Abdominal Trauma: Not Everything That Bleeds Needs an Operation

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Introduction

Tradition has taught us that traumatic bleeding requires operative intervention. Without modern technology, an operation remains both diagnostic and therapeutic for trauma patients. From the time when ultrasound, CT scan, and angiography became mainstream, treatment options for patients have grown exponentially.

Physiology of a Trauma Patient

The lethal triad of trauma consists of hypotension, coagulopathy and acidosis. Bleeding leads to this downwards spiral, and extensive research has been done to determine the best way to prevent poor outcomes due to this physiology. Studies have shown that keeping patients warm can help minimize acidosis and coagulopathy. In addition, judicious use of intravenous fluids, focusing on early administration of packed red blood cells, fresh frozen plasma and platelets in a 1:1:1 ratio, can improve coagulopathy [1]. However, there is no substitute for rapidly controlling the bleeding. An operation remains the method of choice for unstable trauma patients, but alternatives now exist for the stable patient.

Blunt Intra-abdominal Injuries

Mechanism

Trauma is the leading cause of death in people between the ages of 1 and 44. Injuries to intra-abdominal organs are a huge source of morbidity and mortality among all age groups. There are three main mechanisms that lead to injuries during blunt trauma. The first mechanism is deceleration, which causes internal structures to stop moving from rapid speed. Some organs, such as the aorta, the liver and the kidneys, have fixed points of attachment and can have significant damage from the shear forces associated with rapid deceleration. Motor vehicle collisions, pedestrians' struck and falls from height are the most common mechanisms of injury associated with deceleration. The second mechanism involves crushing. Victims of this type of injury most often suffer damage to solid organs when they are crushed between the anterior abdominal wall and the vertebral column or posterior rib cage. Lastly there is external compression. This differs from the crush mechanism in that external compression causes a sudden,

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dramatic rise in the intra-abdominal pressure. This pressure change renders hollow organs the most susceptible to damage and is often suspected in bladder and bowel rupture.

Workup

While unrecognized bleeding in the abdomen may be rapidly fatal, the diagnosis of hollow viscus injury is equally important. The diagnostic workup is primarily geared towards these two types of potential injuries. Reliable physical exam remains essential. Hemodynamic lability suggests bleeding while peritonitis is suggestive of irritation from the spillage of a ruptured organ. Short of operative exploration and direct inspection, the remaining adjuncts to the physical exam include mainly imaging techniques including FAST and CT scanning. DPL continues to be an option in very few cases, but has largely been surplanted by the use of the FAST.

In 2002, the Eastern Association for the Surgery of Trauma (EAST) convened a work group to determine best practices for evaluation of patients with blunt abdominal trauma. The literature was reviewed and the following level 1 recommendations were made [2]:

1. Exploratory laparotomy is indicated for patients with grossly positive diagnostic peritoneal lavage (DPL).
2. CT is recommended for the evaluation of hemodynamically stable patients with equivocal findings on physical examination, associated neurologic injury, or multiple extra-abdominal injuries.
3. CT is the diagnostic modality of choice for nonoperative management of solid visceral injuries.
4. In hemodynamically stable patients, DPL and CT are complementary diagnostic modalities.

Of note, the following level 2 recommendations were made regarding focused abdominal sonography for trauma (FAST) [2]:

1. FAST may be considered as the initial diagnostic modality to exclude hemoperitoneum.
2. Exploratory laparotomy is indicated in hemodynamically unstable patients with a positive nonoperative management of select injuries.

These suggestions were based on the existing data that illustrated the strengths of FAST. Benefits included the ability to perform the test quickly in a noninvasive manner. The technology is portable and, therefore, the patient does not have to move from the trauma bay. In addition, the exam is repeatable. However, the reliability of the test is operator dependent, it does not give information regarding grade of injury and it is a poor determinant of hollow viscus injury. A positive FAST exam in a hemodynamically stable patient should lead to a CT scan for further diagnosis. CT has a sensitivity of ~95 % and a specificity of ~99 %, leading to reliable diagnosis of injuries. With a negative predictive value of over 99 %, providers can feel confident discharging patients from the emergency department if the abdominal CT scan is negative [3]. Figure 12.1 shows the suggested workup for a stable patient with blunt abdominal trauma [4].

Management

Successful nonoperative management of intra-abdominal injuries is predicated on the stability of the patient. Unstable patients or patients with diffuse peritonitis after blunt abdominal trauma require a laparotomy. Expectant management should only be attempted in a clinical setting capable of intensive monitoring, serial clinical examinations and where an operating room is available for urgent laparotomy at all times.

Liver

In the early 1900s, blunt hepatic injuries were treated primarily by observation alone. Due to poor outcomes, the pendulum then swung the complete opposite direction and laparotomy became the treatment of choice. For hemodynamically stable patients, several options exist for management [5].

The widespread use of CT scans for trauma patients has allowed for the development of a grading scale for solid organ injuries. Liver injuries range from mild (Grade I) to severely

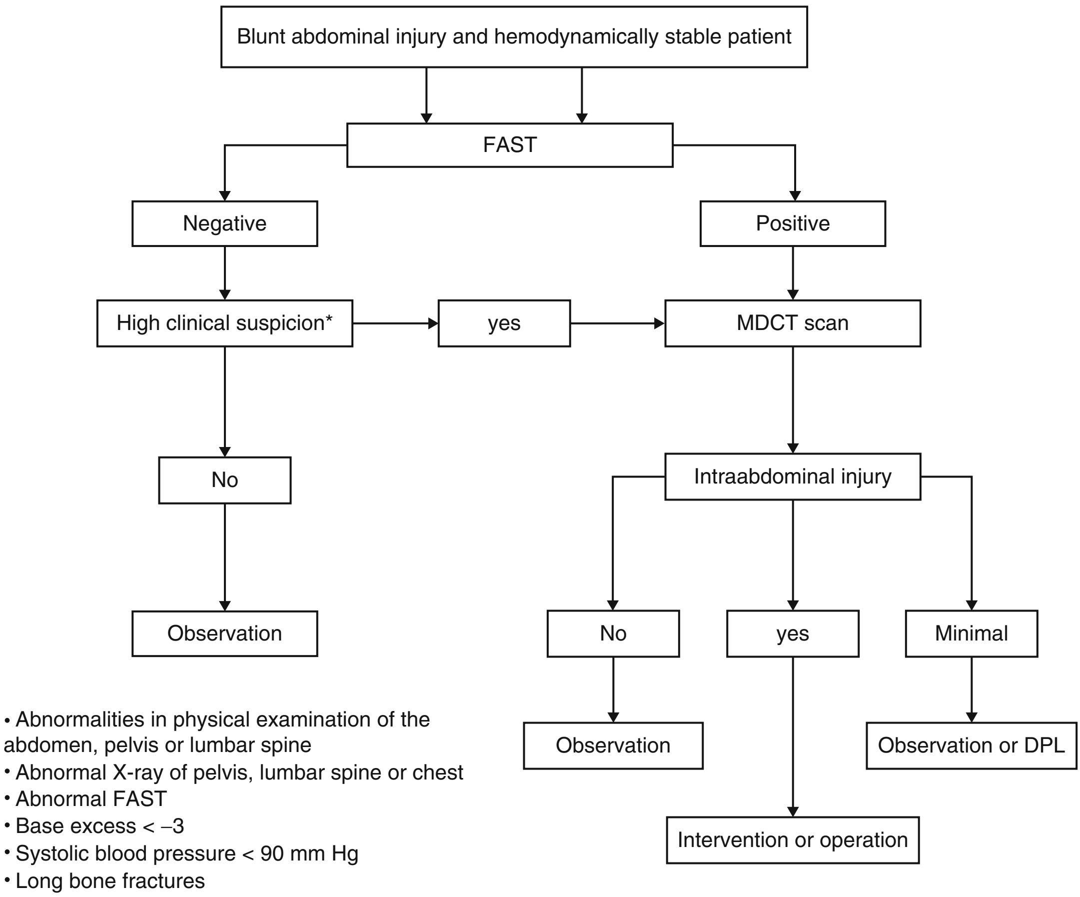

Fig. 12.1 Blunt abdominal trauma workup. (Used with permission from van der Vlies CH, Olthof DC, Gaakeer M, Ponsen KJ, van Delden OM, Goslings JC. Changing patterns in diagnostic strategies and the treatment of blunt injury to solid abdominal organs. Int J Emerg Med 2011 Jul 27;4:47-1380-4-47)

life-threatening (Grade VI) (Fig. 12.2a–c). Table 12.1 shows a representation of the AAST liver injury grading system.

In addition to allowing the injury to be graded, the newer multichannel detector CT scanners allow for more accurate visualization of vascular structures and active bleeding in the form of a "blush" (contrast extravasation). While certain CT findings, such as high grade injuries, active extravasation, periportal blood and large amount of hemoperitoneum, have previously been thought to preclude nonoperative management, recent literature suggests that these risk factors are not absolute contraindications to a trial of expectant management in a hemodynamically stable patient [6]. That said, more severe injuries and patients at with active bleeding are at high risk for needing intervention, and should be considered for early angiography with embolization.

While angioembolization of high-risk patients who suffer liver trauma is highly successful at controlling bleeding, it is not without its own morbidity. Contrast-induced nephropathy is a concern, especially since the vast majority of these patients have already undergone a CT scan with IV dye for diagnostic purposes. Embolization can lead to hepatic necrosis with the delayed complications of infection and abscess formation. Additionally, embolization only addresses vascular extravasation and cannot target bile ducts. Biliary leaks are especially prevalent in higher grade injuries, and can cause ongoing systemic inflammation, bilomas or biliary peritonitis.

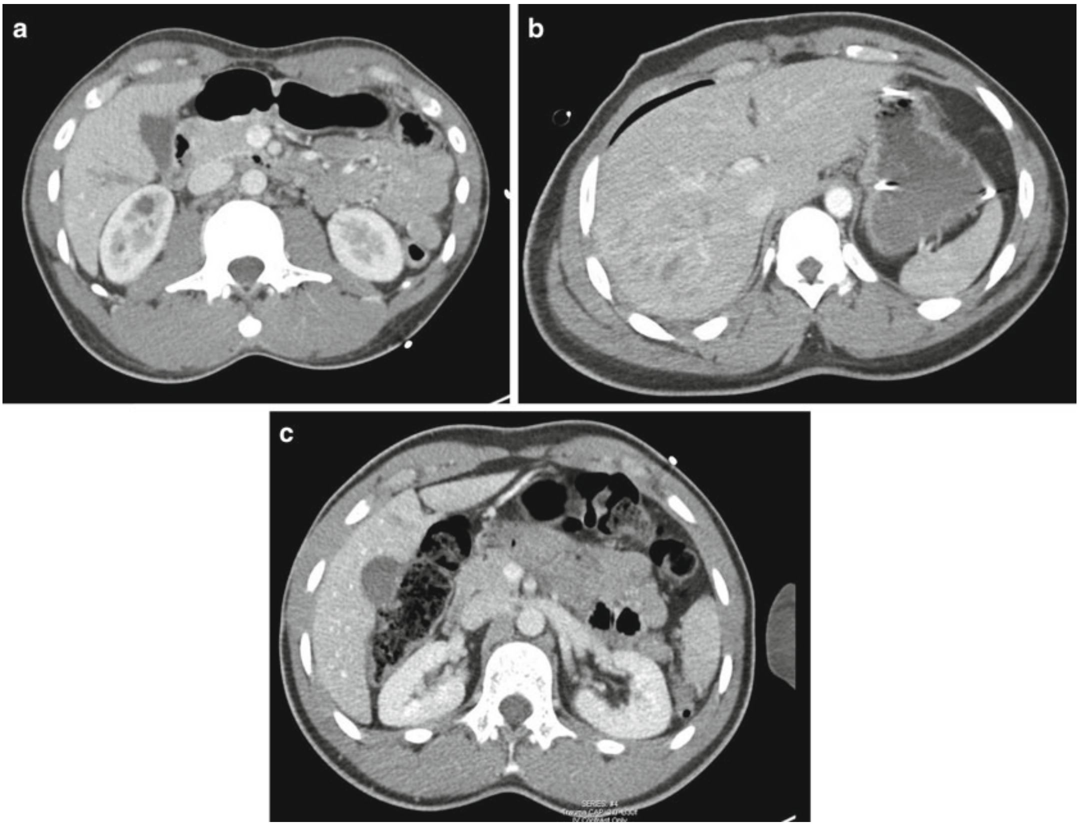

Fig. 12.2 (**a**–**c**) CT scan images of liver injuries following blunt trauma. (**a**) Grade II liver laceration. (**b**) Grade IV liver laceration. (**c**) Grade I liver laceration

Table 12.1 AAST hepatic injury grading scale

Grade	Injury type	Description
I	Hematoma	Subcapsular, <10 % surface area
I	Laceration	<1 cm parenchymal depth
II	Hematoma	Subcapsular, 10–50 % surface area
		Intraparenchymal, <10 cm diameter
II	Laceration	1-3 cm parenchymal depth, and <10 cm in length
III	Hematoma	Subcapsular, >50 % surface area or explanding/ruptured
		Intraparenchymal, >10 cm
III	Laceration	>3 cm parenchymal depth
IV	Laceration	Parenchymal disruption, 25–75 % of hepatic lobe
V	Laceration	Parenchymal disruption, >75 % of hepatic lobe
V	Vascular	Juxtavenous hepatic injuries (e.g., Major hepatic veins, retrocaval IVC)
VI	Vascular	Hepatic avulsion

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Most of these patients can be treated without the need for laparotomy with percutaneous drainage and endoscopic retrograde cholangiopancreatography (ERCP) [7].

Spleen

Attempting splenic salvage after blunt trauma has become the norm in modern day trauma practice. While unstable patients still belong in the operating room, stable patients and transient responders have options for treatment that include expectant management and angiography with embolization. A CT scan with IV contrast should be performed in this patient population to define the severity of injury and guide the management [8] (Fig. 12.3). Much like with liver trauma, injuries to the spleen are graded based on severity. Table 12.2 shows the AAST grading scale for splenic injuries.

Common sense would dictate that patients with increased hemoperitoneum, higher grade injuries and active extravasation seen on CT would lead to higher failure rates of nonoperative management, and multiple studies proved this to be true [8]. However, there are no absolute contraindications to attempting splenic salvage based on age, severity of injury or presence of concomitant injuries as long as the infrastructure exists for appropriate monitoring [8]. The failure of nonoperative management can be significantly decreased by reevaluating patients with blunt splenic injury 48 h after their trauma with a repeat CT scan to look for pseudoaneurysms [9].

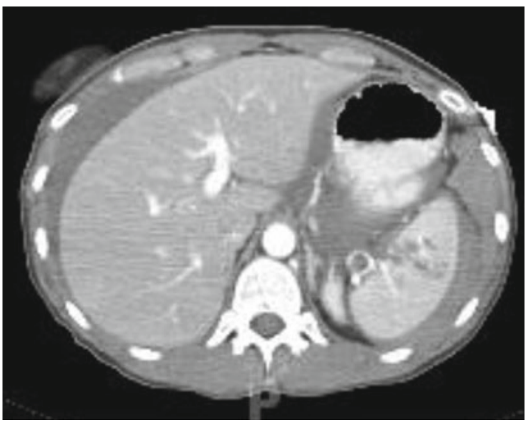

Fig. 12.3 CT scan image of grade III splenic laceration following blunt trauma to the abdomen

When embolization initially became popular, the main splenic artery was the most frequent target (Fig. 12.4a, b). As technology has improved, selective and superselective embolizations have become possible. One of the main reasons to attempt splenic salvage is to avoid overwhelming postsplenectomy sepsis (OPSI). There was concern that with main artery embolization, the immune function of the spleen would be compromised and patients could suffer the same fate as with splenectomy, hence the trend towards more selective targets. These fears have not been realized; small studies have shown that not only is immune function preserved in patients with main artery embolization [10] but there is no difference in complication rates between main artery and selective embolization [11].

Kidney

Historically, many blunt renal injuries were explored in the operating room with a resultant high nephrectomy rate. To attempt to increase the kidney salvage rate, nonoperative management of renal injuries became common. The proof that nonoperative management could be successfully carried out came in the form of retrospective

Table 12.2 AAST splenic injury grading scale

Grade	Injury type	Description
I	Hematoma	Subcapsular, <10 % surface area
I	Laceration	<1 cm parenchymal depth
II	Hematoma	Subcapsular, 10–50 % surface area
		Intraparenchymal, <5 cm diameter
II	Laceration	1–3 cm parenchymal depth that does not involve a trabecular vessel
III	Hematoma	Subcapsular, >50 % surface area or expanding/ruptured
		Intraparenchymal, >5 cm or expanding
III	Laceration	>3 cm parenchymal depth or involving trabecular vessels
IV	Laceration	Involves segmental or hilar vessels producing major devascularization (>25 % of spleen)
V	Laceration	Shattered spleen
V	Vascular	Hilar vascular injury with devascularized spleen

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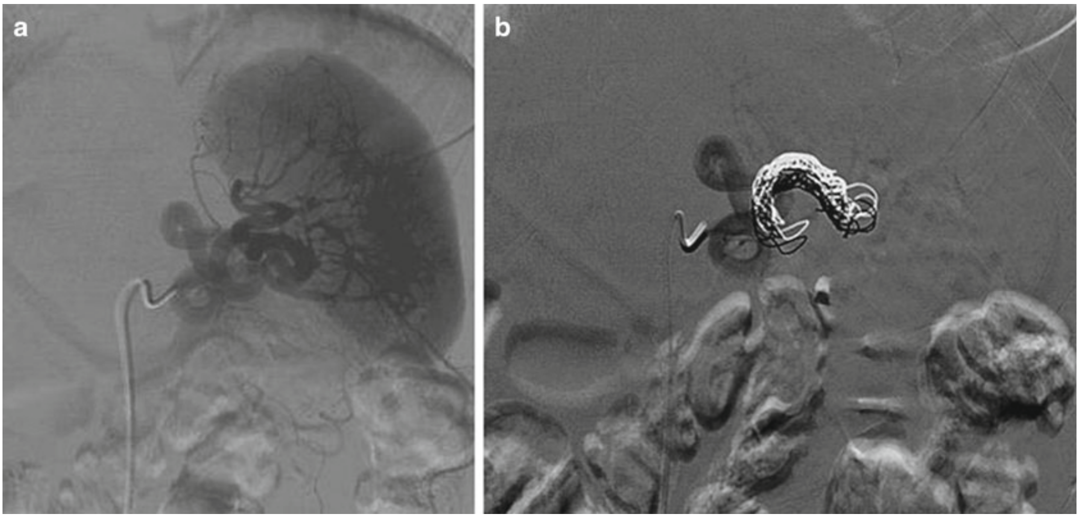

Fig. 12.4 (**a**, **b**) Angiographic management of a grade III splenic injury following blunt abdominal trauma. (**a**) Conventional angiography demonstrating injury and intra-parenchymal splenic blush. (**b**) Post-coil embolization of the main splenic artery

Table 12.3 AAST renal injury grading scale

Grade	Injury type	Description
I	Contusion	Microscopic or gross hematuria with normal urologic radiology
I	Hematoma	Subcapsular, nonexpanding, any size, without parenchymal laceration
II	Hematoma	Nonexpanding perirenal hematoma confined to renal retroperitoneum
II	Laceration	<1 cm parenchymal depth of renal cortex without urinary extravasation
III	Laceration	>1 cm, without extension into the renal pelvis or collecting system and with no evidence of urine extravasation
IV	Laceration	Extends through renal cortex, medulla, and collecting system
IV	Vascular	Main renal artery or vein injury with contained hemorrhage
V	Laceration	Shattered Kidney
V	Vascular	Devascularization of kidney due to avulsion of renal hilum

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studies showing spontaneous healing of injured kidneys on CT imaging [12]. As with the other blunt solid organ injuries, age, severity of injury and presence of head trauma do not exclude non-operative management as a treatment option. The AAST recognizes five grades of injury for the kidney, as seen in Table 12.3.

High grade injuries (III–V) were specifically evaluated in the literature to determine if nonoperative management is safe and effective in this population. Not only did the patients managed without an operation have shorter ICU lengths of stay and lower transfusion requirements, they also had fewer complications [13]. Even if the kidney is shattered, as long as it is perfused non-operative management remains a viable option. Complications, though less than with operative intervention, may exist in the form of pseudoaneurysms, urinomas and unidentified uretural injuries. In the vast majority of cases, these can be addressed with angioembolization, percutaneous drainage or stenting as needed.

Hypertension secondary to renal parenchymal compression from a subcapsular hematoma (Page kidney) is rarely realized and even less frequently sustained.

Penetrating Abdominal Trauma

The dogma that all penetrating abdominal injuries require an operation has been challenged since the 1960s. While still uncommon, nonoperative management of this patient population is being attempted at several trauma centers around the country. Stab wounds are more commonly managed expectantly than gunshot wounds, though the evidence is strong enough to suggest that in stable patients without peritoneal signs, laparotomy is not indicated in either group [14]. Should nonoperative management be attempted, a CT scan to determine trajectory can be highly beneficial (Fig. 12.5). If the injury involves the flank, using oral, rectal, and IV contrast can increase the true negative value of the study to almost 100 % [15]. Tangential wounds are much more likely to be successfully managed without surgery than wounds that clearly penetrate the peritoneal cavity.

If injury should occur to a solid organ via a penetrating mechanism, nonoperative management remains a possibility. Angioembolization is a valuable adjunct for treatment (Fig. 12.6a–c). One prospective study by Demetriades and colleagues found that nonoperative management was feasible in patients with high grade (III–V) solid organ injuries with significantly shorter hospital length of stay than in patients managed operatively [16].

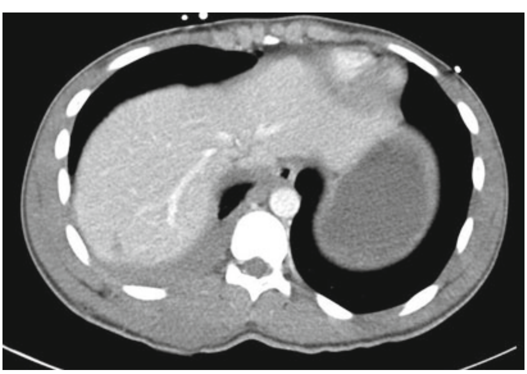

Fig. 12.5 CT scan image of a grade I liver laceration that resulted from a right flank stab wound which was successfully managed nonoperatively

Negative and nontherapeutic laparotomies are not without risk. Complications in general range from atelectasis and pneumonia to wound and urinary tract infections to prolonged ileus, and can occur in up to 40 % of patients. Significant complications have been documented in 8–12 % of patients [17, 18]. In addition, nontherapeutic laparotomies increase hospital length of stay and cost. Studies have shown that the vast majority of stable patients with stab wounds to the abdomen will develop an indication for surgery within 12 h of observation if they have a significant injury. The current recommendation is to observe stable patients with penetrating abdominal injuries of any mechanism for 24 h with serial clinical exams performed by the same individual or team of individuals. This includes patients with penetrating flank and buttock injuries. If they remain stable at 24 h, they can be safely discharged from the trauma service [14].

Pelvic Trauma

Pelvic injuries often exist in the setting of blunt trauma, and can be a major source of blood loss and remain highly mortal and morbid injuries. The majority of bleeding tends to be venous, but arterial sources do exist. The goal of managing pelvic fractures is to stabilize the pelvis and control the bleeding in an expeditious manner. In the trauma bay, a temporary pelvic binder or sheet wrap can be applied quickly and easily with a resultant decrease in pelvic volume by 10–20 %. Patients with pelvic fractures and hemodynamic instability or signs of ongoing bleeding after nonpelvic sources of blood loss have been ruled out should be considered for pelvic angiography/embolization [19]. In an unstable patient, it is essential to determine whether the bleeding is from the abdomen, pelvis or both. A positive fast exam in patients with significant pelvic and abdominal trauma mandates exploration in the operating room for damage control followed by

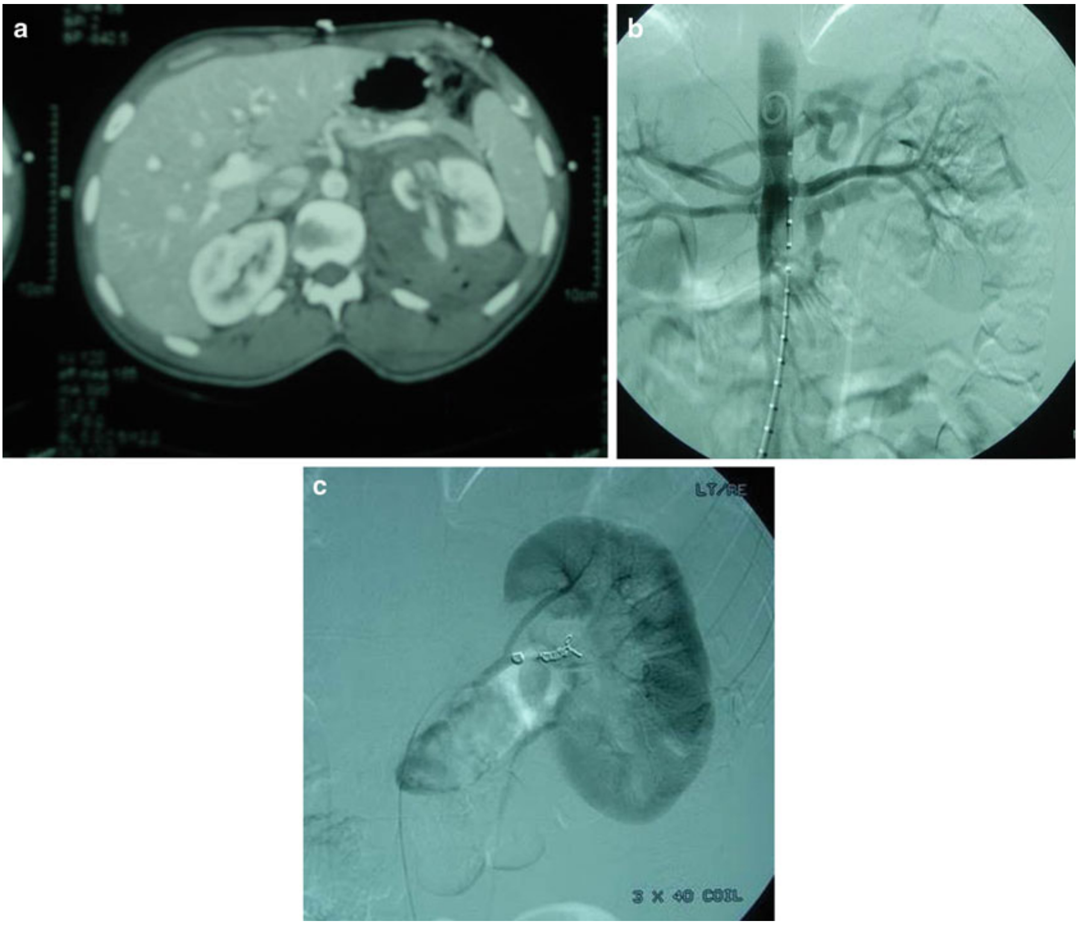

Fig. 12.6 (**a**–**c**) Stab wound to the left back demonstrating left renal hilar injury. (**a**) CT scan showing renal hilar injury and large perinephric hematoma and active contrast extravasation. (**b**) Diagnostic left renal artery angiogram showing intra-parenchymal blush and arterial–venous fistula. (**c**) Post-embolization angiography demonstrating successful control of bleeding and fistula, with minimal loss of perfused renal parenchyma

pelvic angiography. A negative FAST exam would lead to angiography first for definitive control of pelvic bleeding. If angio is not readily available, pelvic packing in the operating room remains a viable option for unstable patients. In a stable patient, a CT scan with IV contrast should be obtained to evaluate for abdominal injury. If the CT scan rules out intraperitoneal injury but shows active arterial extravasation in the pelvis, angiography should be strongly considered regardless of hemodynamic status as this is a significant risk factor for the need for embolization. Even without evidence of active bleeding on CT, there is an up to 18 % chance that patients with pelvic fractures may require embolization early in their hospital stay. Patients who are initially successfully embolized may require repeat embolization ~25 % of the time, and in the majority of those patients bleeding was found at a new site [19].

As with solid organ injuries, pelvic vessels can be embolized proximally or more selectively. There is concern that with proximal embolization, gluteal muscle ischemia and necrosis may ensue. Even though this phenomenon may be subclinical, there is concern in the orthopedic literature about increased complications after formal pelvic fixation in embolized patients [20]. The risks and benefits of pelvic embolization should be weighed, but this intervention remains a valuable option in the armamentarium of the trauma surgeon.

Major Vascular Injuries

Hemorrhage from major vascular injuries remains a substantial cause of morbidity and mortality in trauma patients. Regardless of mechanism, major vascular injuries require some type of intervention. In recent years, endovascular techniques have been employed with great success. Initially, blunt aortic injury was evaluated for feasibility of endovascular intervention. Outcomes were so promising that the Society for Vascular Surgery has recommended this approach preferentially over open surgery in their guidelines for traumatic thoracic aortic injury [21]. Endovascular techniques seem to be especially beneficial in areas of difficult exposure. One recent study evaluating carotid, subclavian and thoracic aortic injuries showed a significant increase in the use of endovascular repair with an associated 35 % decrease in mortality. Of note, 20 % of these patients were hypotensive on arrival but could still be successfully managed without an open operation [22].

Some patients are too unstable upon their arrival to the trauma bay to travel for intervention. These patients generally have severe ongoing blood loss that leads to decompensated shock. In such a population, resuscitative endovascular balloon occlusion of the aorta (REBOA) has been employed with some success. Similar to resuscitative thoracotomy with aortic cross-clamping, REBOA allows the trauma surgeon to occlude the aorta and prevent ongoing intra-abdominal blood loss while maintaining perfusion to the brain and heart. However, REBOA is much less invasive, and can be placed percutaneously or via cut down. Additional endovascular training for trauma surgeons may be beneficial prior to placing an intra-aortic balloon, though it is not necessary [23]. REBOA is a temporizing measure, and must be followed by either surgical exploration or interventional radiology techniques for definitive hemorrhage control.

Conclusion

Though there is a definite trend towards selective nonoperative management of trauma patients, operative intervention will always have a place in the care of the severely injured patient. Hemodynamically unstable patients and patients with diffuse peritonitis after blunt or penetrating abdominal wounds require an operation. Stable patients can be worked up with CT scan and managed nonoperatively regardless of severity of injury as long as the hospital has the capability of providing intensive monitoring and a staffed operating room should emergent intervention be required. As technology advances and imaging improves, we may be able to further delineate the best candidates for nonoperative management.

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