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## Pelvic trauma and vascular emergencies



U. Scemama\*, A. Dabadie, A. Varoquaux, J. Soussan,  
C. Gaudon, G. Louis, K. Chaumoître, V. Vidal

*Department of diagnostic and interventional medical imaging, La Timone Hospital,  
264, rue Saint-Pierre, 13005 Marseille, France*

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**Abstract** Pelvic ring injuries carry a high mortality rate, the main cause of which, in the first 24 hours, is exsanguination. Injured patients are managed by a multidisciplinary damage-control strategy. Unstable patients should have instrumentalized hemostasis without delay. Arterial embolization is an effective way of achieving this and justifies this approach being permanently available in level 1 trauma-centers. After CT assessment of injuries, stable patients can undergo arterial embolization if active arterial bleeding or vascular damage is present. The embolization methods (selective or unselective) and agents used depend on the patient's hemodynamic stage and assessment of the injury whenever possible.

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### General details

#### Epidemiology of pelvic injuries

Injuries are responsible for 10% of deaths worldwide [1] and are the leading cause of death in patients between 5 and 44 years old [2]. They are 2.4 times more common in men than women.

In 80% of cases pelvic injuries occur as a result of road accidents (50% cars, 20% bikes and 30% pedestrians). Ten percent are due to falls, 8% to crush injuries and 2% to other causes. Ninety percent of patients have a concomitant extra-pelvic injury [3].

Deaths from pelvic ring injury are attributable to pelvic exsanguination, concomitant injuries [4,5] or the complications of the injury and of resuscitation (acute respiratory distress syndrome, multi-organ failure, sepsis) [6].

\* Corresponding author.

E-mail address: [ugo.scemama@ap-hm.fr](mailto:ugo.scemama@ap-hm.fr) (U. Scemama).

When deaths are directly due to the pelvic ring injury, the mortality rate increases with more unstable fractures [7] (25%) and with increasingly unstable initial patient hemodynamics (30 to 45%) [8].

### Exsanguination following pelvic injuries

Exsanguination as a result of massive bleeding, defined by loss of the entire body blood volume over 24 hours or half of the body's blood volume over 3 hours is the leading cause of deaths within the first 24 hours (30 to 40%) [9].

Several factors predispose to massive bleeding: these are related to the injury (sites and number of bleeds or vascular injuries), the consequences of the injury (consumption coagulopathy, hypothermia and acidosis) and to the patient (comorbidities, anti-platelet therapy and/or anticoagulants and whether or not these can be stopped) [10].

Exsanguination is a result of vascular damage and is mostly due to bleeding from bone in displaced fractures or venous bleeding from damage to the presacral venous plexus (direct injury by a bone fragment or indirect shearing injury).

In 10 to 20% of cases, and up to 60% of cases if the patient is hemodynamically unstable, an arterial bleed is present [11–15]. As veins are more fragile than arteries, venous bleeding is always present in addition to an arterial bleed [16,17].

In contrast to findings in healthy people, in unstable pelvic ring injuries, the retroperitoneum cannot act as a tamponade to stop bleeding from bone and veins, which may therefore result in exsanguination without instrumentalized hemostasis.

Arterial bleeds exceed the capacity of the retroperitoneal space to tamponade the bleed and lead to exsanguination without instrumentalized hemostasis [18,19].

### Classifications of pelvic injuries

The most widely used classifications for pelvic ring injuries are those produced by Young-Burgess [20] and Tile [21] which guide surgical treatment in terms of stabilizing the pelvic ring based on the mechanism of the injury and stability of the injury. Fractures involving antero-posterior compression, which result in opening of the ring like an open book, can be distinguished from lateral compression fractures, which close the ring, vertical instabilities and combined mechanisms.

These classifications do not, however, establish a correlation between the type of fracture and need for instrumentalized hemostasis irrespective of technique. Some authors however report a relationship between the stability of the pelvic ring (irrespective of fracture mechanism) and identification of active arterial bleeding [14,22–24].

### Initial management of patients with pelvic ring trauma

Management is influenced by the patient's initial hemodynamic state. Three categories of patients can be distinguished [25] (Fig. 1):

- category 1: hemodynamically unstable patients due to hemorrhagic shock, i.e. patients with clinical repercussions of the hemorrhage who do not respond to fluid resuscitation (persistent blood pressure under 90 mmHg and/or a tachycardia of over 120 bpm);
- category 2: patients with clinical features of hemorrhage who respond to vascular filling and remain dependent on it;
- category 3: patients with clinical features of hemorrhage which has been stabilized by vascular filling or without clinical features of hemorrhage.

### Hemodynamically unstable patients (category 1)

Mortality is directly influenced by the time required to control the hemorrhage [26,27].

Patients with hemorrhagic shock and an identified source of bleeding (exteriorized bleeding) should receive instrumentalized control of the bleeding without delay.

A patient with hemorrhagic shock and no identified source of bleeding should undergo an assessment of their injury by Focused Abdominal Sonography in Trauma (FAST) and chest and pelvic radiography in the resuscitation suite.

Some authors report that it is possible to carry out a CT assessment of the injury in hemodynamically unstable patients without any significant increase in mortality if the instrument is located in the resuscitation suite [28,29].

A significant peritoneal effusion seen on FAST is an indication for hemostatic laparotomy without delay.

Absence of a significant peritoneal effusion on FAST together with the presence of a pelvic ring injury is an indication for instrumentalized hemostasis for a presumed pelvic bleed without delay.

First-line instrumentalized hemostasis should target bone and venous bleeding by temporarily stabilizing the pelvic ring. Various means can be used for this (external fixation, pelvic C-Clamp, pelvic compression strapping, pelvic draping) and should be performed in the resuscitation suite.

Persistent hemodynamic instability after temporarily stabilizing the pelvic ring is an indication for salvage instrumentalized hemostasis either with pre-peritoneal packing (PPP) or arterial embolization (AE). These two methods are not mutually exclusive but are complementary [30] and their role depends mostly on the usual practice of the care teams.

PPP is fast to perform (in 15 minutes) in the resuscitation suite after stabilizing the pelvic ring. It is effective although it does not act on arterial bleeds and has its own specific morbidity (scarring, sepsis, compartment syndrome).

In the literature, AE tends to be considered to be more of a third line treatment when PPP has failed than an alternative to PPP. The main arguments are the long length of the AE procedure (although difference in length is not reported between selective and unselective embolization) and the inability to carry out a salvage surgical procedure in an arteriography suite (hence the merit of hybrid suites) [30].

However, the role of AE is still discussed by different authors. Some recommend first-line arterial embolization before temporarily stabilizing the pelvic ring [31]. Whereas others believe AE should be used in preference to PPP after temporarily stabilizing the pelvic ring. These decisions are

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