



## Zone 1 Vascular Abdominal Trauma. Damage Control and Staged Management

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### Abstract

Vascular abdominal injuries of major vessels in zone 1 abdominal cavity are the most common cause of death after penetrating abdominal trauma. Abdominal arterial and vein injuries occur with the same incidence. Patients with retroperitoneal vascular injury and intact retroperitoneum may present hemodynamically stable due to tamponade.

The main goal of staged approach is to control any major haemorrhage into the abdomen until the patient is hemodynamically stabilized in the ICU and reconstruction can be done in final reoperation. Multidisciplinary management is imperative to prevent the “lethal triad” and assures the best optimal outcome for these critically wounded patients.

### Introduction

Abdominal vascular injuries are the most common cause of death after penetrating abdominal trauma. Blunt injuries to major abdominal vessels are rare. Major injuries to large vessels in the abdominal zone 1 usually cause significant hemoperitoneum and shock. The type of clinical presentation varies widely and depends on the presence of retroperitoneal tamponade. Patients with an intact retroperitoneum may be hemodynamically stable on presentation but when the retroperitoneum tamponade is lost, signs of shock and acute hypovolemia are present. Many patients with major abdominal vascular injuries require massive blood transfusions, are hypotensive, and become severely hypothermic, acidotic, and coagulopathic intra operatively. These patients may benefit from early damage control and definitive reconstruction at a later stage when their general condition improves. The patient is returned to the operating room after resuscitation and stabilization for definitive vascular repair and abdominal wall closure.

### Epidemiology

The incidence of abdominal major vascular trauma in civilian penetrating injuries is approximately 10% after stab wound to the abdomen and 20% to 30% after a gunshot wound to the abdomen [1]. The incidence of vascular injuries in patients with blunt abdominal trauma undergoing exploratory laparotomy is 3% [2]. Abdominal arterial and venous injuries occur with the same incidence. The most commonly injured abdominal vessel is the inferior vena cava (IVC), accounting for 25% of injuries, followed by the aorta (21%), the iliac arteries (20%), the iliac veins (17%), the superior mesenteric vein (11%), and the superior mesenteric artery (10%). Hospital mortality rates vary from 30% to 80% for abdominal aortic injuries and from 30% to 65% for IVC injuries. Many patients do not reach the hospital alive; dying at the scene or during transport [3]. Death is usually due to exsanguinations, despite aggressive resuscitation and early operation [4].

### Surgical Anatomy

For vascular trauma purposes, the abdomen is conventionally divided into three anatomic areas (Figure 1): Zone 1, which includes the midline retroperitoneum extending from the aortic hiatus to the sacral promontory. The supramesocolic area contains the suprarenal aorta and its major branches (celiac axis, superior mesenteric artery [SMA], and renal arteries), the supramesocolic Inferior Vena Cava (IVC) with its major branches, and the Superior Mesenteric Vein (SMV). The inframesocolic area contains the infrarenal aorta, the Inferior Mesenteric Artery (IMA), the gonadal

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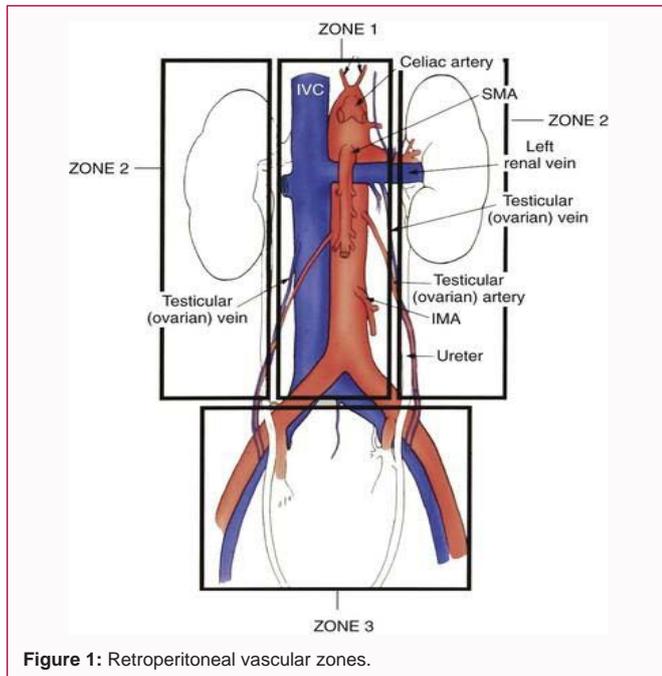


Figure 1: Retroperitoneal vascular zones.

arteries and IVC. Zone 2 (left and right), which includes the kidneys, paracolic gutter, and renal vessels. Zone 3 which includes the pelvic retroperitoneum and contains the iliac vessels.

## Types of Vascular Injuries

The most common arterial lesions (Figure 2) are partial/incomplete transection, transection and contusion of the vascular wall. Usually complete transection leads to arterial spasm and thrombosis with subsequent ischemia of the end organ, while partial transection usually causes persistent bleeding or false aneurysm formation. Additionally, partial transection and contusion of the vascular wall may exhibit an intimal flap that may cause vascular thrombosis. Simultaneous arterial and venous lesions can lead to formation of arteriovenous communication.

## Clinical Presentation

The clinical presentation depends on the injured vessel, the size and type of the injury, the presence of associated injuries, and time elapsed since the injury. Many patients with major abdominal vascular injuries die at the scene and never reach medical care. Vascular injuries due to blunt trauma are often missed on initial examination or even during the initial hospitalization, unless they are associated with significant bleeding or early ischemic changes. Penetrating injuries to the abdomen associated with hypotension and abdominal distension are highly suggestive of vascular injury [5]. Asymmetric femoral pulses may indicate uni-iliac artery injury. Many patients may be normotensive on admission only to decompensate a few minutes later. Some patients present in a hemodynamically stable condition because of thrombosis of the vessel or tamponade of the bleeding in the retroperitoneum. In most cases the diagnosis is made intra operatively.

## Diagnostic Evaluation

The majority of patients presented with penetrating abdominal vascular injury are in critical condition and the need for immediate laparotomy overwhelms further diagnostic investigation. In

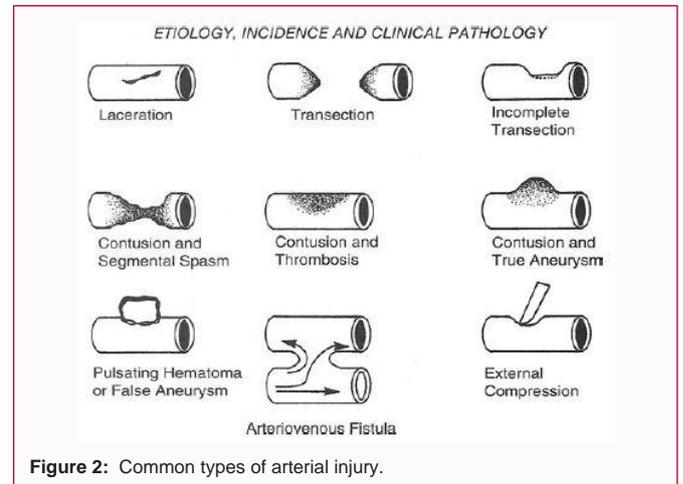


Figure 2: Common types of arterial injury.

blunt trauma, radiographic diagnosis of complex pelvic fractures may increase the suspicion of iliac vascular injuries. Computed tomography may play a useful role in blunt trauma by identifying large hematomas, false aneurysms, or vessel occlusions. Digital Subtraction Angiography (DSA) has an important role both in the evaluation of suspected late complications (ex: pseudoaneurysm and a-v fistula) and in the evaluation and treatment (embolization) of patients with blunt trauma with pelvic fracture and suspected vascular injury.

## Initial Management

In patients with suspected vascular injuries time should not be wasted on fluid resuscitation or diagnostic investigations. Intravenous catheters or central vein catheters should be placed in the upper extremities in case the victim has an injury to the IVC or the iliac veins. The concept of permissive hypotension should be borne in mind, and aggressive fluid resuscitation should not be attempted in the emergency department [6]. Endotracheal intubation should be avoided in the emergency department because rapid-sequence induction is often associated with thrombus dislodgement and increase of the bleeding.

## Damage Control Strategy

The surgical team should be ready, and the skin preparation should be performed from the neck to the knees, before induction of anaesthesia because the latter is often associated with rapid hemodynamic decompensation in these patients. The abdomen should be entered through a long midline incision, temporary control of bleeding by direct compression, and aortic cross-clamping, if necessary, at the diaphragm. To facilitate aortic exposure, division of the left crux of the diaphragm may be necessary. With the damage-control approach, all complex venous injuries are ligated, arterial injuries may be shunted, and any diffuse retroperitoneal or parenchymal bleeding is controlled by tight gauze packing [7,8]. The abdomen is closed temporarily with the use of synthetic mesh or vacuum sponge with aspiration and patient is then transferred into the Intensive Care Unit (ICU) for conclusive hemodynamic and coagulation resuscitation, thermal recovery, correction of acidosis and organ malperfusion [9]. Rewarming the patient is a high priority because coagulopathy and acidosis can be corrected and maintained only after the body temperature returns to normal [10,11].

## Definitive Surgical Treatment

Twenty four to 72 h may be needed to correct metabolic

derangements and after successful stabilization in the ICU the patient is returned to the operating room for definitive surgical treatment. Prior to being taken back to the operating room it is paramount that the resolution of acidosis, hypothermia, and coagulopathy has occurred. Thorough re exploration is made for any additional injuries that may not have been detected in the initial survey and restoration of gastrointestinal continuity and complex vascular repair techniques are done. Not all patients will be able to have their abdomen closed on the first return to the operating room and data suggest that the longer the abdomen is left open from initial laparotomy the higher the rate of complications [12].

### Abdominal Compartment Syndrome

Abdominal compartment syndrome is characterized by a tense abdomen, tachycardia, respiratory dysfunction and oliguria. Elevation of the intra-abdominal pressure above 25 cm to 30 cm H<sub>2</sub>O can cause severe organ dysfunction and result in abdominal compartment syndrome. The intra-abdominal pressure can be measured reliably through the bladder catheter. In general, pressures higher than 30 cm H<sub>2</sub>O are considered strong indicators for surgical decompression of the abdomen. The abdomen can be opened in the operating room or even in the ICU until the intra-abdominal pressure drops to normal.

### Discussion

Damage control strategy represents a surgical emergency approach for the staged management of abdominal vascular trauma in critically wounded patients. The primary goal of this approach is fast control of haemorrhage and prevention of the lethal triad (hypothermia, acidosis and coagulopathy). Damage control is a concept in which the initial surgery becomes part of the resuscitation process rather than part of the curative process. Only when the patient has become physiologically stable is the final therapeutic surgery embarked on and definitive repair with complex vascular anastomosis are undertaken 24 hours to 48 hours later. In the last two decades, this approach became part of the gold standard for treatment in critically wounded patients. Multidisciplinary management and perfectly cooperation between doctors of different specialties (ER, Surgeons, Anaesthesiologists and ICU doctors) assures the best optimal outcome.

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