and his blood pressure was normal. However, the casualty officer was worried about the possibility of an abdominal injury, because there was an abrasion on the epigastrium, so she admitted him. When the registrar saw him in the ward 30mins later, the patient was severely shocked. Urgent laparotomy revealed a ruptured spleen.

MOHAN (25) had been kicked in the abdomen during a fight. His abdomen was bruised and the skin damaged, but he did not look as if he had been seriously injured. The medical assistant who saw him gave him aspirin and sent him home. Three days later he was admitted with severe peritonitis. At laparotomy, much pus and intestinal content were washed out of the abdomen, but he died soon afterwards.

LESSONS (1) Any abdominal abrasion after a blunt injury should make you suspect an internal injury. (2) A young adult can maintain his blood pressure for some hrs after an injury, and it may even rise (because of pain) before it falls catastrophically.

## INJURY PATTERNS

Get an idea of how the injuries occurred. This will provide you with a critical insight into the level of energy transfer and gauge the likelihood of underlying tissue damage. You will then be able to recognize patterns of injury and be forewarned of likely organ damage.

Falls from a height, particularly in children and especially road traffic crashes, account for most blunt injuries of the abdomen and pelvis.

Motorcycle injuries are also very common, affecting principally the lower leg and forearm, thorax and spine. Such wounds may be severely contaminated.

Typical patterns of collisions are frontal, lateral, rear, rotational and rollover. Rear impact is associated with less chance of abdominal trauma, especially if the victim is properly restrained. In rollover, there is a high chance of lethal injury.

Visceral disruption often occurs in rapid deceleration, which is frequent in road crashes.

A shearing injury occurs where internal organs are fixed, for example at the renal pedicles, or in intimal vessels with subsequent organ infarction of liver, kidneys, spleen, or small and large intestine.

Crushing injury occurs between the anterior abdominal wall and the vertebral column or the posterior thoracic cage. Solid organs (liver, spleen or kidneys) are more susceptible to this type of injury.

Compression injury may result from a direct blow or external compression from a fixed object such as a seat belt, or after a fall. This may cause lacerations and subcapsular haematomas in solid visceral organs, or rupture to hollow organs such as bowel.

*N.B.* Whereas, undoubtedly seatbelts and child seats have reduced mortality by preventing much head and maxillofacial injuries, their incorrect use or poor design leads to a specific pattern of injury to the lower thoracic cage, lumbar spine, liver, spleen, or mesentery. Loosely fitted lap belts may lead to pelvic and urinary bladder trauma, or even abdominal aortic dissection.

**CAUTION!** Always look for bruising from the seat belt, as this implies a significant underlying intra-abdominal injury.

Blast injury affects principally air-containing organs (lungs & intestines), but also the brain. They are much worse in underwater blasts, because water is relatively incompressible, and so transmits the pressure of the shock wave rather than absorbing it as air does.

Penetrating injuries may of course affect any organ. Details of ballistics need understanding (46.14).

## 55.2 Management of abdominal injury

### HISTORY

Ask the patient about the injury if conscious. Otherwise, try to get information from eye witnesses at the scene. Get details of the overall mechanisms of injury. In a road crash, get the estimated speed of the vehicles, the nature of the impact, whether the collision involved a truck, bus, car, motorcycle, bicycle or pedestrian, and whether it was a frontal, lateral, sideswipe, rear, rotational or rollover type of collision. Was a seat belt worn, an air-bag deployment, or impact on the steering wheel? What was the victim's position in the vehicle and the extent of its destruction? Establish if the victim was ejected from the vehicle, or extricated himself.

Enquire if there were other victims and any fatalities (and ask if they are expected to arrive at your hospital).

In the case of falls, establish the height of the fall. In blast injuries, ask how far away the victim was from the explosion.

In direct blunt impacts, ask what struck the patient's abdomen, and where (think especially of an injury to the spleen after a blow to the left lower chest). In assaults, ask how much force was used, and if it was repeated.

Such information is relevant for initial evaluation and management of blunt abdominal trauma and you should always seek such when taking a history.

PAIN is usually present following an abdominal injury, so assess its intensity by a scoring method (2.11), its location, factors exacerbating it, and whether it is getting worse.

Ask about pain at the tips of either shoulder (*but make sure that this is not caused by an injured shoulder!*), because this is typically caused by diaphragm irritation by blood from the liver (right side) or spleen (left side), especially if tilting the patient's head down makes it worse.

**CAUTION!** Almost all patients with significant abdominal pathology after a blunt injury have persistent pain and may vomit. These are very important symptoms, though vomiting without abdominal pain is very unspecific.

*N.B.* A victim with multiple injuries may not complain of abdominal pain when he has even more painful injuries elsewhere!

*N.B.* Adequate pain relief minimizes stress responses and facilitates patient co-operation during the physical examination. *Judicious use of analgesia does not mask or alter physical examination findings.*

### ABDOMINAL EXAMINATION

Carry out a full clinical examination, including inspection of the abdomen, flanks and back.

Do this as part of your assessment of the circulation (43.1), but *do it again if the patient is unstable or deteriorates.*

Record any noted abnormalities including their size, shape and location.

#### (a) Inspection

Remove all the victim's clothes, but avoid hypothermia and safeguard the patient's privacy. Carefully observe breathing; *N.B. shallow, irregular, or grunting respiration is typical of an abdominal injury*, owing to restricted abdominal excursion during breathing.

Check if the abdomen moves with respiration: if it does not, this suggests peritoneal irritation. Check if one hemidiaphragm moves less than the other. If the patient is bleeding, he is likely to be pale, anxious, and still, with cold extremities (43.1).

*N.B. Remember that large amount of blood may be present in the peritoneal cavity without any change in girth or abdominal appearance.*

Systematically inspect the:

- (1) anterior abdomen (and urethral meatus in males),
- (2) flanks,
- (3) axillae,
- (4) posterior structures including the back, skin folds, buttocks and perineum, for distension, bruises, abrasions, contusions, lacerations, tyres and steering wheel, seatbelt or handlebar marks, localized swelling or penetrating wounds.

Look for ecchymosis on the lower flanks (Grey-Turner's sign) or around the umbilicus (Cullen's sign) which suggest retroperitoneal haematoma.

Cautiously log-roll the victim to examine the back, and perineum. If there is a spinal deformity or a paravertebral haematoma, this may suggest retroperitoneal bleeding.

Examine the rectum (and vagina in a female) to assess its integrity, and the presence of blood on your glove. You may be able to feel pelvic bone fragments in cases of pubic rami fracture from inside the lumen. Fulness, boggyness or tenderness in the rectovesical (or rectovaginal) pouch may indicate a haemoperitoneum.

*N.B. The rectum (& vagina) is completely out of sight at laparotomy.*

In a male, feel if the prostate is further from the anal margin than usual, indicating urethral disruption. Also, remember to assess reduced or absent anal sphincter tone if there is a spinal cord injury.

*N.B. Proctoscopy & sigmoidoscopy may be necessary to evaluate a severe anorectal injury.*

Look for wounds of the perineum or buttocks at the same time. *Remember that disruption of the pubic rami or symphysis may cause a vaginal or rectal injury.*

### **(b) Palpation**

Palpate to elicit tenderness; even minimal guarding or rigidity suggest peritoneal irritation from bleeding or visceral rupture. Start furthest from the site of injury.

*N.B. Initially blood is not a peritoneal irritant!*

Check the lower ribs for fractures. Assess integrity of the pelvic ring by applying direct pressure in 2 planes to both anterior superior iliac spines.

Palpate the superior pubic rami in addition to the *symphysis pubis*.

*N.B. Findings may be equivocal or unreliable if there is a reduced level of consciousness secondary to alcohol or drug intoxication, head or spinal injury.*

*N.B. Don't forget to examine the male urethral meatus, and look for the presence of blood and for a scrotal haematoma, and evidence of lacerations or bruises in the perineum. If there is evidence of urethral injury then don't rush to insert a urethral catheter; this is contraindicated as it may further injure the urethra.*

### **(c) Percussion**

Percuss gently to elicit subtle signs of tenderness, or ask the patient to cough. (*Rebound tenderness is unreliable and may arise from muscle injury*).

### **(d) Auscultation**

This is not very reliable. Bowel sounds may be absent after trivial trauma, and may occasionally be present even with serious injury. In the rush of the trauma situation, you may anyway not be able to be patient for enough time to be sure, nor hear well enough!

In a more stable patient, though, an abdomen which becomes silent where there were previously audible bowel sounds suggests peritonism.

However, *always listen to the chest*: you may hear *borborygmi* in the thorax if the diaphragm is ruptured and stomach or bowel has herniated into the chest.

*N.B. If while completing your full abdominal examination as part of the secondary survey (45.1), you discover signs of on-going intra-abdominal bleeding or peritonism, you must take the victim to theatre for an exploratory laparotomy. You should not delay to complete a protocol!*

*N.B. Always consider that a female of child-bearing age may be pregnant!*

**CAUTION!** Retroperitoneal injuries are rather difficult to diagnose by physical examination alone. But you should always have high index of suspicion if there is evidence of associated spinal deformity or paravertebral haematoma.

The mechanism of injury may suggest the possibility of damage to the retroperitoneal structures.

**CAUTION!** Even minimal tenderness and guarding are significant.

### **(e) Supplementary actions**

Pass a nasogastric tube (or an orogastric tube where there is a serious frontonasal head injury), if there is vomiting, or evidence of a full stomach where the conscious level is impaired.

*Don't insert a tube to look for gastric bleeding: this may damage the oesophagus, promote vomiting or even bleeding!*

Perform a FAST (44.3).

Pass a urinary catheter to monitor urine output in an unstable patient (44.1). *Don't insert a catheter for diagnostic purposes! Don't insert a catheter if there is blood at the external urethral meatus or suspicion of an 'open-book' type of pelvic disruption.*

**If there are no definite signs**, and a FAST did not help and you suspect bleeding in the abdomen, perform a DPL (44.3)

#### MANAGEMENT

*The critical question is whether the patient needs a laparotomy or not, and if so, how soon.*

**If in doubt**, look & see rather than wait & see. An occasional negative laparotomy is better than waiting till it is too late!

**If a patient is unconscious**, you have to rely on clinical signs, increasing abdominal girth (measured 4hrly at umbilical level with a centimetre), oft repeated examinations, DPL & supplementary tests.

#### **DON'T PERFORM UNNECESSARY INVESTIGATIONS IN AN EMERGENCY!**

#### **MISSED INJURIES MAY KILL A PATIENT**

#### LAPAROTOMY FOR ABDOMINAL TRAUMA (GRADE 3.2)

##### INDICATIONS

- (1) Signs of internal abdominal bleeding.
- (2) Signs of peritonitis.
- (3) Perforating injuries by bullets or multiple objects (such as knives), or by a foreign body not identified on radiography, or by cow or buffalo horn.
- (4) Herniation of viscera through the abdominal wall or diaphragm.
- (5) Thoraco-abdominal wounds.
- (6) Penetrating anorectal or vaginal injuries.
- (7) Obvious blood on rectal examination.

**If there is a clear indication for laparotomy**, then start immediately. *Don't delay longer than is necessary to organize the theatre and cross match more blood.*

The principles for trauma laparotomy are:

- (1) control haemorrhage,
- (2) limit contamination, &
- (3) repair visceral damage

**If there are signs of peritonitis**, administer prophylactic chloramphenicol or gentamicin IV & metronidazole PR, preferably with the anaesthetic as a single dose.

*N.B. If laparotomy shows no contamination*, stop the antibiotics.

*N.B. If peritoneal contamination occurs during surgery*, but you have dealt with it adequately, administer antibiotics as above, if you have not already done so.

*N.B. If there is established contamination* (duration >6h), continue antibiotics for 5days.

*It is much more important to start antibiotics early than to continue for long.* Starting them after the patient returns to the ward is certainly too late.

**If the patient is unstable**, your aim is to complete your intervention in 45mins. In this case, you must practice damage control (41.5). So, you should transfer the patient to the operating theatre while you are continuing resuscitation.

**If the result of your FAST** (which may miss solid or hollow organ injury) **or DPL** do not give you an answer, observe the patient closely and repeat the examinations every 30mins, or every 15mins for children.

#### PATIENT PREPARATION

*Make sure the theatre & IV fluids are warmed.* Place the patient supine on the operating table with arms abducted at right angles on arm boards (*don't forget restraints so the arms don't slip off*).

Be prepared to allow exposure to the chest, abdomen and groins. For perineal or rectal injuries, get leg stirrups & put the patient in lithotomy position.

*Make sure the electrocardiogram leads, monitoring equipment and tubes are NOT present on the anterior or lateral chest wall.*

*Make sure you have plenty of swabs & packs.* Remember you are a team, so *communication is the key to success*. It's up to you to make sure if the right instruments are ready.

Check this list:

- (1) Make sure the airway is clear (42.1).
- (2) Insert a chest drain if necessary (43.2).
- (3) Cross-match blood.
- (4) Make sure you have 2 IV lines running.
- (5) Pass a nasogastric tube.
- (6) Introduce a urinary catheter.
- (7) Explain the procedure to the patient (even if he appears drowsy) and get consent.
- (8) Make sure the suction is functioning.
- (9) Have auto-transfusion equipment ready.
- (10) Tell the theatre sister what special instruments you need.

*N.B. Don't delay surgery to put in a central venous line.*

*Remember, emergency laparotomy is not just performing a laparotomy quickly. You must combine rapid intervention with meticulous dissection.*

*Remember: abdominal trauma often occurs as part of multiple trauma. Therefore, prioritize resuscitation, according to the principles of ABCDE (41.2).*

This means that a patient who has blunt abdominal trauma and co-existing severe chest & pelvic injury, multiple fractures, and head injury should have treatment directed first toward the most life-threatening injury. This would probably mean inserting a chest drain, swiftly applying an external fixator on the pelvis, and splinting the broken limbs, and then proceeding with a laparotomy. If necessary, you could try to arrange a craniotomy simultaneously, starting this whilst your assistant closes the abdomen.

Clearly in such a situation, you must not use up valuable time in definitive repair (41.4).

**These patients need damage control surgery (41.5):**

- (1) Severe hypotension <90mmHg >60mins, or need of inotrope treatment.
- (2) Hypothermia <35°C.
- (3) pH <7.2 or Lactate >5mM.
- (4) Already has a clotting disorder, or has needed >5 units of blood transfusion.
- (5) Resuscitation + operating time predicted to take >90mins.

*N.B. If you suspect severe haemorrhage, use a muscle relaxant only at the last minute when you are ready to open the abdomen.*

Good relaxation however makes any bleeding site easier to find; and packing away the viscera, extending your incision, and tilting the table, will improve your vision.

*More harm arises by not exploring an abdomen than by doing so. You will not know the extent of injury until you open the victim's abdomen.*

#### YOUR MENTAL PREPARATION

The key decision is whether you go for definitive repair or damage control. *Make this decision as early as you can.*

**DAMAGE CONTROL APPLIES TO ALL ORGAN SYSTEMS: (1) INITIAL EXPLORATION, (2) SECONDARY RESUSCITATION, (3) DEFINITIVE CORRECTION.**

#### DAMAGE CONTROL SURGERY

The aims are to:

- (1) Stop the bleeding**
- (2) Control contamination**
- (3) Protect the viscera**

#### INCISION

Rapidly clean the patient from chin to mid-thighs, with aqueous antiseptic, extending down each side to the table.

Make a long midline incision extending from the xiphoid process to the pubic symphysis.

**CAUTION! If you suspect a severe pelvic fracture, take the incision only to just below the umbilicus** to avoid opening a potential large pelvic haematoma which may bleed torrentially if you open it. Continue downwards *under direct vision* if necessary.

*Don't hesitate to extend the incision superiorly, laterally, or both ways, to give you better exposure if you need to. Balance this against the increased time it will take you to close a bigger incision. If you are struggling, always make the incision bigger!*

*Don't try to perform a laparotomy through a small incision. Adequate exposure saves time.*

*Don't extend penetrating wounds (unless in the midline).*

*Don't waste time by cauterizing abdominal wall vessels: use haemostats for the larger vessels and move on.*

Attempt to make 3 clean cuts through skin & subcutaneous tissue, to the *line alba*, and then with heavy scissors into the abdominal cavity.

**DEFINITIVE SURGERY IS NOT INDICATED WHERE A SEVERELY INJURED PATIENT HAS SIGNIFICANT PHYSIOLOGICAL IMPAIRMENT.**

#### OPENING THE PERITONEAL CAVITY



**Fig. 55-3 OPENING THE PERITONEUM.** Use your finger to make a hole just cranial to the umbilicus. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

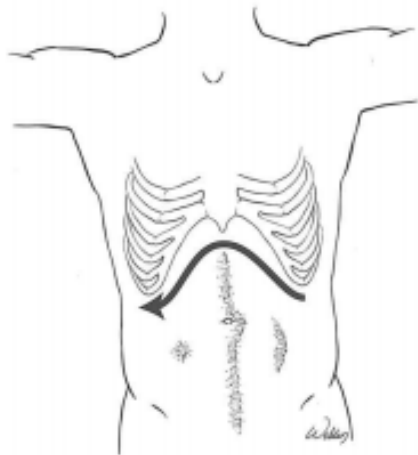
Make a hole just above the umbilicus with your finger (55-3) and then hold up the peritoneum with 2 fingers of your non-dominant hand and open the peritoneum carefully avoiding inadvertent trauma to any *viscera* stuck to the anterior abdominal wall.

*Avoid injury to the left lateral lobe of the liver in the upper abdomen, the small bowel in the middle, and the bladder in the lower abdomen.*

**If there is an old abdominal scar** and adhesions, start at a distance from the old scars, and open towards the scar bit by bit under direct vision. You might have to abandon one attempt, and start again at another site.

**If there are multiple scars and adhesions, and you cannot proceed safely**, abandon the midline and use a bilateral subcostal ('rooftop') incision.

### THE 'ROOFTOP' INCISION



**Fig. 55-4 THE ROOFTOP INCISION.** If there are previous scars and dense adhesions, enter the abdomen via a double subcostal approach. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

### EXPLORATION

When you open the abdomen, it may be full of blood, or pus and intestinal contents, or have a relatively small amount of both. In all cases, approach the operation calmly and systematically. *Note any sudden extrusion of gas, the colour of fluid present, and any odour (faecal smell indicates injury to the colon or rectum).*

You will need space to manoeuvre and to be able to diagnose the injuries. Begin by rapidly emptying the peritoneal cavity of clots and liquid blood by using both your hands or using a kidney dish or basin; then *bring all the bowel loops quickly out of the abdomen towards you and support them! Don't pull on them, but scoop them out from below with your palm.* Get your assistant to lift the abdominal wall of each quadrant in turn.

This will often give you a hint from which quadrant(s) the most blood is coming. Use an efficient sucker. Consider if you wish to re-infuse blood spilt as auto-transfusion (5-1).

### PACKING THE ABDOMEN

Now place an abdominal pack over the spleen, a 2<sup>nd</sup> in the left paracolic gutter, and a 3<sup>rd</sup> over the major vessels at the root of the mesentery in the midline.

Then, gently swing the bowel loops over to your assistant and place a 4<sup>th</sup> pack over the liver, a 5<sup>th</sup> in the right paracolic gutter, a 6<sup>th</sup> over the midline vessels, and finally a 7<sup>th</sup> in the pouch of Douglas.

### CONTROLLING HAEMORRHAGE

*This is absolutely the first priority.*

**If there is severe haemorrhage from the midline**, often audible, go straight to aortic compression.

**If there is severe haemorrhage from a penetrating wound**, follow the trajectory to try to find where the bleeding is coming from, and pack there first.

After placing your packs, you can now determine the site of major bleeding (you may already have a clue from FAST scans), and deal with it either temporarily by packing or definitively depending on the severity & site of injury.

After blunt trauma, the most common causes of haemorrhage are a ruptured spleen, liver, or kidney. In the latter case, and if it is the only injury, there will be a retroperitoneal haematoma and no intraperitoneal blood. Splenectomy (55.6) is the best treatment for severe splenic injury.

With penetrating injury (55.3), any organ including the major blood vessels are possible sites of bleeding. Upon opening the abdomen, if there is an obviously spouting blood vessel, immediately pinch it between your fingers, isolate it carefully, and clamp it. *Don't clamp blindly with frantic efforts in a pool of blood!* In penetrating trauma, you may find a single bleeding vessel, but rarely in blunt trauma.

*N.B.* Severe haemorrhage can be difficult to control. The secret is to control it temporarily with pressure, packing, and patience - especially patience. Then, slowly and carefully try to find the bleeding site. *Don't try to find the source of bleeding first and then use packs!*

*N.B.* Packing from outside the organs compresses the tissues and reapproximates tissue planes; packing from within fills a cavity.

**Is this a case for damage control surgery (41.5) or definitive repair?** *An abdomen full of blood, bile, intestinal content or urine requires an early decision!*

**If there is an aortic injury**, try to get formal control:

*N.B. Controlling haemorrhage from the liver or spleen rarely needs clamping of the aorta (55.4). A rapid splenectomy (55.6) is the best option for a damaged bleeding spleen in an unstable patient. Likewise packing the liver (55.7) is usually the best immediate treatment for hepatic bleeding.*

**Once major bleeding has been controlled**, by temporary packing or clamping, make a thorough systematic exploration of the abdomen (55-5, 11-2).

*N.B. If blood for transfusion is sparse, use it only after you have stopped the bleeding! Think of auto-transfusion (5-1).*

**Now control any contamination.** For an abdomen full of pus or intestinal content or both, use an efficient sucker, then a moistened abdominal pack to mop any residue. Then, using a moistened swab or compress, carefully control any leak from the gastro-oesophageal junction to the rectum.

Use the swab to remove any clinging blood clots. Note any greenish discolouration around the duodenum, or over the pancreas, and any brownish colour around the retroperitoneal colon. *This is particularly important in penetrating injuries.*

### FIND AND TREAT ALL INJURIES 'PRESSURE, PACKING AND PATIENCE'

#### SURVEY

Whether the case is severe or simple, you *must* identify *all* the injuries. This requires a systematic exploration of the abdomen: follow the same routine each time and *don't make a haphazard survey*.

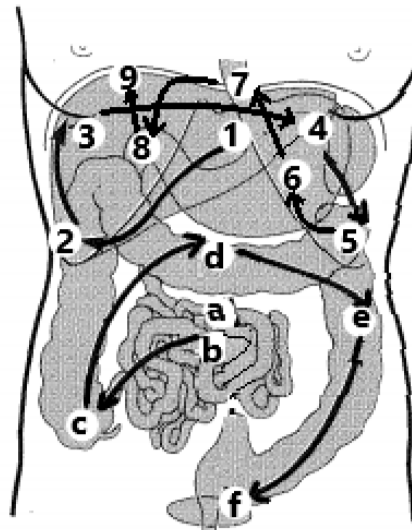
There are 2 main compartments, supra- and infra-mesocolic. The first contains the liver, stomach and spleen; the second contains the rest.

#### EXPLORATION

Start by pulling the transverse colon downwards. Look at and palpate the liver, gallbladder & right kidney, then the spleen and left kidney. Inspect the whole stomach up to the diaphragmatic hiatus, and what you can see of the duodenum. Inspect the whole diaphragm, including any deformation from the thoracic side.

Then lift up the transverse colon and follow the whole bowel from the duodeno-jejunal junction (ligament of Treitz) to the rectum. For this you need both your and your assistant's hands to flip over the bowel and examine both anterior & posterior surfaces as you progress to the rectum (55.12). It is best to palpate the bowel with your fingers, using a moist compress to remove any blood clots.

### EXPLORING FOR ABDOMINAL TRAUMA



**Fig. 55-5: EXPLORING THE ABDOMEN.** Pull the transverse colon and follow from liver (1) to rt kidney (2) to gallbladder (3), to spleen (4) to lt kidney (5) to stomach (6) to diaphragmatic hiatus (7), to duodenum (8) to dome of the diaphragm (9). Then lift the transverse colon, and follow from D-J flexure (a) to small bowel (b) to caecum (c) to transverse colon (d) to descending colon (e) to rectum (f). *After Dudley HAF (ed), Hamilton Bailey's Emergency Surgery, Wright, 11<sup>th</sup> ed 1986 with kind permission.*

**If you need to explore the lesser sac** (because there is a gastric perforation), make a hole in the greater omentum in an avascular area, which is usually on the left. To find this, get your assistant to lift up the stomach and transverse colon; this gives you a good view of the posterior stomach and pancreatic body & tail.

**If you need to look at the posterior part of the duodenum** (because of a greenish discolouration or a per-duodenal haematoma), perform the Kocher manoeuvre (13.5), but don't do this routinely.

**If you find a bowel perforation**, put soft clamps on either side over a gauze compress and continue the exploration. You might have noticed this earlier upon opening the abdomen and clamped the bowel already: *don't forget to continue a systematic exploration!* There may be other trouble brewing.

**If you find a peri-colic haematoma or brownish discolouration**, mobilize that part of the colon: you will probably find a posterior wall injury.



Lastly, remember to examine the bladder, uterus & tubes in the pelvis. For penetrating injuries with a hole in the posterior peritoneum that is anatomically close to the ureter, you will have to open & inspect for any damage.

#### CONTAMINATION CONTROL

After you have controlled the bleeding, you need to control the spillage of intestinal contents or urine from hollow viscus injuries. *The goal is to stop further contamination, NOT to repair the damage, so don't perform anastomoses or fashion stomas at this stage.*

We describe definitive repair under the organs concerned.

#### (a) Gastric injury (55.9)

**If there are one or two simple perforations**, it is quickest to close these with a simple continuous suture.

**If a significant portion of stomach is damaged**, resect it, & close off the open end with a continuous suture or with a linear stapler (4-16).

#### (b) Peri-duodenal haematoma (55.10)

Perform a Kocher manoeuvre (13.5) to mobilize the duodenum, as it is most likely injured.

#### (c) Bowel injury (55.11, 13)

**If there are one or two simple perforations**, it is quickest to close these with a simple continuous suture.

**If there is much soiling**, practice damage control and interrupt the bowel's continuity with a tape (55-6)

#### BOWEL INTERRUPTION



Fig. 55-6 ISOLATION OF A PERFORATED BOWEL SEGMENT. Using tape means making a small hole in the mesentery next to the bowel, but is neat. *Clamps may slip off and get in the way.* After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

**If you have linear staplers**, quick bowel resection is easy (55-7)

#### QUICK BOWEL RESECTION

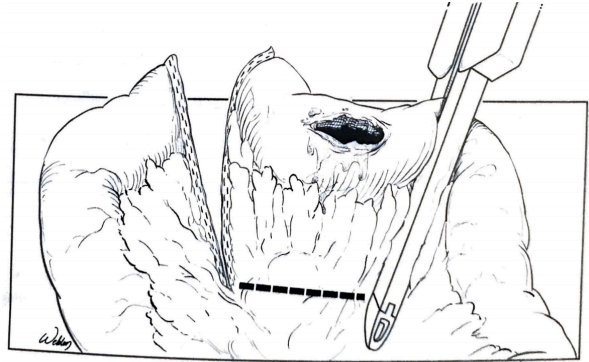


Fig. 55-7 Rapid bowel resection is easy with linear staplers. Otherwise, if there is bleeding in the near-by mesentery, use crushing clamps across the mesentery. Excise the damage portion and decide if you should perform an anastomosis (*definitive care*) or follow damage control. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

**If there are many perforations**, resect the entire segment and simply tie off the ends with a thick ligature, tape or with a cutting stapler if you have one (4-16). Put crushing clamps across the involved mesentery, remove it and then either tie it off or use a cutting stapler. This is the same for both small and large bowel.

**If you find a peri-colic haematoma**, mobilize that part of the colon: you will probably find a posterior wall injury. *N.B. There is no place for a stoma – ileostomy or colostomy – as a damage control procedure, although you can bring out a loop of injured ileum.*

#### (d) Pancreatico-biliary injury (55.7,13)

*This is often accompanied by a duodenal injury.* Use a simple drain to convert these into controlled fistulae. Bring the drains out laterally through the flank at the mid-axillary line. *Be careful not to kink these drains with packs you are leaving inside.*

#### (e) Diaphragmatic injury (43.4)

Repair a hole in the diaphragm with continuous 0 non-absorbable, taking large bites and pulling up the suture to prevent the edges from inverting. Reduce and repair or resect any organ that has herniated through the hole first, and wash out the pleural space.

#### (f) Ureteric injury (55.16)

Cannulate the ureter proximal to the injury (a paediatric feeding tube is ideal), and pass the catheter down into the bladder; leave it there if cystoscopy is available. Otherwise bring out the end suprapubically. Place a simple Penrose drain at the site of injury and bring this out extraperitoneally in the flank.

An alternative is simply to put in a T-tube without attempting an anastomosis, fix it with a ligature, lead the long leg out of the abdomen

*N.B. A uretero-cutaneous fistula often results in ascending pyelonephritis.*

In extremis, you can tie off both ends of the ureter, make a defunctioning nephrostomy, leaving an anastomosis for the 2<sup>nd</sup> look operation.

#### **(g) Bladder injury (55.17)**

Repair the hole with a continuous suture. Leave a urinary catheter. If the hole is too large to close simply, cannulate both ureters from inside the bladder and lead them to the outside suprapubically. *Fix the cannulae so they don't fall out!* Pack the bladder cavity if it is bleeding.

#### **(h) Uterine injury (55.18)**

If there is only a small hole, debride and close it in two continuous layers, as at a Caesarean section (21.10). If there is significant rupture of the uterus, pack the cavity.

#### REVIEW

**If the patient remains stable, and is in good health, especially if you needed no packing,** proceed to definitive repair, if you can finish this within the 90min grace period. *Check the patient's temperature: avoid hypothermia at all costs! Don't submit a young patient with a simple injury to damage control protocols unless he needs it!*

**If you have controlled bleeding after your original packing,** it is wise to leave the packs alone. Write down the number of packs left inside. *Removing packs may restart the bleeding!*

**If the abdomen is now dry,** remove packs sequentially, starting with the quadrant where there was less bleeding. Work your way to the quadrant with the most severe bleeding/injury.

**If the patient remains haemodynamically unstable, or has been significantly unstable, especially for >45mins, or there is considerable soiling,** wash out the abdomen & finish the surgical intervention here. Leave the abdomen open for a second look in c. 48h (11.10).

Carry out a repeat exploration afterwards to check if you have not missed anything. Then thoroughly wash out the abdomen; you can use sterile water for this. *Make sure it is warm!*

Finally, close the abdomen (11.8)

## 55.3 Penetrating abdominal injury

### SPECIAL FEATURES

All trauma, blunt or penetrating, is the result of transfer of kinetic energy to the tissues that causes their disruption. Sometimes this energy transfer is of a very low level (stab wound or a punch) and sometimes very high (blast or rifle bullet or high-speed vehicle crash). You should understand the mechanism of injury in order best to make a diagnosis and plan the management of your patient.

Blunt injury transfers energy in a very diffuse manner, easily affecting an entire organ. Penetrating injury generally affects only the tissues closely around the trajectory of the wounding instrument, with a few exceptions.

Blunt injury selectively affects certain organs much more than others; a fall from a height or road traffic crash often shatters the liver, but does not often affect the small intestines. The liver, spleen, kidneys, and less often the pancreas, are most commonly injured after blunt trauma.

Penetrating trauma can injure **any** abdominal organ or blood vessel. Most perforations of a hollow viscus will be from penetrating trauma. Many missile injuries also devitalize the tissues surrounding the trajectory, so these tissues will need debridement till you reach healthy bleeding tissue.

The most common penetrating injuries of the abdomen include:

- (1) Stab wounds: (usually of criminal intent).
- (2) Animal horn impalement: (buffalo, cow, goat: 46.10).
- (3) Gunshot wounds, handguns or high-powered rifles: (criminal activity or armed conflict: 46.14).
- (4) Blast injury giving off metal fragments: (bombs, shells, landmines), & rarely volcanic eruptions (46.15).

Although all of these are penetrating injuries, their consequences are very different. Some points of management are the same, but you should know the differences as well.

*N.B. Any penetrating injury between the nipple line and the knees may enter the abdomen. You must carefully examine the front and back of the abdomen, chest, perineum, buttocks and upper thighs.*

## A PENETRATING ABDOMINAL INJURY

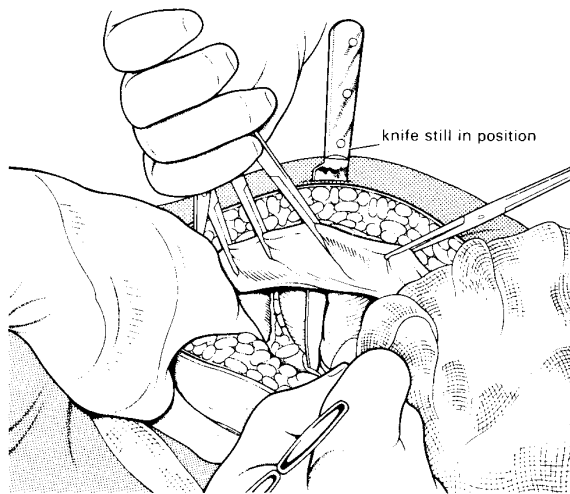


Fig. 55-8 A PENETRATING ABDOMINAL INJURY, illustrating the value of making a separate incision which enables you to see the track of the knife. *N.B.* leave the knife in place until you get the patient to theatre. Immobilize the penetrating object with adjacent bandages and pack a cardboard box around the patient if he needs to be moved. Kindly contributed by Peter Bewes.

### MANAGEMENT OF STAB WOUNDS

Some knives have short blades, others long. Some stab wounds of the abdomen don't even enter the peritoneal cavity, but only damage the muscles of the abdominal wall, especially in fit muscular young men.

Up to 50% of intraperitoneal stab injuries don't hit an organ, the blade sliding between coils of the intestines or creating a superficial laceration of the liver or intestine that does not require suturing. So some stab wounds may not need laparotomy. You must take a good history of the injury, and make a good clinical examination of the patient.

**If a patient arrives with the impaled object still *in situ*, don't take it out except in the operating theatre.** You may need to transport the victim, so fix the object with bulky dressings and hold it in place with sticky tape. Then cover the whole with a cardboard box in which you have cut edges to stop the box moving about (55-9).

### A PROTECTIVE COVER

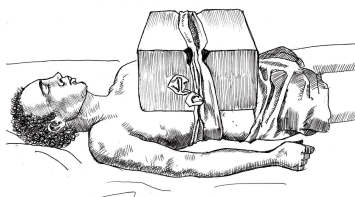


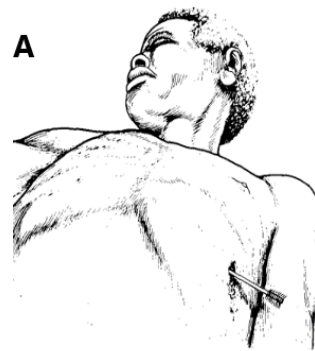
Fig. 55-9 FIXING PROTECTION for a foreign object impaled in the abdomen. After Giannou C, Baldan M, Molde, A. *War Surgery*, ICRC Geneva 2013

**If a patient has no signs of visceral damage and remains haemodynamically stable**, you may be able to manage things conservatively. Explore the penetrating wound (which may be in the chest, flank, back or buttocks, as well as the abdomen), in theatre under LA. Use sedation if necessary.

Leave a penetrating object *in situ* if it is still there, so you can see if it has breached the peritoneum. And if it has, still leave it in place until laparotomy. You don't know where the point has reached. (This is a general rule for any impaling foreign object anywhere in the body.)

## PENETRATING THORACO-ABDOMINAL TRAUMA

A



B

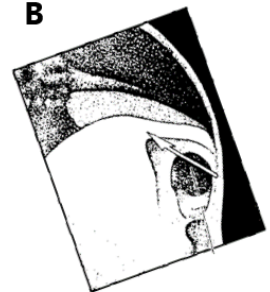


Fig. 55-10 A PENETRATING THORACO-ABDOMINAL INJURY. A, the arrow only appears to have gone into the chest, B, but has in fact entered the stomach. *N.B.* Don't think an arrow penetrating a little lower, which appears only to enter the abdomen, has not also gone into the chest! Kindly contributed by Peter Bewes.

Explore the wound down to the peritoneum, and open up the plane between the *transversus* and the peritoneum over a reasonable area and inspect it.

**If the peritoneum is intact**, close the wound by immediate primary suture, unless it is soiled, in which case you must debride it thoroughly and leave it open. *Continue to monitor the patient, in case your assessment of the peritoneum was wrong.*

**If there are >2 perforating abdominal injuries**, don't waste time exploring each one in turn: proceed to laparotomy. The chances of injury with two stabs is much greater than with just one.

**If you have found a breach of the peritoneum or a plug of omentum protrudes through the peritoneal wound**, open the peritoneum fully & proceed to a laparotomy.

**If there is an intact organ herniating out of the abdomen through a stab wound**, proceed to laparotomy.

Where the abdominal wall is opened, and viscera are exposed, they are in danger of getting infected, herniating out, or being damaged.

Rarely the abdominal wall may bleed, especially the epigastric arteries. You should make a separate formal laparotomy incision; don't *try to explore the abdomen through the stab wound*.

**If herniated bowel is still viable**, and there will be a *delay getting to theatre*, infiltrate LA in the wound from which it is herniating, and enlarge the hole to release the strangulation. Time is critical. Few patients survive if peritonitis has been developing for >12h, but most will survive if you operate within 4h.

**If the herniated bowel is perforated**, clamp it with a non-crushing clamp so leaking bowel content does not contaminate the wound.

**If there are serious wounds on the back**, explore these first, if the patient is haemodynamically stable. Otherwise, roll him on the side after the abdominal operation.

**If you have found nothing amiss**, repeat the exploration routine, including the Kocher manoeuvre (13.5) and exploration of the lesser sac. Check the 6 common places where you may miss an injury (55-18).

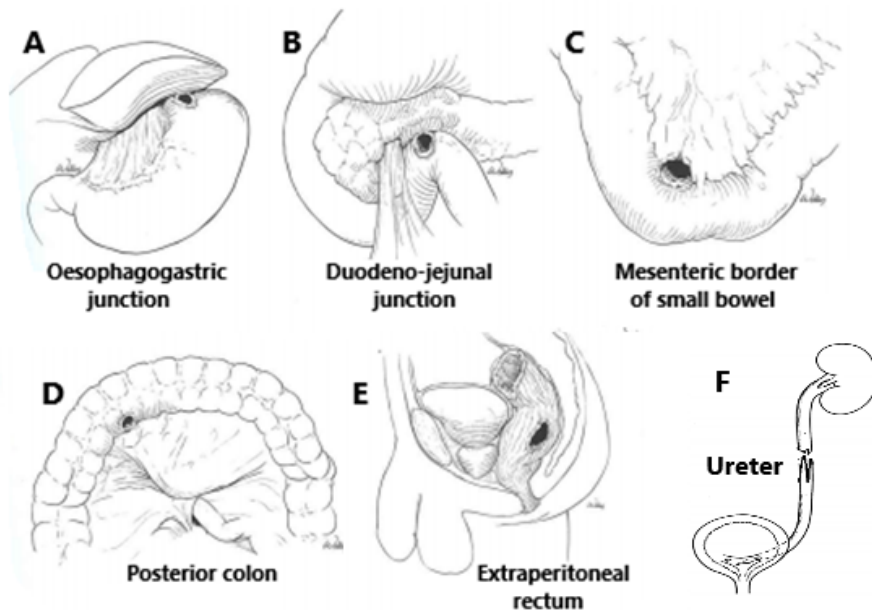
The injuries you may commonly overlook at laparotomy are:

- (1) gastric perforations high up on the lesser curve or on the posterior wall,
- (2) perforations at the duodeno-jejunal junction,
- (3) small bowel perforations on their mesenteric border,
- (4) colonic perforations, especially on their posterior wall. *N.B. any subserosal haematoma might hide a perforation: unroof it!*
- (5) extraperitoneal rectal perforations,
- (6) ureteric injuries.

*Remember to count the number of perforations in penetrating injuries.* If they are an odd number >2, keep looking. Be satisfied with an uneven number only after a very careful search. With stab wounds, the knife blade often cuts just one surface of the intestine, unlike with bullets.

Similar to stab wounds by a knife are puncture wounds from some other object: a screwdriver, a splinter of metal or wood. The latter will show up on a plain radiograph of the abdomen and should always lead you to do a laparotomy.

AMOS (6 years) was playing on a child's slide. He went down on his front, feet first, and subsequently complained of abdominal pain. There was a small laceration on the abdominal wall near the umbilicus. Signs of general peritonitis developed, and laparotomy showed a splinter of wood 15 cm long and 3 cm wide, & which had entered the abdomen and penetrated the anterior wall of his stomach. This was removed, the stomach repaired, and he recovered.



### COMMON MISSED INJURIES

**Fig. 55-11 COMMON MISSED BOWEL INJURIES.** These places where a rushed exploration may miss include: A, oesophago-gastric junction. B, duodeno-jejunal junction. C mesenteric border of the small bowel. D, posterior colonic wall. E, extraperitoneal rectum. F, ureter. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

### MANAGEMENT OF IMPALING BY ANIMAL HORNS

The upward lift of an animal horn has much more kinetic energy than a knife stab, and the horn is definitely not clean. Often, the animal strikes the victim in the buttocks or tears out a piece of the abdominal wall. You should always perform a laparotomy and debride the edges of any and all wounds, in the abdominal organs, buttocks or abdominal wall.

### PROJECTILE WOUNDS

Injury is related to the kinetic energy of the projectile, bullet or metal, which is a function of its mass and velocity. Projectile wounds are dirty and contaminated and you will have to debride all wound edges in the abdominal wall and injured organs.

The wounds caused by fragments may also be accompanied by primary blast effects (46-9). You must do a very careful examination of the patient: a close palpation, front and back and sides. A very small entry hole can easily hide in the skin folds of the groin or scrotum or buttocks. Make a note of the number and nature of the wounds, which may be small and multiple punctate holes or a single gaping wound, or even with evisceration of the abdominal organs.

**Simple radiographs of chest, abdomen & pelvis are useful to locate bullets or fragments.**

*N.B. You occasionally find these, having ricocheted off bone in bizarre places far from the entry point.*

You may be able to determine the trajectory of a bullet, but its passage is unpredictable, especially if it is still inside! People are not usually injured when standing in a textbook anatomic position! *Mark any projectile wounds with radio-opaque markers (e.g. paper clips) before taking a AP & lateral radiograph.*

#### MANAGEMENT

*N.B. Fragments from explosions are often of low velocity, low mass and, therefore, low kinetic energy, not penetrating the peritoneum. The same rule governing a stab wound applies: explore under local anaesthesia in a non-symptomatising patient.*

*N.B. The general rule is that all projectile wounds of the abdomen should proceed to laparotomy.*

Any abdominal organ or vessel may be injured and injury to multiple organs is frequent. Be prepared to deal with solid and hollow organs, and blood vessels. The ballistic and blast effects of projectiles mean that you must debride all wounds of all organs back to healthy bleeding tissue, removing necrotic, devitalized and contaminated tissues.

The more focalized damage to the liver, in perforating rather than blunt injuries, means that you need to perform debridement and use liver suture techniques more often than liver packing. The spleen can sometimes be saved, but *don't attempt this unless you are experienced and have good post-operative nursing care!* (55.6)

See, for perforations of the stomach (55.9), duodenum (55.10), small bowel (55.11), large bowel (55.13), rectum (55.14), & bladder (55.17).

*Remember to count the number of perforations in penetrating injuries.* If they are an odd number >2, keep looking until you find one, or a foreign body (usually the bullet or fragment) inside a hollow organ! Be satisfied with an uneven number only after a very careful search.

#### MANAGEMENT OF THE ABDOMINAL WALL

In ordinary circumstances, close the abdomen in standard fashion. *Never close the abdomen under tension!*

**If a segment of abdominal wall is missing, or if the bowel has become very distended, don't try to stretch the abdominal wall to close it!** This is especially important if the wound has been caused by an animal or a projectile and therefore needs debridement (46.10). As with a damage control laparotomy, *leave it open as a laparostomy* (11.10) and plan definitive repair later.

#### 55.4 Aortic control

**If, when you open the abdomen, blood wells up filling the field of view** (often with a 'whoosh' sound), try pressing on the aorta. Get your assistant to take over whilst you continue.

Bluntly open the avascular portion of the lesser omentum, feel the aorta immediately to the right of the lesser curve of the stomach, with a nasogastric tube within by now).

Compress the aorta against the spine, or pinch it between your index finger and thumb. If pressing on the aorta allows you to identify a vascular injury that you can repair, you will need to clamp it. *Otherwise there is no point! Don't bail out here thinking this is too much for you! If you have got thus far, and don't continue, the patient will die. Hold the aorta with sutures on a 4/0 round-bodied needle or with non-toothed forceps; cutting needles & sharp instruments may tear the wall & cause further damage!*

*Remember when you clamp the aorta, there will be ischaemia of entire abdomen, pelvis and lower extremities.*

*N.B. After aortic repair, you may need to perform leg fasciotomies (49.6) to avoid re-vascularisation compartment syndromes.*

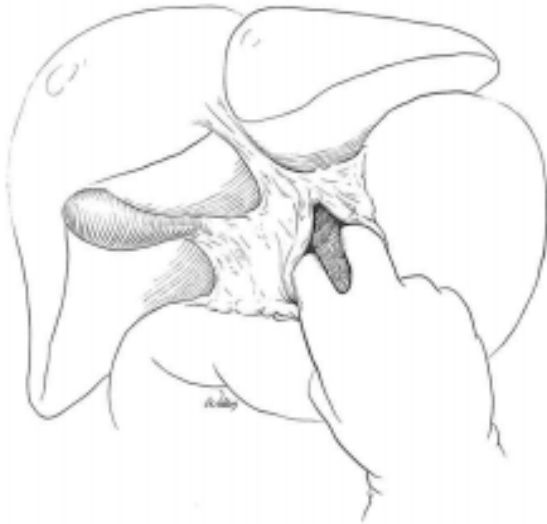
**If you have already performed a thoracotomy,** an easier alternative is a clamp on the descending portion of the thoracic aorta.

#### AORTIC CLAMPING (GRADE 3.4)

From the abdomen, you should try to clamp the lower thoracic aorta above the coeliac axis. Make a hole in the avascular portion of the lesser omentum (immediately adjacent to gastric lesser curve) and insert a long retractor into the hole (55-12).

Retract the stomach and duodenum to the left of the abdomen. Palpate the pulsatile aorta. Make a hole bluntly into the posterior peritoneum, and separate the two limbs of the right crus of the diaphragm with finger or scissors (55-13).

### OPENING THE LESSER SAC



**Fig. 55-12 OPENING THE LESSER SAC.** Getting access to clamp the aorta. Opening an avascular portion of lesser omentum adjacent to the lesser curve of the stomach. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

### OPENING THE RIGHT CRUS OF THE DIAPHRAGM



**Fig. 55-13 OPENING THE RIGHT CRUS.** After opening the posterior peritoneum, palpate the aorta and separate the 2 limbs of the crus over it. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

Make enough space to place the clamp by insinuating your fingers on either side of the aorta, down to the vertebra (55-14).

### GETTING READY TO CLAMP THE AORTA



**Fig. 55-14 GETTING READY TO CLAMP THE AORTA.** Make enough space with your fingers on either side of the aorta to place the clamp. Then check if there is no more pulsation distally. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

Guide the aortic clamp into place using the fingers of your left hand. It's best to use a straight clamp placed vertically at right angles to the spine. Clamp the aorta carefully and check the distal aorta for pulsation. Secure the clamp with tape to the drapes to keep it from falling into your wound. *Note the time.*

Remove the clamp as soon as you can or at least place it more distally, preferably on the infrarenal aorta. *Remember when you clamp the aorta, there will be ischaemia of the entire abdominal contents, pelvis and lower extremities!*

### 55.5 Inferior vena caval control

**If, when you open the abdomen, dark blood wells up from below,** and pressure on the aorta does not make much difference, and you suspect the IVC is ruptured, you need to press on the IVC on both sides of the site of its perforation.

Press on the IVC with 2 swabs held on sponge-holding forceps (55-16) and, if this does not allow you to get adequate control for a repair, apply Rumel tourniquets above & below, and if necessary, on both renal veins. *Don't use suction as you can easily exsanguinate a patient this way!*

*N.B. You need to approach a hole in the posterior wall of the IVC through the anterior wall!*

### CONTROLLING THE INFERIOR VENA CAVA

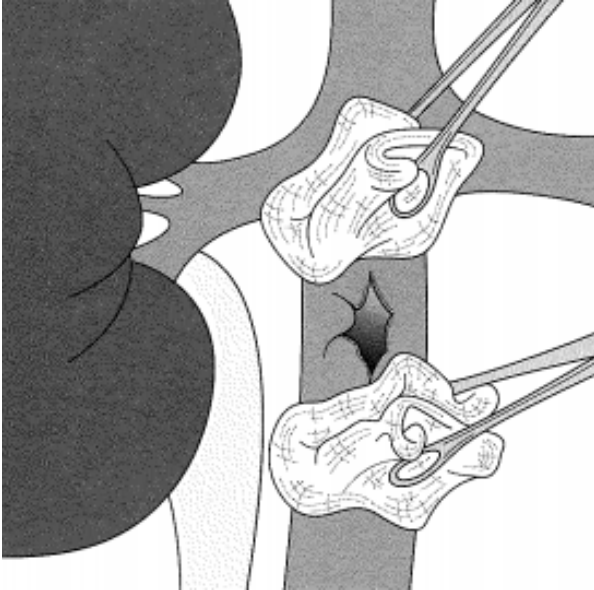


Fig. 55-15 CONTROLLING THE IVC. To get access to the IVC, perform a right medial visceral rotation (55-27) and if you need access to the part of the IVC just below the liver, the left medial visceral rotation (55-26). After Boffard KD ed, *Manual of Definitive Surgical Trauma Care*. CRC 3<sup>rd</sup> ed 2011

### 55.6 Splenic injury

The spleen is a commonly damaged abdominal organ in blunt trauma. It lies under the 9<sup>th</sup>-11<sup>th</sup> left ribs and you must always think it may be injured if these ribs are damaged, or there is an impact to the lower left hemithorax.

A classic history is a cyclist who is thrown against the handlebars of a cycle. The spleen is very vulnerable in children, and in splenomegaly due to malaria. A classic symptom is pain in the tip of the left shoulder (referred pain from left hemidiaphragm irritation by collected blood)

The spleen may also be injured by knives, gunshots or animals, by excessive traction or mobilization of the colon in surgery, and occasionally by a chest drain inserted too low.

The spleen has important haematological, as well as immunological functions, protecting against pneumococcal pneumonia, *haemophylus B* & meningococcal infection, malaria & tick-bite fever, so if you can preserve it, do so. It receives 5% of the total cardiac output, and *can bleed massively* (55.2). An initial haemorrhage may be contained by the splenic capsule, which *may rupture catastrophically later* (the latent period of Baudet).

### MANAGEMENT

*This is not the sort of case you can safely refer!*  
Non-operative management for minor splenic injuries with little bleeding is not an option unless you can guarantee very close observation for at least 48h.

During packing the abdomen, you should have put a back behind the spleen, thus bringing it forward. This is essential, because you need to see what you are doing, and otherwise the spleen will remain hidden.

The spleen is usually mobile, and big malarial spleens are particularly fragile (adherent tubercular or bilharzial spleens don't rupture so easily). This means you can put your left hand round the back of the spleen and bring it forwards, leaving it attached to the splenorenal ligament, which you can now divide under direct vision.

### MOBILIZING A NORMAL LACERATED SPLEEN

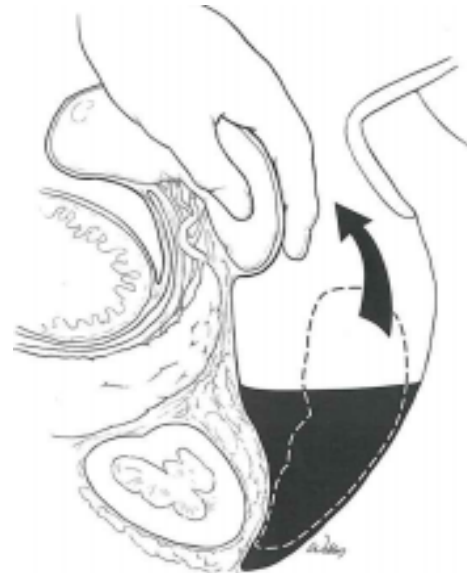


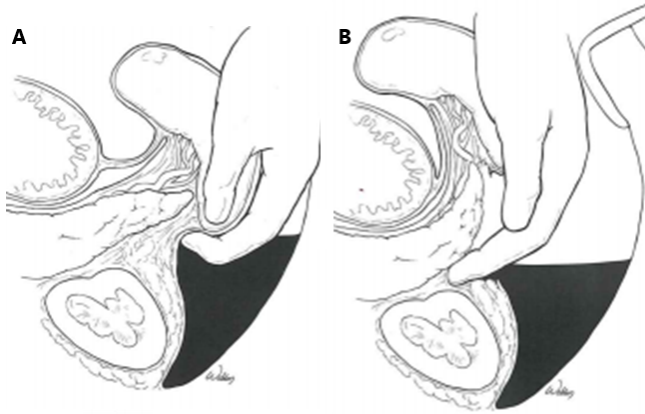
Fig. 55-16 MOBILIZING A NORMAL LACERATED SPLEEN. Bring out the spleen from its bed by pulling it out from behind. After Hirschberg A, Mattox KL. *Top Knife*. Tim Shrewsbury 2005 with kind permission.

**If the spleen is adherent** to the lateral abdominal wall or diaphragm, you might not be able to get your hand round it. Use long scissors (and your fingers) to prise the adhesions apart. Put a large pack behind the spleen: this controls bleeding & pushes the spleen forwards.

Even if you split the splenic capsule doing so, you will be committed to removing the spleen anyway: just work fast till the spleen is held by the splenorenal ligament (55-17A). You might have to divide this blind: just bring the spleen & pancreatic tail into the midline.

Develop the plane between the spleen and left kidney so you can mobilize it to the midline (55-17B). Now pinch the splenic pedicle (which contains the splenic & short gastric vessels), and control this with a tape or non-crushing clamp.

### MOBILIZING AN ADHERENT SPLEEN



**Fig. 55-17 MOBILIZING AN ADHERENT SPLEEN.** A, after dividing adhesions to the lateral abdominal wall, feel for the splenorenal ligament with your finger and cut or break it. B, then work your finger between the spleen and left kidney. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

**If the spleen is totally stuck and mangled, and you cannot mobilize it,** isolate the pedicle from in front first. Pull the stomach forwards, and divide the gastrosplenic ligament between clamps. Behind it is the splenic hilum; occlude this with a tape or non-crushing clamp.

#### SAVING OR RESECTING THE SPLEEN?

Try to preserve the spleen, especially in children. However, if a patient's life is in danger, *the safest solution is splenectomy!* Splenic repair by bolstered suture or wrapping is a specialized technique and fraught with uncertainty. Reimplantation of pieces of spleen (15.17) *protects against pneumococcal (and maybe other bacterial) infection* and may also protect against malaria.

#### EMERGENCY SPLENECTOMY (GRADE 3.4)

The emphasis is on speed, so *this is not like the elective splenectomy* (15.17)

To remove the spleen, put an arterial clamp across each of the vessels at the splenic hilum; stay close to the body of the spleen so you don't damage the pancreatic tail or the stomach. Cut distal to the clamps, one by one. Don't put one big clamp on the hilum and try to ligate this: *it is too likely to come off!*

Similarly clamp and divide the gastrosplenic ligament as far from the stomach as possible, and then deal similarly with the remaining splenocolic ligament.

For extra security, suture-ligate the hilar vessels. Doubly ligate the vessels proximal to the clamps and remove them one by one.

Put a big dry pack in the splenic bed, and leave it there for a few minutes. Remove it and check for any residual bleeding. Check also if there is damage to the stomach (close it) & pancreas (drain it).

*N.B.* Look for other abdominal injuries before you close the abdomen.

#### PROPHYLAXIS AGAINST INFECTION

Infants and children are very susceptible to infections after splenectomy, as are immunosuppressed adults, and those with sickle-cell disease. Follow a standard protocol, such as:

(1) Penicillin or ampicillin intra- and post-operatively  
(2) Pneumovax-23 vaccine (v. *Streptococcus pneumoniae*) at day 14 post-injury or on day of discharge, whichever comes first.

*N.B.* Heptavalent vaccine is not effective.

(3) *Haemophilus influenzae B* vaccine only if the patient is <13yrs and not immunized.

(4) Meningococcal vaccine (v. *Neisseria meningitidis*) only in endemic areas, as the Pneumovax-23 cross-covers this as well.

(5) Re-vaccination after 5yrs for children <10yrs.

*N.B.* Long-term antibiotic prophylaxis is not recommended except for children with rheumatic heart disease and immunocompromised adults. Treat splenectomized children early even for 'minor' respiratory infections with amoxicillin-clavulanic acid (1g tds).

*N.B.* Take specific prophylactic measures where malaria, meningitis, and tick bites are common.

#### DIFFICULTIES WITH EMERGENCY SPLENECTOMY

**If oozing is uncontrollable,** insert large packs in the splenic bed and change to damage control mode (41.5, 55.2).

**If you have damaged the pancreatic tail,** leave 2 closed drains in place till they stop draining.

**If a patient suddenly becomes hypotensive postoperatively,** perform a re-laparotomy immediately: a ligature has probably slipped. don't waste time with investigations, except perhaps an ultrasound examination if you can do this very quickly.

**If a pleural effusion develops post-operatively,** drain the fluid and check it for amylase levels. It usually resolves. Check for the development of a subphrenic abscess or pancreatitis.



If the wound becomes infected, suspect a pancreatic leak. Open the wound and wash out the abdomen, and splenic bed especially; leave in a drain.

If portal vein thrombosis ensues (which you may be able to diagnose with ultrasound, and is more common in cirrhotics), start heparin.

## 55.7 Hepatic & biliary injury

The liver has several segments related to their specific blood supply: these *don't* correspond to the anatomical lobes. It has a special double blood supply from the hepatic arteries & the portal vein. It is protected by the lower right rib cage; so anything which damages this may also injure the liver. The liver is commonly injured (especially when it is enlarged): certain injuries may cause only minor bleeding, but high-speed or penetrating injury can disrupt the liver severely.

The liver does not tolerate compression, shearing & deceleration forces well. Severe shearing may cause the hepatic veins or IVC to tear off from the posterior liver surface causing massive bleeding. A deceleration injury may produce a stellate rupture of the liver tissue. Liver injuries, if they bleed, usually also leak bile.

The liver is commonly injured, but bleeding tends to be more obvious than from the spleen. In a cirrhotic or a patient with portal hypertension (e.g. secondary to schistosomiasis), even a minor injury may cause catastrophic bleeding.

Pain & tenderness in the right hypochondrium or epigastric area after trauma are highly suspicious of hepatic damage.

An associated intestinal haemorrhage suggests blood is passing into the biliary tree.

### MANAGEMENT

When you have opened the abdomen, a great many liver injuries, whether due to blunt trauma or a stab wound, have stopped bleeding or present a subcapsular haematoma. *Don't fiddle with this!* Place a moistened abdominal pack on the laceration or haematoma. Nonetheless such patients still need further assessment.

In mild or moderate bleeding, look at the inferior and feel the superior hepatic surface with your hand. Pack the liver (55-18).

### PACKING THE LIVER FROM OUTSIDE

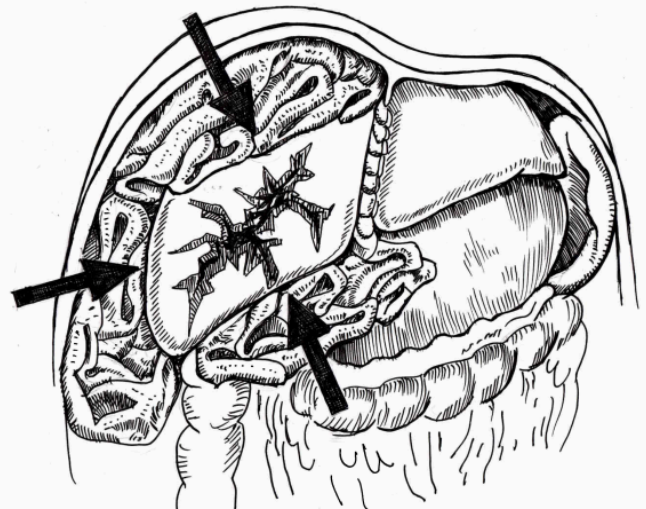


Fig. 55-18 PACKING THE LIVER FROM OUTSIDE. Compression of a fractured liver by proper placement of packs above and below the liver. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

For moderate to heavy bleeding, get your assistant to grasp the liver between both hands and compress it to re-establish the normal anatomy, whilst you pack the liver from outside (55-18). Get another assistant or the scrub nurse to lift the abdominal wall of the upper right quadrant.

### COMPRESSING THE LIVER

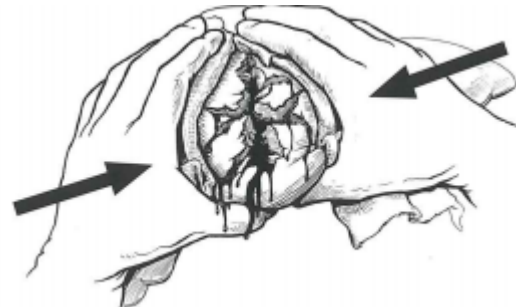


Fig. 55-19 COMPRESSING THE LIVER between both palms. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

Put your hand over the dome of the liver, pulling it gently forwards, and put *folded* packs above your hand superior, and then inferior, to the liver (55-18). Then place packs between the lower ribs and the anterior and lateral surfaces of the liver: *don't cut any suspensory ligaments.*

Packs must create pressure in the right directions to be effective. Try to create a sandwich with the packs as the 'bread' and the damaged organ as the 'jam'. You need support for your packs: the diaphragm, abdominal wall, rib edge or other organs.

*N.B. Packing does not usually stop arterial bleeding, but gives you time to get organized.*

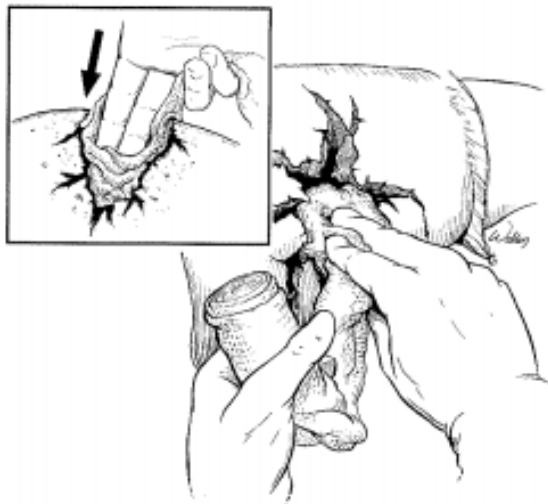
*N.B. Don't overpack.* If you put in too many packs, you can create a compartment syndrome (11.10), so watch the patient's BP.

*N.B. It is also possible to obstruct the inferior vena cava when packing the liver.*

So, in these instances, remove some packs and reassess the situation.

Since packs can absorb a lot of blood, *make sure they are compressing an organ and not just soaking up blood.* If you are not sure, remove the outer layers and look again. If it is obviously not working, rebuild your 'sandwich' so that it compresses more effectively. If this does not work, try manual pressure, balloon tamponade or a figure of 8 suture.

### PACKING THE LIVER FROM INSIDE

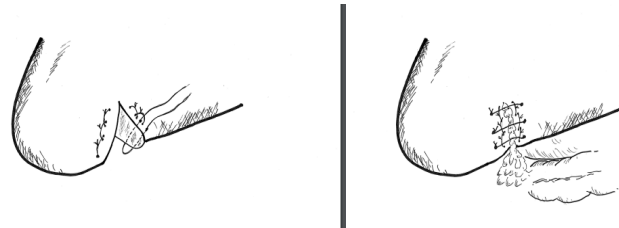


**Fig. 55-20 PACKING THE LIVER FROM INSIDE.** Internal packing of a stellate fracture of the liver using roll gauze. You may need to combine it with external packing. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005* with kind permission.

Packing from within is the stuffing of a crevice or cavity with absorption gauze. Unfold a gauze roll (or 2 or 3, if 1 doesn't suffice) and push it in until the filling exerts outward pressure (55-20). You always need both external & internal packing (e.g. for a stellate fracture of the liver), as the internal packing keeps the liver wound open.

Good packing should provide good control of most venous or solid organ bleeding. If the haemorrhage has stopped, continue your work with the rest of the abdomen and then come back to the liver. Gently remove the packs and note if you can repair the injury primarily. If not, repack.

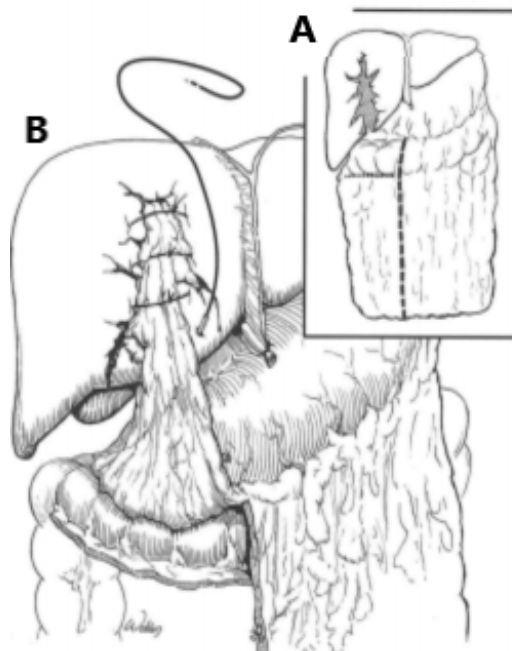
### DEEP LIVER SUTURES



**Fig. 55-21 DEEP HAEMOSTATIC MATTRESS LIVER SUTURES.** A, place sutures parallel to the laceration, or B, over a leaf of omentum. Tie them at right angles. *N.B. You can make long needles by threading a suture through a spinal anaesthesia needle.* After Giannou C, Baldan M, Molde, Á. *War Surgery, ICRC Geneva 2013*

*N.B. Liver suture is very useful in war situations.* The liver capsule must be reasonably intact to hold the suture. Use omentum or pledgets, if you can, to stop the thread cutting through the liver tissue.

### THE PEDICLED OMENTAL FLAP



**Fig. 55-22 PEDICLED OMENTAL FLAP.** A, divide the omentum so both parts retain their blood supply. Use the right-sided part to tamponade a large liver injury. B, suture the omental flap, with its blood supply, onto the liver, taking wide bites of the liver capsule. *N.B. Remove non-viable liver tissue by a finger-fracture technique.* After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005* with kind permission.

### BALLOON TAMPONADE



**Fig. 55-23 BALLOON TAMPONADE.** Introduce a condom balloon (or Foley or Sengstaken tube) into a through-and-through liver defect and inflate it with saline to produce compression from within for haemostasis. Pass its end out of the abdomen through a lateral incision. Deflate the balloon after 48h and assess if bleeding has stopped.

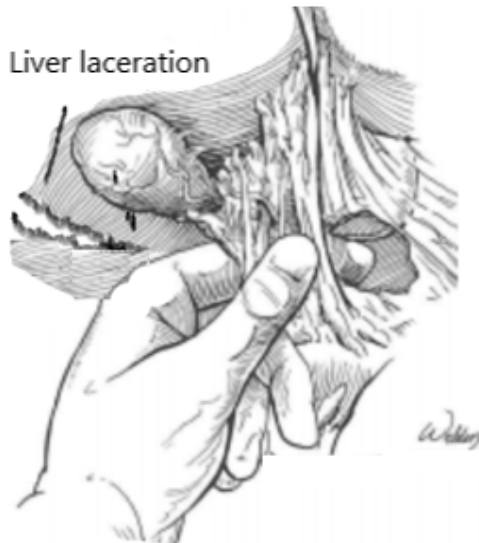
See if you can (1) grasp a lacerated liver between the palms of both hands, (2) use wide deep sutures parallel to the laceration and at right angles across the laceration to draw the edges together (55-21), if enough of the capsule is intact, (3) pack the laceration with a vascularized omental pedicle (55-22), or (4) tamponade a through-and-through penetrating injury with a condom balloon (55-23).

*N.B. Post-operatively, any liver injury will ooze blood and bile; place a closed drain for 24-48h. After 48-72h, re-explore the abdomen and soak the packs with saline & glycerine, and gently remove them.*

**If bleeding is so severe that blood wells up in the wound or hypotension persists,** try pressure on the aorta, (or pinching it between index and thumb) through a hole in the lesser omentum (55.3). Be patient, and find an assistant to take over pressing from you.

**If packing of the liver fails to stop the bleeding,** perform the Pringle manoeuvre: remember though that you have about 20mins only and need c. 8 units of blood to save such a patient with massive haemorrhage!

#### THE PRINGLE MANOEUVRE



**Fig. 55-24 THE PRINGLE MANOEUVRE. This may be life-saving!** Pass a finger through a hole in the lesser omentum into the lesser sac. Pinch the vessels in the portal triad between your index finger and thumb, and clamp them in a Satinsky or bulldog clamp. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

Make a hole in an avascular portion of the lesser omentum to the left of the portal triad (55-24). Put your left index finger into the lesser sac and pinch the vessels in the portal triad between your index and thumb (55-24), and then in a non-crushing clamp. Wait 10mins.

**If the Pringle manoeuvre controls bleeding,** it is coming from branches of the portal vein or hepatic arteries. If the blood is bright red, then selective ligation of the right or left hepatic artery will control the haemorrhage.

These are not end-arteries and will not cause hepatic necrosis. Try to avoid ligation of the common hepatic artery, however, which has a high mortality. If you have ligated the right hepatic artery, then the patient will need a cholecystectomy at definitive repair.

**If pressure, packing, and Pringle don't stop the bleeding,** and blood continues to well up, especially from behind the liver, bleeding is probably from the short hepatic veins entering the IVC posteriorly or the retrohepatic IVC itself. Mobilize the liver medially and pack behind and laterally with two or three sterilized gauze rolls, and bring out their ends through a lateral stab wound. Leave a drain.

Post-operatively, keep the patient lying on the back; the weight of the liver presses on the gauze packs and helps maintain the tamponade effect. After 48h, under light anaesthesia, gently pull out the gauze rolls. If the bleeding has stopped, your patient will survive. If bleeding resumes, proceed to damage control.

Proceed to damage control (41.5. 55.2) if:

- (1) Bleeding has been controlled by packing, but recommences after removal of the packs,
- (2) The damage is too great for primary repair (especially if you are lacking blood for transfusion),
- (3) Hypothermia or acidosis supervene.

Temporarily close the abdomen and monitor the patient in a critical care facility.

**If there is a bile leak,** insert a closed drain. Subsequently the leak may close without further intervention. Rarely, if there is a clean tear of the common bile duct, if the duct is >Ch8 size, and the patient is stable, and access is not too difficult, you may attempt a primary repair. Insert a T-tube proximal to the repair. *don't put this across an injured bile duct,* as a stricture will follow.

The same advice follows iatrogenic bile injuries, usually following cholecystectomy. The definitive procedure, if primary repair is not possible because of loss of bile duct length, is a choledochojejunostomy-en-Y (15.4), which needs an expert.

**If the gallbladder has ruptured,** insert a Foley catheter into the remnants of the gallbladder, and secure the catheter in place, letting it drain into a bag outside the abdomen. *Don't attempt a cholecystectomy in difficult circumstances!*

## DIFFICULTIES WITH LIVER INJURIES

If the wound discharges bile, there is a biliary fistula. Insert a drain and wait till it stops leaking. Add initial antibiotic treatment till a track has formed.

If jaundice supervenes, provided there are no other complications, support nutrition and try to monitor liver function & coagulation.

## 55.8 Retroperitoneal exploration

Retroperitoneal injuries after blunt trauma usually involve the kidneys, or pancreas. Penetrating trauma can injure any retroperitoneal structure. You only need to explore the retroperitoneum in exceptional circumstances; unfortunately, most patients with such severe injuries will die before they reach hospital.

The retroperitoneal space contains significant potential sources of haemorrhage: the abdominal aorta, inferior vena cava, and kidneys. Sources of contamination include most of the duodenum, pancreas, ureters, and posterior aspects of the ascending and descending colon.

Being a closed space, the retroperitoneal space often has a tamponade effect, limiting further bleeding, but this is not always so. Severe retroperitoneal bleeding is usually associated with intra-peritoneal bleeding. So, the indication for retroperitoneal exploration is usually if you have failed to control haemorrhage with packing, or if there is a perforating injury, typically by gunshot wounds.

### ZONES

Deciding whether to explore a retroperitoneal haematoma can be difficult. To help you, divide the retroperitoneal space into 3 imaginary zones having the following sources of bleeding (55-2):

- (a) **Central Zone I:** great vessels
- (b) **Lateral Zone II:** kidneys
- (c) **Pelvic Zone III:** iliac vessels and pelvic bones

In all cases (blunt or penetrating trauma), explore a central Zone I supracolic haematoma: likely pancreatic or duodenal injury will require contamination control.

Explore an infracolic haematoma in all cases of penetrating injury, but only after blunt trauma, if it is expanding or pulsatile.

**N.B. Never explore a psoas haematoma!** This is in effect an extension of an aortic or an IVC injury after penetrating injury. Use a Foley balloon tamponade in the hole!

In general, *don't explore lateral Zone II haematomas*. *Don't attempt to open a haematoma around the kidney! Don't jeopardize a patient's life to save the kidney*. There are always exceptions, of course: a pulsatile or expanding haematoma overlying the injured kidney requires exploration. A nephrectomy is necessary for a totally disrupted kidney.

**N.B. Don't explore a Zone III pelvic haematoma with an intact peritoneum**, usually the case after blunt trauma. If you do, you may well not be able to control the bleeding!

Explore for penetrating trauma, as after a gunshot wound, because of the possibility of injury to the iliac vessels, rectum or bladder. Control of bleeding from the pelvic bones, especially the sacrum, in these cases, is often not successful.

**IN ALL CASES, OBSERVE THE HAEMATOMA. IS IT STABLE? IS IT PULSATING OR EXPANDING?**

### MOST MAJOR VESSEL BLEEDING PRESENTS AS A RETROPERITONEAL HAEMATOMA

Begin by packing over the haematoma and to take a moment to pause and think. Put in retractors (a circular one is ideal), if you have not yet done so.

Plan your next steps, determine what supplies you need (and wait until you get them), and let your anaesthetist catch up with the resuscitation of the patient. Notify your team of your plan and where you will need their help and attention. Gently remove the packs and look again, to confirm your decision to explore or not.

*Don't attempt to open a haematoma around the kidney or a pelvic haematoma! (It will probably start bleeding again.) Don't jeopardize a patient's life to save the kidney.*

There are 2 vital manoeuvres to expose the retroperitoneal space:

(a) **The left visceral medial rotation** (Mattox manoeuvre) mobilizes the left colon and mesentery, spleen and pancreatic tail. This allows access to the side of the suprarenal aorta and left kidney.

(b) **The right visceral medial rotation** (Cattell-Braasch manoeuvre) has 3 stages, mobilizing the duodenum, head of pancreas, right colon and root of the small bowel mesentery. This allows access to the infrarenal aorta, IVC, right kidney, posterior duodenum, superior mesenteric & iliac vessels.

THE LEFT VISCERAL MEDIATION ROTATION (GRADE 3.3) is easier. Pull the descending colon forwards, and divide the peritoneal line of reflection (white line of Toldt) lateral to the left colon from the pelvic brim to the splenic flexure (55-25), just as for a left hemicolectomy (12.11).

### MOBILIZING THE DESCENDING COLON



**Fig. 55-25 MOBILIZING THE DESCENDING COLON.** Left-sided medial visceral rotation; mobilizing the descending colon along the white line of Toldt. After Hirschberg A, Mattox KL. *Top Knife*. 2005 Tfm Shrewsbury with kind permission.

Using your finger, carefully enlarge the plane between the left mesocolon and the retroperitoneum. This procedure is easier than it sounds because the haematoma will have already separated out the peritoneum from the posterior anatomic structures and your hand will easily sweep between them.

*Make sure to leave the ureter and gonadal vessels posteriorly.* Division of the peritoneal reflections holding the spleen will allow you to mobilize the spleen and tail of pancreas medially until you reach the aorta (55-17). This will also mobilize the 4<sup>th</sup> part of the duodenum at the ligament of Treitz.

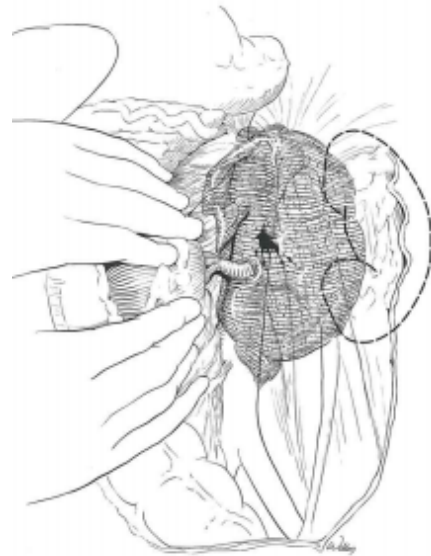
THE RIGHT VISCERAL MEDIAL ROTATION (GRADE 3.4) allows mobilization from the common bile duct to the ligament of Treitz. If you perform all 3 steps, you can put the small bowel and the right colon upon on the chest!

Begin with the classic Kocher manoeuvre (13.5, 55-14A). Make a peritoneal incision lateral to the head of the duodenum and put your hand behind the duodenum to mobilize it and the head of the pancreas forwards.

Mobilize from the common bile duct superiorly to the superior mesenteric vein inferiorly. You may have to mobilize the hepatic flexure of the colon too. This exposes the IVC and the right renal hilum. *Avoid injury to the right gonadal vein* as it enters the inferior vena cava.

The 2<sup>nd</sup> stage continues the incision of the posterior peritoneum towards the white line of Toldt immediately lateral to the ascending colon down to the cecum as in a right hemicolectomy (12.11).

### EXPOSURE OF THE PANCREATIC TAIL, SPLEEN & LEFT KIDNEY



**Fig. 55-26 EXPOSURE OF THE PANCREATIC TAIL, SPLEEN, LEFT KIDNEY.** After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

Mobilize the right colon medially (55-27B). *Be careful to elevate the ureter or gonadal vessels.* This exposes the entire IVC, the right kidney and its hilum and the right iliac vessels.

The 3<sup>rd</sup> stage continues the incision round the cecum and to the left of the small bowel mesentery up the ligament of Treitz (55-27C). Retract small bowel to the patient's left side. Now you should have a view of the entire inframesocolic retroperitoneum including the infrarenal aorta, IVC, iliac vessels and right kidney.

You now have access to the 3<sup>rd</sup> & 4<sup>th</sup> parts of the duodenum and the superior mesenteric vessels.

### EXPLORING HAEMATOMAS

(1) Ask yourself whether this is the correct thing to do at that moment; assess the patient's total physiological burden. Prepare your team and get the necessary instruments ready.

(2) Gain proximal and distal vascular control. You need a tape or clamp for both proximal and distal control. If distal access is difficult, then secure proximal control first and use an abdominal pack to apply pressure over the site of the lesion.

Then slowly remove the clot to isolate the tear in the vessel. Once identified, place the appropriate clamp over or across the lesion.

(3) Early on, decide if you are going to repair or shunt a damaged vessel.

(4) Before any repair or shunting, pass Fogarty (or Foley for the aorta or IVC) balloon catheters of the right size, proximally and distally.

(5) With a syringe and 18G cannula, flush arterial injuries with diluted heparin (10-50U/mL N/saline) proximally and distally to the repair.

(6) *Don't use systemic heparin IV.*

(7) Try to repair large veins if you can, although you can even ligate the IVC if necessary.

(8) Try to get a postoperative arteriogram, if you can, once the patient is stable.

(9) Always perform a distal leg fasciotomy (49.6) on the affected side if the injury involves the common iliac or leg vessels

(10) Make bilateral distal leg fasciotomies if the injury involves the aorta, if it was clamped, or you have ligated the IVC.

*N.B. An aorta in spasm in a fit young person may only be 1cm wide.*

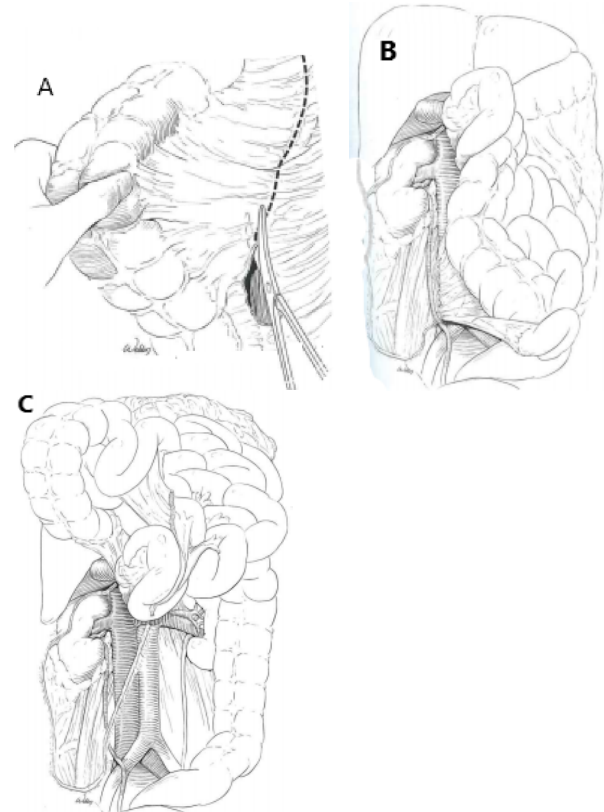
**N.B. Midline hematomas above the mesocolon** require exploration. You need to get proximal control by compressing the aorta above the coeliac axis. Then perform a left medial visceral rotation (55-22) to get distal control of the aorta above the iliac bifurcation.

A lateral suture repair of the aorta or IVC is the best option; anything else is difficult, bloody and often lethal.

Repair of other vessels is fraught with difficulty and needs great expertise; placing a temporary shunt is often the best damage control solution until you get everything under control. Then plan your definitive repair for the second operation.

**N.B. Midline hematomas below the mesocolon** also require exploration after penetrating injury. You need proximal control of the aorta as before. Pull the transverse colon upwards to the patient's left side out of the way. Check if the haematoma is more on the left side. Get distal control and try to make a lateral suture repair of the aorta as before.

## MOBILIZING THE DUODENUM, ASCENDING COLON & SMALL BOWEL MESENTERY ROOT



**Figure 55-27. MOBILIZING THE DUODENUM; ASCENDING COLON & SMALL BOWEL MESENTERY ROOT.** Right-sided visceral medial rotation. **A.** The traditional Kocher manoeuvre (13.5). **B.** the extension mobilizing the descending colon. **C.** a further extension mobilizing the small bowel mesentery. You can then put the colon and small intestine on the chest! After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

*Beware of damaging the left renal vein or IVC.*

**If the haematoma is more on the right, behind the ascending colon,** it is arising from the IVC and you should better leave it alone. The damage control procedure is to place abdominal packs over the haematoma for tamponade effect. When you re-explore, make sure you have plenty of blood for transfusion. This is true for all major vascular injuries.

If you are confident of your technical skills or if the haematoma is still expanding on re-exploration, then you must perform a right medial visceral rotation (55-17, 55-18). Be prepared to ligate the IVC if necessary.

## 55.9 Gastric injury

A missile or stab wound can penetrate the stomach or duodenum. It is also occasionally injured at endoscopy. It is very vascular, and its mucosa readily bleeds.

The presence of free air under the diaphragm on a radiograph is a sign of gastro-intestinal perforation. If the patient cannot sit up, get a lateral view. Use the context of the injury to decide whether this is likely to be gastro-duodenal or intestinal. (You may need a laparotomy to be sure.)

**If there are no signs of peritonitis**, but you still suspect a perforation, ask the patient to swallow 100ml of gastrograffin and take more films.

*Make sure there is a nasogastric tube in place.*

Examine the stomach by lifting its wall up, using the NG tube as an anchor to hold 2 Babcock forceps. Remember if you find one hole anteriorly; *look for another on the posterior surface*. To do this, enter the lesser sac by making a hole in the greater omentum on the left side where it is less vascular (55-28).

### EXPLORING THE PROXIMAL STOMACH



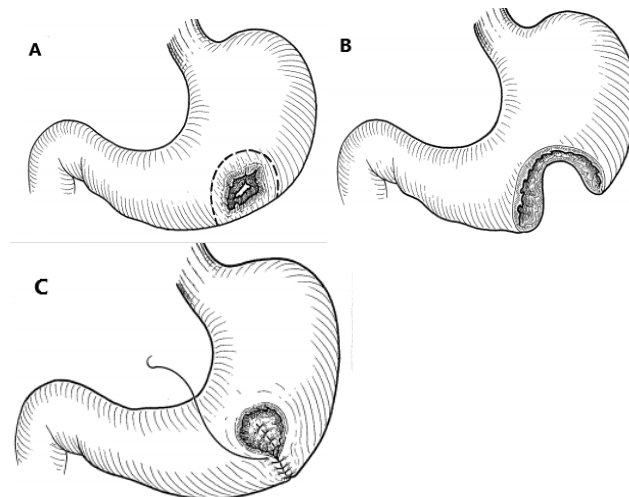
**Fig. 55-28 EXPLORING THE PROXIMAL STOMACH.** Lift up the left lateral liver lobe, and open the posterior peritoneum overlying the oesophagus. Get your index finger round behind it and pull it gently forwards. *N.B.* To look at the posterior gastric wall, and pancreatic body, get into the lesser sac (55-12) by making a hole in the left side of the greater omentum. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

This is similar to treating spontaneous perforations (13.3). Trim the edges of a perforation if they are ragged or non-viable up till fresh tissue, close the hole in 2 layers: continuous long-acting absorbable full thickness & then seromuscular sutures (11-5E), and fix some omentum around the closure with 1-2 sutures.

**If the edges of the hole are very sloughy** from a neglected perforation, *refresh the wound edges & tie sutures over omentum*. Divert the flow, or excise the necrotic portion.

### GASTRIC CLOSURE (GRADE 3.2)

#### CLOSURE OF GASTRIC PERFORATION



**Fig.55-29 CLOSING A GASTRIC PERFORATION.** A, trim back the hole to fresh tissue, B, C, close the defect in 2 layers, starting from the inside posteriorly. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989,

## 55.10 Duodenal & pancreatic injury

The duodenum & pancreatic head are so closely related anatomically that it is rare one is injured without the other, especially in penetrating trauma. The pancreas is a retroperitoneal structure, lying at the level of L1 & L2.

It lies over the IVC, right renal vessels and left renal vein; its uncinete process encircles the superior mesenteric vessels, its body covers the aorta and left renal vessels, and its tail is surrounded by the hilum of the spleen. The body and tail are anatomically practically different organs, as resecting the tail is not so difficult, but operating on the head quite the opposite.

A missile may (usually fatally) penetrate the duodenum and pancreatic head, which are also occasionally damaged at endoscopy.

In blunt trauma, damage is usually caused by deceleration impact (e.g. where the steering wheel is pushed into the driver's epigastrium in a head-on vehicle collision, or where bicycle handlebars crush the midriff of a child).

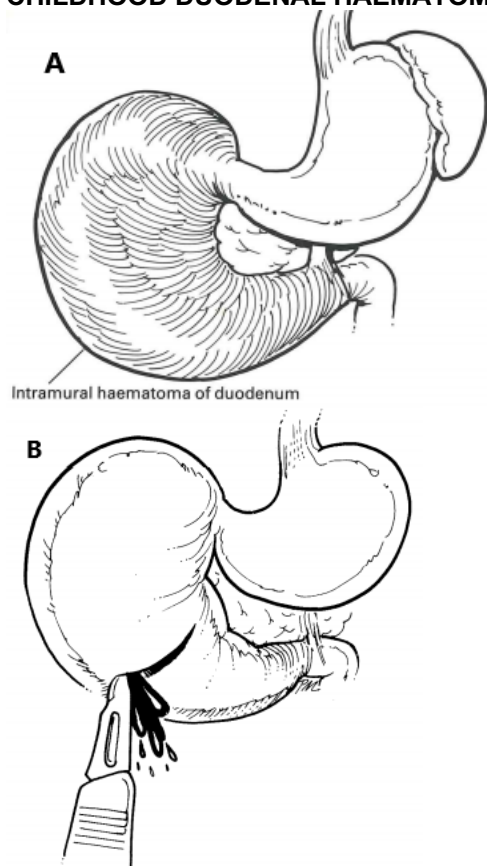
A nasogastric tube may bring up blood from the duodenum, but not always. Neither US nor DPL will reliably diagnose a duodenal or pancreatic injury. Raised serum amylase levels are suspicious but *not* diagnostic, unless tested at least 3h after injury. An abdominal radiograph (especially a lateral view) may show free retroperitoneal air.

#### EXPLORATION

Inspect the duodenum from the pylorus to the ligament of Treitz. For duodenal injuries, a useful temporary measure is to introduce a Foley catheter proximal to the perforation and inflate the balloon. Place a feeding jejunostomy (11.7) if you can.

*N.B.* A perforation at the duodeno-jejunal junction needs proper mobilization, which means dividing the ligament of Treitz, or even performing a right-sided medial visceral rotation (55-18).

#### CHILDHOOD DUODENAL HAEMATOMA



**Fig. 55-30. CHILDHOOD DUODENAL HAEMATOMA:** A, the swelling may completely occlude the lumen. B, a transverse incision laterally in the serosa only drains the blood. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989,

**If non-bilious vomiting follows a direct blunt epigastric injury in a child**, suspect an intramural duodenal haematoma (55-30A). Introduce a nasogastric tube.

A plain abdominal radiograph may show a 'coiled spring' sign reminiscent of an intussusception. The haematoma may completely obstruct the duodenal lumen. Incise this with a small transverse incision on the serosa of the lateral aspect of the 2<sup>nd</sup> part of the duodenum (55-30B), and drain the haematoma, which typically liquefies some days after injury.

**If there is a periduodenal haematoma, or greenish discoloration**, perform a Kocher manoeuvre (13.5) and look at the posterior surface of the duodenum for a perforation. Check if the pancreatic head is damaged. *If there is emphysema (air) in the tissues*, suspect a colonic injury.

Because of its location, the pancreas lies hidden. Explore the lesser sac, and look at the pancreas through the greater omentum (55-28). To expose it, perform a left medial visceral rotation (55-22).

**If the pancreas is damaged**, it is very likely there will be significant bleeding also. This, and any leakage of pancreatic fluid may not be evident initially, but will give rise to peritonitis and fat necrosis later.

#### DUODENAL CLOSURE (GRADE 3.3)

For simple perforations, proceed as with gastric perforations. *Don't struggle to make a transverse closure*. Use omentum to bolster your repair.

**If the hole is not easily accessible, or not easy to close**, *don't try to cobble together the wound*. Divert the gastric contents by creating a gastrojejunostomy (13-16). Close the pylorus from inside with an annular absorbable suture (pyloric exclusion), which will dissolve after 3-4 weeks, thus re-opening the pylorus.

**If there is a large duodenal injury**, where repair is impossible, perform an upper rectus abdominis plasty (13.3).

#### MANAGEMENT OF PANCREATIC INJURY

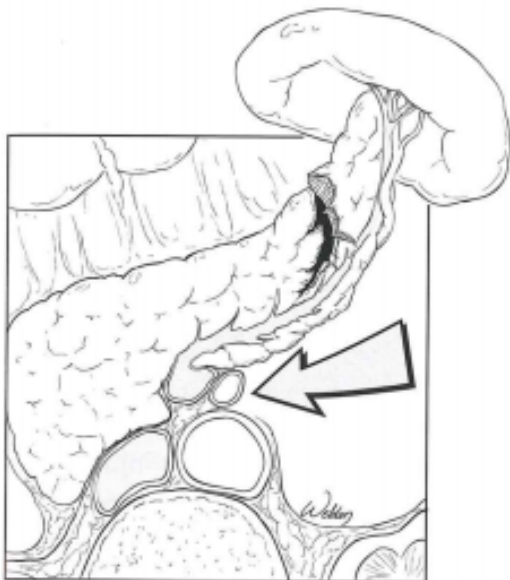
You might have to pack bleeding here; **don't open a stable retroperitoneal haematoma!** You will be able to do little else for significant bleeding, apart from clamping the aorta (55-12). The crucial element, apart from bleeding, is whether the pancreatic duct is damaged. However, this is often not easy to see, unless the pancreas is split in two. Remove as much necrotic pancreatic tissue and infected material as possible. A CT scan or an ultrasound will help delineate what parts need removal.



For a proximal pancreatic injury near the duodenum, leave a wide-bore drain to the pancreatic bed. This will control a pancreatic fluid leak. Often you need to leave an abdominal pack over the pancreas as well. Bypass the pylorus with a gastrojejunostomy.

Otherwise, and especially for injury to the body of the pancreas, make 2 parallel running through-and-through non-absorbable locking sutures to ligate the pancreas proximal to where you wish to divide it (or use a linear stapler across the organ).

### DISTAL PANCREATECTOMY



**Fig. 55-31 EXCISING THE DAMAGED DISTAL PANCREAS.** Hold up the spleen (with packing around it) and the mobilized distal portion of the pancreas. If you have a linear stapler, use this to amputate the pancreas; otherwise use a through-and-through non-absorbable locking suture. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

### DISTAL PANCREATECTOMY (GRADE 3.5)

For a distal pancreatic injury, mobilize the spleen and the posterior aspect of the pancreatic tail from its bed *en bloc*, till you can lift it up to the midline. Then resect the injured part; a linear stapler is very useful for this (55-31).

**If you can locate the pancreatic duct**, tie it off doubly with a non-absorbable suture; in any event *always leave a wide-bore drain*.

*Post-operatively the serum amylase level will be raised, but usually settles after 72h.* Add a feeding jejunostomy (11.7) for better nutrition.

### DIFFICULTIES WITH PANCREATIC INJURIES

**If the drain continues to pour out >2L/day**, a high output fistula has developed. This is unlikely to close spontaneously (as other fistulae will), and needs expert attention. Keep fluids and electrolytes replaced.

**If a swelling develops in the left upper abdomen**, this is a pancreatic pseudocyst (15.14). Drain this as non-traumatic pseudocysts through a Roux-en-Y jejunal anastomosis, or directly into the stomach. *Don't drain it externally*, especially if there might be a pancreatic duct injury.

**If a fever develops whose origin is obscure**, consider infected haematomas, or a pancreatic abscess owing to inadequate removal of necrotic pancreatic tissue. This needs necrosectomy & drainage of infected material.

## 55.11 Small bowel injury

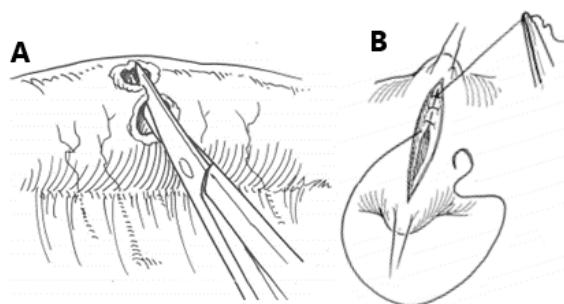
Blunt injuries either tear or burst small bowel, especially if it is full, by pressing it against the spine. Penetrating injuries from bullets or knives frequently make holes in the small bowel and its mesentery. You must therefore take great care to look at all the bowel meticulously with your assistant.

*Make sure both of you are looking at the bowel when you examine it on each side!* It is easy to miss a perforation adjacent to the mesentery. *Be suspicious: make sure you look for an extra perforation if you count an odd number of them!*

### CLOSURE (GRADE 3.2)

*Don't start the repair until you have examined the entire bowel and identified all the damage!*

### ADJACENT SMALL BOWEL PERFORATIONS

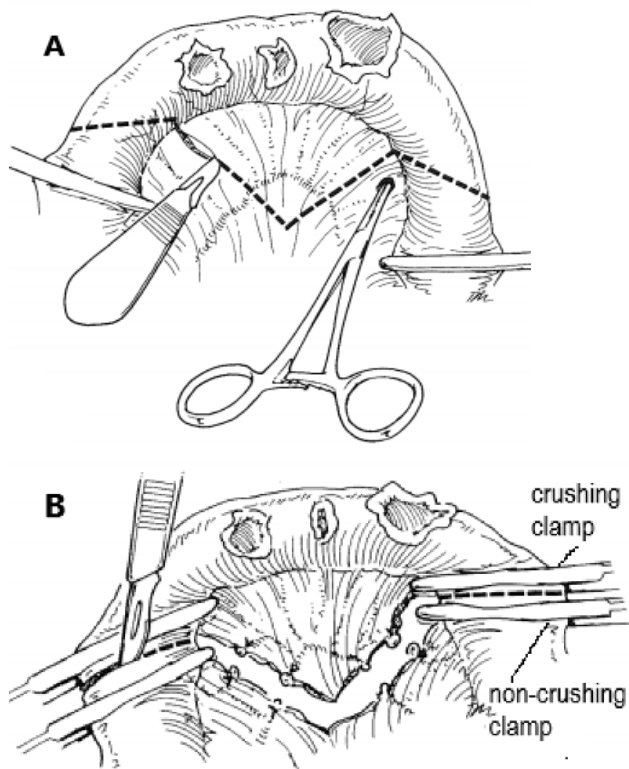


**Fig.55-32 JOINING TOGETHER ADJACENT SMALL BOWEL PERFORATIONS.** A, debride the edges to fresh tissue. B, close the wound *transversely* in 2 layers. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989,

**If there are only a few small-sized perforations**, repair these with 2 *transverse* continuous layers of long-acting absorbable Lembert seromuscular sutures (11-5E), *provided there is no gross soiling*. *Make sure the edges of a perforation are healthy and bleed nicely*; if it is bluish or ragged, trim it till you get to healthy bowel.

Cover the closures with omentum if you can, *but don't suture the bowel to omentum* because that creates a route for an internal hernia.

### MULTIPLE SMALL BOWEL INJURIES



**Fig.55-33 RESECTING MULTIPLY INJURED BOWEL.** A, incorporate all the injuries into one segment for resection. Divide the mesentery and clamp its vessels by making holes in it. B, place a crushing clamp on the side you will remove, and a non-crushing clamp on the side you will save to anastomose. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989,

If there are several perforations, mark each with a suture to save time searching for them later. Try to minimize the number of anastomoses or closures by resecting a badly injured segment.

If the omentum is injured, excise the affected segment.

*N.B* Although your aim is to avoid contamination, make your repair carefully so it will last! This is definitive therapy.

*N.B.* A longitudinal closure along the bowel is likely to produce a stricture: always use a transverse closure (55-32B).

*N.B.* A gunshot wound may make considerable damage to bowel. Don't leave parts, however small, whose condition is poor, or whose blood supply is suspect.

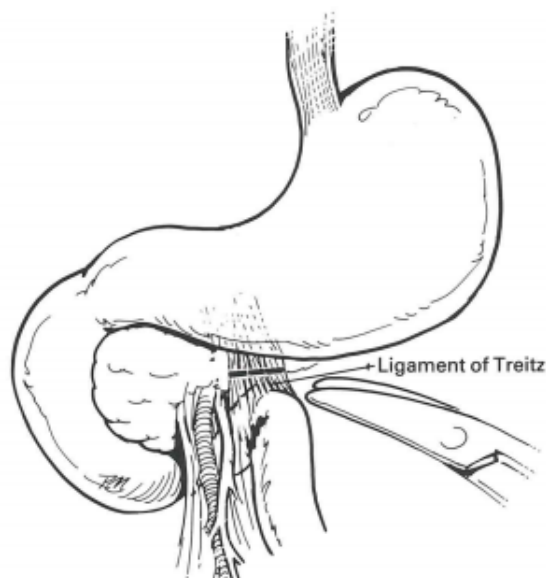
*N.B.* Perforation close to the duodenojejunal flexure occurs in deceleration injuries, as this part is fixed by the ligament of Treitz. Unless you divide this ligament, you may not see the injury (55-34).

### Small bowel resection (55-33B) is indicated for:

- (1) major disruption of the bowel lumen,
- (2) multiple perforations (in a segment <50% the length of the bowel)
- (3) disruption of the mesenteric border
- (4) compromised blood supply (55-39)

If there is much soiling or bleeding, isolate the perforated segments with tapes (55-35); close the perforations only if the patient's condition is good. Put warm packs over bowel of questionable viability.

### BOWEL INJURY AT THE D-J FLEXURE



**Fig. 55-34 BOWEL INJURY AT THE D-J FLEXURE.** A deceleration injury may damage the bowel where it is fixed at the ligament of Treitz. Incision of this ligament will allow you to see & repair the damage. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989,

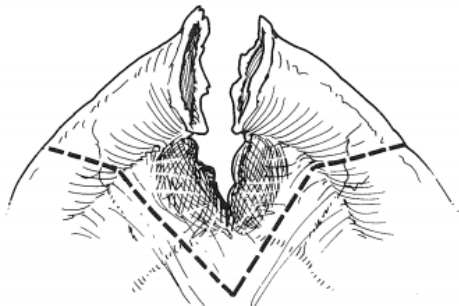
### PUTTING TAPES TO ISOLATE BOWEL



**Fig. 55-35 PUTTING TAPES TO ISOLATE A BOWEL PERFORATION.** This can also be used as a damage control method. After Hirschberg A, Mattox KL. *Top Knife*. Tfm Shrewsbury 2005 with kind permission.

## 55.12 Mesenteric injury

### INJURED MESENTERY COMPROMISING THE BOWEL BLOOD SUPPLY



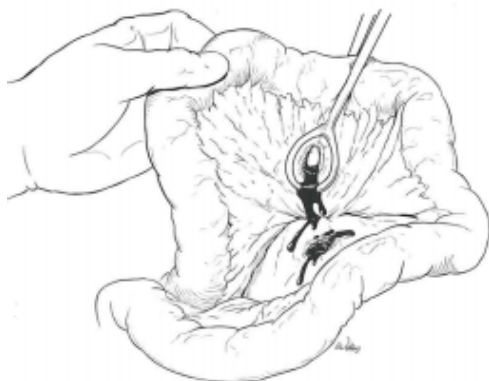
**Fig. 55-36 INJURED MESENTERY COMPROMISING THE SMALL BOWEL BLOOD SUPPLY.** In both circumstances, resect the bowel & mesentery as shown. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989.

The mesentery can bleed profusely after an open or a closed injury. As its vessels are loosely held in fatty tissue, they can bleed quite copiously within the mesentery and form an expanding haematoma, which itself may occlude blood supply to the bowel.

**If there is a haematoma in the small bowel mesentery**, grasp the mesentery between your fingers to see if you can stop the bleeding, or use a sponge-holding forceps (55-37).

Then carefully open the mesentery to find the bleeding vessel, clamp and ligate it. *Don't put blind figure-of-8 sutures in the mesentery hoping you might arrest the bleeding!* A laceration of the mesentery may impair blood supply to the bowel; check if ligating such a vessel makes the bowel become purple. If so, resect that portion.

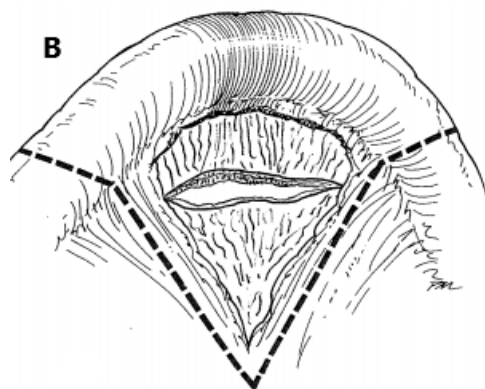
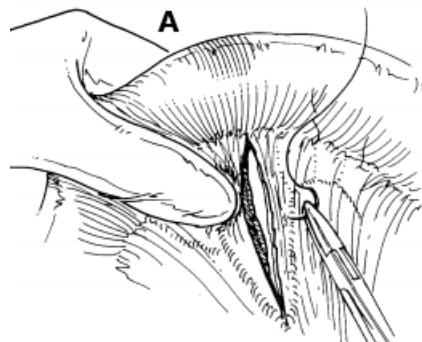
### CONTROLLING SMALL BOWEL MESENTERY BLEEDING



**Fig. 55-37 USING SPONGE-HOLDING FORCEPS TO CONTROL BLEEDING FROM THE SMALL BOWEL MESENTERY.** This is a useful method if pressure with your fingers does not succeed: beware that the handles of the forceps does crush the bowel: you may need to empty that segment into a bowl outside the abdomen beforehand. After Hirschberg A, Mattox KL. *Top Knife. Tfm Shrewsbury 2005 with kind permission.*

Examine the anatomy of the small bowel mesentery. You should ligate the vessels & repair short radial tears, perpendicular to the bowel (55-38A), with interrupted sutures in order to avoid any gap for a future internal hernia.

### MESENTERIC LACERATIONS



**Fig. 55-38 MESENTERIC LACERATIONS.** A, radial tears often allow the small bowel to receive enough blood supply through the vascular arcade. B, transverse tears usually cause bowel ischaemia, needing resection. *Always check the viability of bowel before closing the abdomen.* After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989.

When the mesentery is torn, division of any of the distal vessels near the bowel is usually not a problem. At the root of the mesentery, *be very careful. Don't ligate the superior mesenteric artery;* bowel ischaemia will follow. Get your hand behind it and pinch the bleeding area between fingers and thumb. Then carefully open the serosa of the vessel to see where the damage is, and try to repair it. *Be careful with tributaries of the superior mesenteric vein which avulse easily.*

**If blood is on the surface of the bowel**, it is usually from a mesenteric vessel. Compress this between your fingers or clamp it with sponge forceps.

Transverse mesenteric lacerations (55-38B) often divide the blood supply producing bowel ischaemia: you need then to resect the affected segment of bowel and perform an anastomosis.

If there is a haematoma in the large bowel mesentery, especially related to a fractured pelvis, you can usually leave it alone, unless it is expanding. Palpate the artery along the colon to see if its viability is likely to be impaired. Otherwise, explore the underlying vessels as before. *With a penetrating injury, you must explore the haematoma.*

Examine the anatomy of the large bowel mesentery; even if a supply vessel is damaged, the collateral blood supply to the colon may remain sufficient, but *this does not apply to injuries of the inferior mesenteric & left colic arteries (55-39).*

### LARGE BOWEL MESENTERY LACERATIONS

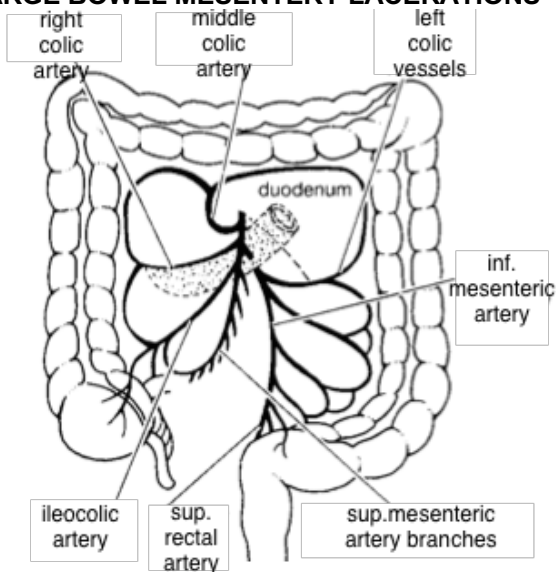


Fig. 55-39 LARGE BOWEL MESENTERIC VESSELS. Arcades near the bowel support its blood supply, but lacerations of the inferior mesenteric & left colic arteries are likely to cause bowel ischaemia.

### 55.13 Large bowel injury

Blunt injury rarely damages the colon (unless the caecum is distended), but penetrating injuries from bullets or knives frequently do. Perforations are also sometimes caused by endoscopy.

**If, on opening the abdomen, you smell a foul faecal odour,** look at the colon & rectum. *Take great care to look at all the bowel meticulously with your assistant.*

*Make sure both of you are looking at the bowel when you examine it on each side! Make sure you look for an extra perforation if you count an odd number of them!*

It is easy to miss a perforation on the posterior wall of the colon, or in the pelvis. Leakage into a closed retroperitoneal or pelvic space may easily result in septicaemia.

Leaks from the large bowel contain anaerobes and other faecal organisms which are particularly lethal.

Rectal bleeding suggests an injury to the bowel, small or large.

### MANAGEMENT

You must take many factors into account, because not all large bowel injuries are the same. What you do must depend on your experience, not only in performing the surgery but especially in evaluating the situation.

Your options are:

- (1) Direct primary suture.
- (2) Resection with anastomosis without faecal diversion.
- (3) Resection with anastomosis & faecal diversion.
- (4) Resection without anastomosis (Hartmann's operation or closing proximal & distal ends temporarily as damage control)
- (5) Colostomy or exteriorization (either as semi-definitive, or damage control).

Your decision should depend on the:

- (1) size of perforation,
- (2) extent of faecal soiling,
- (3) delay since the injury,
- (4) presence of other organ injury,
- (5) extent of blood loss & shock,
- (6) need for a damage control approach (41.5).

Normally do what is safest for the patient, taking your experience & the patient's general condition into account. *Don't launch into difficult surgery for an unstable patient!*

In general:

- (1) Small perforations with no, or minimal, soiling, you can close with a 2-layer suture. A perforation at endoscopy is usually clean unless the colon was not well emptied beforehand, so you can close this readily.

(2) *Don't hesitate to treat several perforations by resection* (ileo-caecal resection (12.7), right hemicolectomy (12.11), transverse colectomy, or left hemicolectomy (12.11)).

(3) After resection, if all the conditions are favourable, perform an anastomosis. If less than completely favourable, protect this with a proximal defunctioning colostomy (11.6) or caecostomy, or ileostomy (ghost or formal) (11.5)

(4) If conditions are not at all favourable after resection, bring out the cut ends as:

- (a) a double-barrel colostomy or,
- (b) an exteriorization (12.9) of the injured colon itself or,
- (c) (for the lower sigmoid and rectum), a Hartmann's operation (12.9).
- (d) (for the right colon & caecum), an ileostomy and colonic mucous fistula.

Here are some technical hints:-

- (1) If there is a sero-muscular tear without penetration of the mucosa, suture-plicate it.
- (2) If there is a faecal smell or a retroperitoneal haematoma (especially with surgical emphysema), mobilize the whole colon to examine the posterior walls.
- (3) *Don't perform an anastomosis under tension:* mobilize the bowel adequately.
- (4) Cut back the edges of the colon to where it is viable, bleeding freely, before fashioning an anastomosis; cut the anti-mesenteric border more than the mesenteric, thus creating an oblique cut.
- (5) Mobilize the large bowel adequately when making a stoma to prevent retraction, especially in an obese patient.
- (6) When fashioning a proximal colostomy and distal mucous fistula, place them as close together as possible in order to make the anastomosis easier later on.
- (7) *In damage control, don't attempt to create any anastomosis or stoma.*
- (8) *Never place a stoma inside a stab wound, or within your original abdominal incision.*
- (9) *Don't forget to administer antibiotics!*

**If you do find a rectal perforation**, perform a laparotomy; you need to see how badly a penetrating injury has soiled the peritoneal cavity; perform a proctoscopy in the early post-operative period for an assessment.

#### MANAGEMENT OF A RECTAL INJURY

Put the patient in the lithotomy position, so you can operate from above or below.

**If there is active rectal bleeding**, try to see from where it is coming: for this you need a good light and suction. If you cannot identify the source, pack the rectum.

Begin by performing a laparotomy and wash out the pelvis thoroughly. If you find active bleeding, deal with this before controlling the contamination (55.2).

Then turn your attention to the perineum, and debride any wounds around the anus or buttocks. Palpate any deep wounds carefully: instilling dye may help you identify if they penetrate the rectum.

Check for pelvic fractures, and any injury to vagina, urethra, ureter or bladder.

For an extra-peritoneal injury, debride the wound edges as necessary and attempt a closure if the wound is easily accessible. Otherwise leave it to close on its own. *Always fashion a defunctioning sigmoid colostomy* where there is a significant rectal injury (11.6)

**If there is active abdominal bleeding**, deal with this before trying to control the contamination (55.2).

**If there is a large pelvic haematoma with a penetrating rectal injury**, explore the haematoma to see if the origin is from iliac vessel branches or fractured bone. Tie a torn vessel if you can; otherwise pack the pelvis, fashion a defunctioning colostomy away from the injury, and wash out the distal colon and rectum.

**If there is a pelvic fracture penetrating the rectum**, but no intra-peritoneal injury, perform a defunctioning colostomy and wash out the distal colon and rectum.

*Don't, in this case, contaminate the peritoneal cavity by opening the retroperitoneal space!*

*N.B. Don't rely on pre-sacral drains: they achieve little in practice and may complicate a rectal injury further. Never perform an anal stretch!*

**If a rectal foreign body is *in situ***, and you suspect a perforation, anaesthetize the patient, and try without force to extract the foreign body (26.11). This may mean an approach *via* a laparotomy.

### 55.14 Renal injury

Although the kidneys are in a protected retroperitoneal position, blunt injury to them with visible haematuria is quite common. Fortunately, you rarely have to intervene unless the injury causes serious bleeding, and then other organs are usually damaged, such as the liver or spleen, and require a laparotomy. The kidneys are more vulnerable in children.

Penetrating injury can obviously injure the kidney just like any other intra-abdominal organ.

Suspect a kidney injury if the posterolateral parts of the 10-12<sup>th</sup> ribs are fractured. A perirenal haematoma or urinoma may cause a paralytic ileus. There is usually pain and sometimes tenderness in the flanks, and scoliosis towards the injured side.

The presence or absence of haematuria can mislead you. Even in serious kidney injuries there may be no haematuria; it appears only if the calyceal system has been entered. On the other hand, any severe abdominal injury can provoke microscopic haematuria without significant damage to the kidneys.

*N.B. There may be no haematuria if shock has made the patient oliguric.*

Mild injuries cause just a small break in the renal capsule and a small haematoma (Grade 1-2); more serious injuries involve the renal pelvis or calyceal system (Grade 3-4), and may damage a major artery or vein. Most seriously, the kidney may be shattered or avulsed from its pedicle (Grade 5) (55-40).

### INVESTIGATIONS

*Always test the urine.* You can take blood-stained urine from the victim in test tubes, and watch if the urine becomes more diluted or not as you collect further samples.

An ultrasound scan can show a perirenal haematoma or urinoma, but tells you nothing about renal function. Provided the patient is not in shock, perform a double-dose contrast intravenous urogram (IVU, 38.1A) This is especially useful in penetrating injuries and if there is frank haematuria. You may see extravasation, a pelvi-ureteric junction rupture, or any anatomic abnormality (horseshoe or polycystic kidney, hydronephrosis, or congenital absence).

*It will also tell you if the contralateral kidney is functioning! But don't rely on this if the patient is hypotensive!!*

*N.B. (1) A hydronephrotic kidney is more liable to damage than an unenlarged one. (2) A child's kidney is less protected by ribs, Gerota's fascia & less perirenal fat and so is more easily damaged.*

A cystoscopy is only useful if you find haematuria, but you have ruled out a kidney injury.

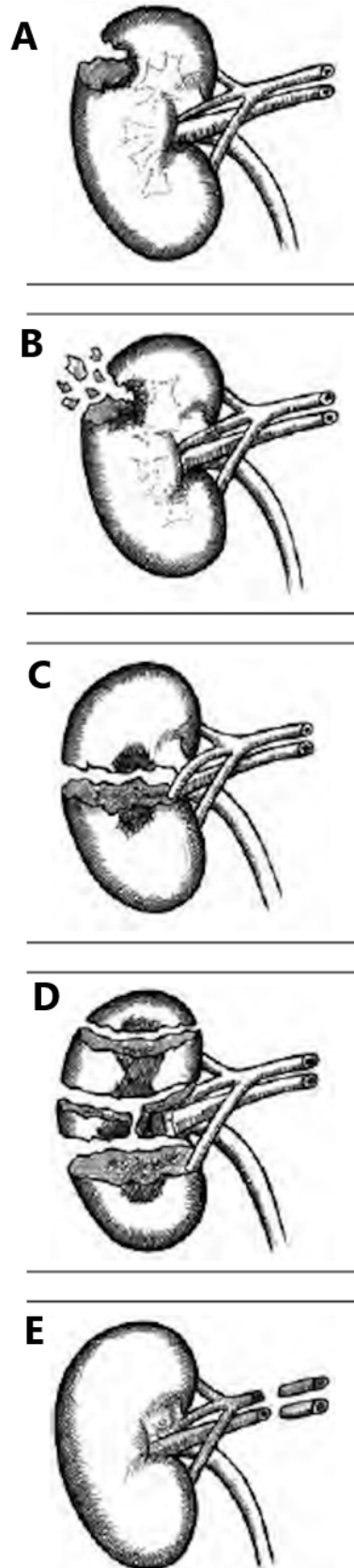
If your theatre is equipped for it with a mobile X-ray machine, you can perform an intra-operative double-dose IVU if necessary to make sure the other kidney is working.

Otherwise, an IV injection of dye (methylene blue or indigo carmine) will allow you to visualize its excretion directly: just insert a very thin needle into the renal pelvis and aspirate urine to make you are in a calyx.

### MANAGEMENT

The kidneys are surrounded by Gerota's fascia, which acts as a natural tamponade in blunt injury. Most blunt injuries are relatively minor and can be treated conservatively.

### TYPES OF KIDNEY INJURY



**Fig. 55-40 GRADES OF KIDNEY INJURY. A, I parenchymal laceration without urine leak. B, II deep laceration into a calyx with urine leak. C, III complete rupture. D, IV shattered kidney. E, V vascular pedicle injury. After Giannou C, Baldan M, Molde, Á. War Surgery, ICRC Geneva 2013**

Make sure the victim has a good fluid intake: damaged kidneys must not suffer further injury to the renal tubules because of dehydration! Closely observe the urine output (which should be 250ml/8h), make serial checks of Hb or haematocrit, and colour of the urine. It might take 10 days till the urine clears.

**If the patient becomes anxious, is in severe pain, and loses appetite**, then something is wrong. Serial plain radiographs or ultrasound scans may show increase in size of a soft tissue shadow of a haematoma; a repeat IVU may be of great value.

**If there is severe kidney injury, and the patient is becoming unstable, or there is important injury to other organs**, proceed to laparotomy. Follow the procedure for controlling haemorrhage first (55.8). Pack the abdomen and/or retroperitoneal space and inspect. *Don't rush to explore the retroperitoneum!*

*N.B. Even if there is a serious kidney injury, this will buy you time!*

**If there is an expanding haematoma in the flank or a penetrating injury**, you must explore.

*N.B. Late diagnosis is not unusual.*

Get control of the renal pedicle first. Open the haematoma through a medial visceral rotation (55-26,22). The presence of the haematoma makes dissection easier; sweep your hand through the haematoma to the kidney. Scoop out the blood and clots, and carefully pack the space round the kidney. Ask your assistant to compress the packs around the kidney.

Where Gerota's fascia is ruptured, the location of the kidneys in the renal fossae make for a natural space to pack during a laparotomy.

**If only part of a kidney is severely damaged**, debride this, performing a partial nephrectomy, and either close the cortex if you can or suture in place an omental patch, after closing the renal pelvis (55-40D,D). Alternatively, if the damage is more superficial, close the wound in layers (55-40E,F). Insert a nephrostomy drain and also a closed suction drain in the perirenal space.

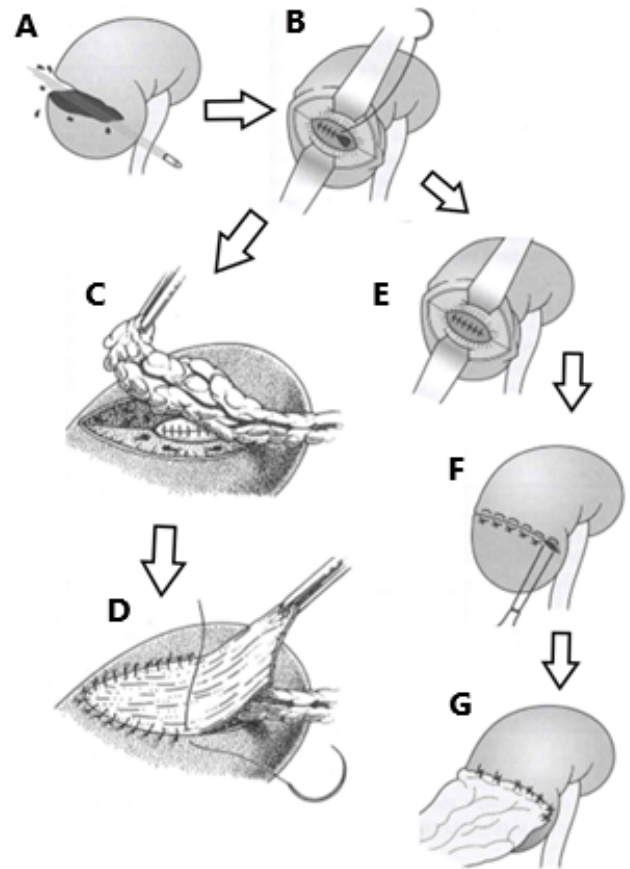
*Don't forget to label which is which!*

*N.B. Try to preserve renal tissue in children.*

**A shattered kidney requires a nephrectomy**, and this is the usual result of injury to the renal vessels.

To attempt a repair of the renal artery, you will have to perform a left (55-26) or right (55-27) medial visceral rotation for good access. You can ligate the left renal vein without any problem if this is the only vessel injured; the gonadal and adrenal veins will assure the drainage.

#### REPAIR OF A KIDNEY LACERATION



**Fig. 55-41. RENAL REPAIR (GRADE 3.5).** A, gunshot injury sparing the central part of the renal pelvis. B, after debridement. C,D, omental patch. E,F repair in layers. G omental cover. After Boffard KD ed, *Manual of Definitive Surgical Trauma Care*. CRC 3<sup>rd</sup> ed. 2011.

*N.B. Nephrectomy is heroic, difficult surgery. Pack the kidneys first of all and assess the situation, especially the presence and functioning of the other kidney before proceeding to nephrectomy. Resuscitate the patient; blood transfusion is often needed. Consider if you should operate or refer the victim.*

Nephrectomy requires control of the renal hilum first: these vessels need great care; *the kidney also may easily tear on rough handling!*

### 55.15 Ureteric injury

Most injuries to the ureter are not diagnosed on table but delayed postoperatively because of complications. An IVU or injection of dye intra-operatively are of great help in diagnosis.

*N.B.* The ureter is protected behind the peritoneum, but may of course be injured by a penetrating object, or adjacent blast injury which ruptures its blood supply. Avulsion may occur in children.

Direct inspection during laparotomy is the best diagnostic tool, but you must know when to explore, especially after penetrating injury.

*N.B.* There is no haematuria in 50% of cases. Avulsion may occur in children. The ureter is of course vulnerable in obstetric and gynaecological (23.15) and any pelvic surgery!

The most common signs and symptoms of delayed presentation are pain in the flank, prolonged paralytic ileus, fever, urinary leakage through drains, and deteriorating renal function tests.

**If there is a high- or mid-ureteric injury**, excise the damaged portion, but *don't dissect off the tissues adjacent to the surviving portion of ureter* because you will then disrupt its delicate blood supply (55-41A,B).

**If the damaged segment is small**, perform an ureteric anastomosis with 4/0 interrupted long-acting absorbable suture. Make spatulated ends of the proximal and distal segments by an incision on opposite sides of the ureter (55-41C).

Start by putting two stay sutures (55-41D). Fashion an end-to-end anastomosis over a double-J-stent, which you must pass into the renal pelvis & and the bladder, so it does not migrate up or down, and you can retrieve later it by cystoscopy.

If you don't have cystoscopy available, bring out the bladder end suprapubically. The final anastomosis should look bulbous (55-41E).

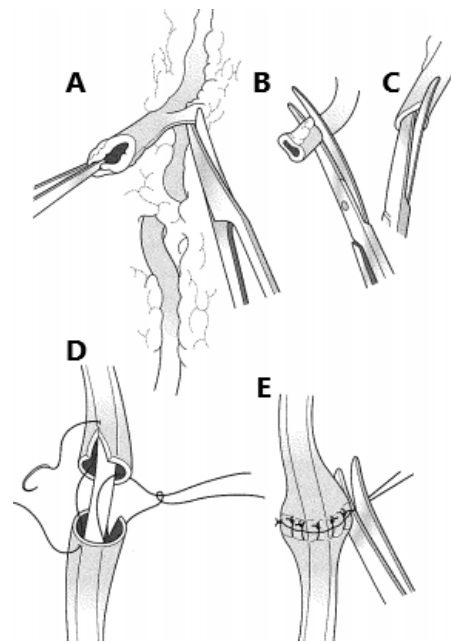
A paediatric feeding tube is a good alternative to use as a stent. Alternatively, use a fine T-tube as a stent, bringing out the long leg of the T to the abdominal wall. *Don't fashion an external ureterostomy (uretero-cutaneous fistula)*, as this will stenose, and cause ascending infection.

Check that the other ureter is intact.

Add a defunctioning nephrostomy (27-15) if you think the anastomosis might stenose, or you have no double-J stents (or home-made variations, 23.15), or if the ureteric injury is close to the pelvi-ureteric junction.

**If the ureter is damaged close to the bladder**, re-implantation of the ureter is necessary. If you cannot do this, drain the urine either via a nephrostomy or a T-tube. Reflux of urine up the ureter does not normally occur because the ureter passes through the bladder muscle wall, and its contraction prevents this.

### URETERIC REPAIR & ANASTOMOSIS



**Fig. 55-42 REPAIR OF THE URETER.** A, carefully dissect off tissue around the damaged ureter. B, cut off the damaged part. C, make spatulating incisions on opposite sides of the proximal & distal parts. D, make an anastomosis with interrupted sutures over a stent. E, final result. After Boffard *KD ed, Manual of Definitive Surgical Trauma Care. CRC 3<sup>rd</sup> ed. 2011.*

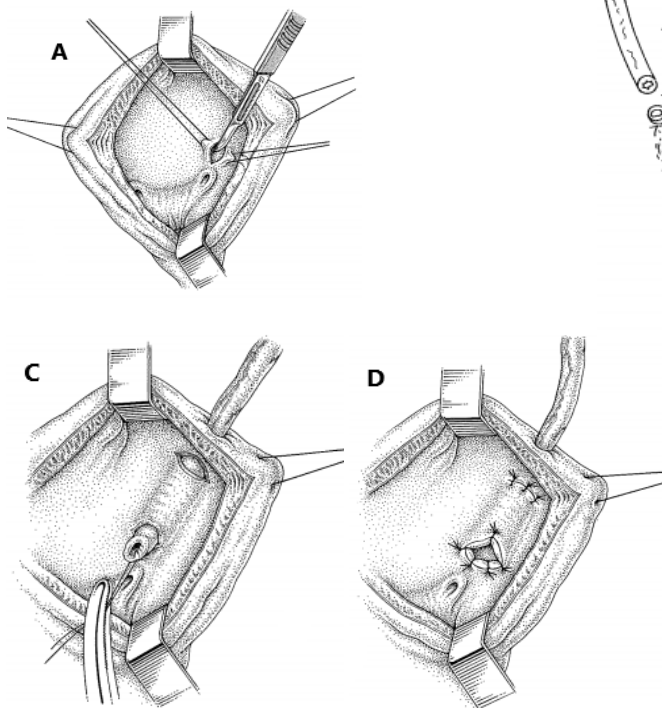
Therefore when you re-insert a divided ureter into the bladder, you must make a tunnel in the bladder wall to pull the ureter through. You may also have to create an elongation of the bladder to reach the ureter, particularly if some length of the ureter is lost.

### URETERIC RE-IMPLANTATION (GRADE 3.3)

Open the bladder with a vertical incision, and identify the ureteric orifice. Insert 2 stay sutures above & lateral to it, and open the bladder mucosa between these sutures (55-43A). Then use a large angled forceps to create a submucosal tunnel towards the top of the bladder on the affected side (55-43B, 55-44), and make an opening there.



## RE-IMPLANTING THE URETER



**Fig. 55-43 RE-IMPLANTING THE URETER.** A, make an incision above & lateral to the ureteric orifice. B, fashion a submucosal tunnel with an angled forceps. C, manipulate the ureter through the tunnel. D, fix it with everting sutures. After Dudley H, Carter D, Russell RCG (eds), *Trauma Surgery Part 1 in Rob & Smith's Operative Surgery*, Butterworth, London, 4<sup>th</sup> ed. 1989.

Attach a suture (or soft tube) to the proximal end of the divided ureter, check that you have sufficiently mobilized it, and gently manipulate it through the bladder tunnel.

Fix the end of the ureter with interrupted everting 4/0 long-acting absorbable sutures (55-43C), and close the other end of the tunnel (55-43D). Finally close the bladder in 2 layers, and leave a catheter & pre-vesical drain.

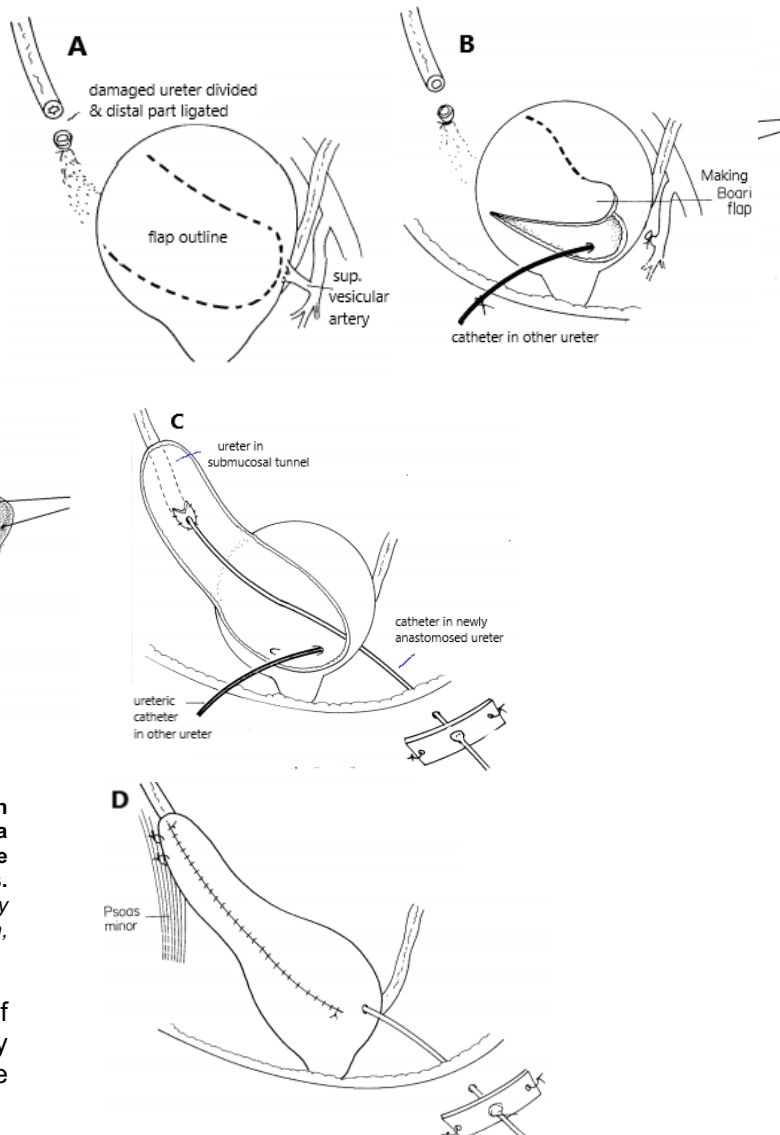
*N.B. Delayed long-acting absorbable is needed for ureter repair, but catgut will work adequately!*

## NON-REFLUX RE-IMPLANTATION TECHNIQUE



**Fig. 55-44 NON-REFLUX RE-IMPLANTATION TECHNIQUE.** Make a submucosal tunnel of at least 3cm length to prevent reflux proximally.

## BOARI FLAP NEO-URETEROCYSTOSOMY



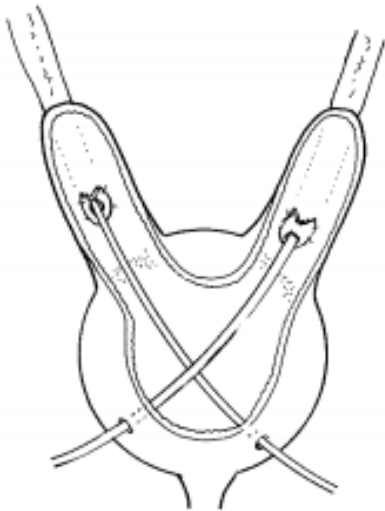
**Fig. 55-45 BOARI FLAP NEO-URETEROCYSTOSOMY (GRADE 3.4).** A, divide the damaged ureter & ligate its distal end. Mark out the flap with enough length with 3 stay sutures. B, cut out the flap, ensuring haemostasis with ligatures *not* diathermy. C, catheterize the other ureter (to protect it) & make a submucosal tunnel to pull the divided ureter through. D, close the bladder, and fix it to the *psoas minor* if there is tension on the anastomosis. After Blandy J, *Operative Urology*, Blackwell, Oxford 2<sup>nd</sup> ed, 1986.

*Don't use other techniques* such as anastomosing one ureter onto the other, or using the appendix as a conduit, or using omentum to close a perforation, as they are more likely to cause complications.

*N.B. This may look pretty daunting if you haven't done any urological surgery before. However, the great advantage is you need not feel pressed for time, and you can prepare a clean field. Make sure access and light are adequate!*

**If both ureters are damaged**, you can prepare a double Boari flap (55-46).

## DOUBLE BOARI FLAP



**Fig. 55-46 DOUBLE BOARI FLAP** if both ureters need re-implantation. After Blandy J, *Operative Urology*, Blackwell, Oxford 2<sup>nd</sup> ed, 1986.

## 55.16 Abdominal closure after trauma

### DAMAGE CONTROL CLOSURE

**When you have finished your damage control**, (also called an abbreviated laparotomy), check: Have you stopped bleeding? Are packs in place & ligatures placed? Have you counted the packs left in the abdomen, and noted their position? Have you controlled the source(s) of contamination, tied off or stapled injured gut, or placed any necessary drains over the pancreas?

Now wash out the peritoneal cavity with copious amounts of warm saline. Suction the excess saline and mop up the rest by going over the entire gut quickly (you need to get out of the abdomen as soon as you can) to confirm that you have identified all the injuries.

It is now time to decide on how to close the laparotomy incision in a temporary manner, since you are going to go back in in 24-48h for definitive repair. There are several methods, some more preferable than others.

You can use towel clips in a row to close only the skin or a continuous non-absorbable suture, again only on the skin. You can open up a sterile renal dialysis bag or several IV fluid bags and suture them to the edges of the abdominal wall (Bogotá bag). Never include the fascia in these techniques. The Bogotá bag is the surest of these temporary measures. By far the most preferable technique, if your patient can withstand the time, and you have the material available, is the laparostomy (11.10).

**If the condition of the patient is stable**, close the abdomen in standard fashion (11.8)

## 55.17 Second look laparotomy

This might still be part of damage control (41.4). Prepare the patient as before including the chest and groins. Make sure you have resuscitated your patient during the last 24-48h. Check that the physiological parameters are now normal. Your patient will now be ready for definitive treatment of injuries sustained.

**If you re-open an abdomen where you have left in packs**, verify how many packs were left inside.

Back in theatre, remove your laparostomy pack and gently remove any abdominal packs, carefully counting the number. Soak these thoroughly, so they don't stick to viscera, and pull them out gently one by one, starting with the least bloody (where bleeding is least likely).

Check to make sure that bleeding or contamination is controlled. If not, decide whether you need to re-pack the abdomen, or if you can control any new haemorrhage. If so, continue to explore the abdomen (55-5)

*N.B. Don't dislodge clots to see what injury is underneath, except small haematomas on the bowel surface.*

**If massive re-bleeding occurs**, pack again. *Don't attempt to repair the problem during this operation*, but you do consider restoring gastrointestinal continuity this time before you get out.

Now look for potential sources of contamination.

*N.B. Take a good note of the state of the bowel. If the intestines are oedematous and engorged, you will have to continue with a temporary closure laparostomy to prevent abdominal compartment syndrome.*

Look for injuries you might have missed the first time and especially look at the areas you repaired the first time. Reprioritize your approach based on this new information.

Control any additional sites of bleeding, perform any necessary vascular repairs and restore intestinal continuity (including any stomas or feeding tubes). Cut back all intestines until you find healthy bleeding tissue.

Perform any repairs as necessary, such as hepatic suture, gastro-jejunostomy, Roux en-Y anastomosis, arterial suture, closure of the abdominal wall defect etc.

*N.B.* Some temporary damage control procedures are also definitive, e.g. splenectomy, suction drainage for pancreatic injuries.

Closure of the abdomen without tension can be difficult. Ideally, approximate the fascial edges with gentle adduction and perform a regular fascial closure.

**If the abdominal tension is too great** or the anaesthetist tells you that the peak airway pressure increases by  $>10$  cm H<sub>2</sub>O, leave the fascia open and leave a laparostomy.

**If you cannot close the fascia**, use aggressive diuresis (to remove the oedema as much as the patient's hemodynamic and oncotic status permits). You may need washouts of the abdominal cavity, reinspection and careful replacement of the abdominal closure devices until you can close the fascia. The goal is to get fascia closure without tension  $<7$  days from the 2<sup>nd</sup> operation.

**If you still cannot close the fascia then**, close the anterior abdominal wall or allow the wound to granulate, knowing a ventral hernia will inevitably ensue.

*N.B. Second-look laparotomy is a planned procedure!* It is not the same as a re-laparotomy for complications of previous surgery or a new event.

## 55.18 Late presentation

Assess any patient who presents many hrs after an injury just like any other, according to the ABCDE system (41.1).

There may often be no need for surgery at all, but if there is peritonitis, it is likely to be severe, so apply Damage Control principles (41.4). The likelihood of overwhelming sepsis and renal failure is high.