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Pelvic trauma and vascular emergencies


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KEYWORDS
Pelvis; Multiple injury; Embolization

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].

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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].

- 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
related to the organization of the "trauma-centers" (duty or on-call radiologists and orthopedic surgeons, accessibility of the angiography suite in both working and non-working hours).

Patients who are not hemodynamically unstable (categories 2 and 3)

These require a computed tomography assessment of their injuries [10,32]. Images should include an arterial phase, a venous phase and possibly a late phase in certain cases. An unenhanced phase is not required [33,34].

CT has intrinsic features (sensitivity, specificity, positive and negative predictive values), which are superior to those of plain film radiography in diagnosing and classifying pelvic injuries.

CT can identify an active bleed or vascular injury (with a sensitivity of 66 to 90% and specificity of 85 to 98% [35]) before hemodynamic failure develops. It can describe concomitant pelvic lesions (retroperitoneal effusion, urogenital and gastrointestinal organ damage) and extra-pelvic lesions.

CT should be performed before the AE as it guides the procedure, optimizes the radioscopy time, dose received by the patient and volume of contrast medium used during the procedure. It may even reduce mortality [36].

Computed tomography injury assessment: what the radiologist should know

The arterial vascular anatomy of the pelvis

A hemi-pelvis is vascularized by the internal iliac artery. This gives rise to the visceral branches (uterine artery, superior and inferior vesical arteries, middle and inferior rectal arteries) and the parietal branches (ilio-lumbar artery, lateral sacral artery, superior and inferior gluteal arteries, obturator artery and internal pudendal artery) [37,38] (Figs. 2 and 3).

The distribution of the arteries of the pelvis varies. In the majority of cases, a common trunk gives rise to an anterior trunk which carries the visceral branches (uterine artery, superior and inferior vesical arteries, middle and inferior rectal arteries) and parietal branches (inferior gluteal artery, obturator artery, internal pudendal artery) and a posterior trunk carrying the parietal branches (ilio-lumbar artery, lateral sacral artery and superior gluteal artery).
The arterial vasculature of the pelvis involves an arterial, arteriolar and pre-capillary anastomotic network. Unilateral or bilateral proximal ligation of the internal iliac arteries therefore only result in a 49 or 48% fall in distal arterial flow, respectively [39].

Both horizontal (between two internal iliac artery territories) and vertical (between the branches of the internal iliac artery and branches for other arterial territories: branches of the aorta and external iliac artery) anastomoses exist.

These include anastomoses between the gonadal arteries and uterine arteries, between the superior (arising from the inferior mesenteric artery) and inferior rectal arteries, between the lumbar arteries and the ilio-lumbar arteries, between the median sacral artery and the lateral sacral arteries, between the internal and external pudendal arteries and between the obturator and external iliac arteries.

The corona mortis artery describes an obturator artery arising exclusively from the external iliac artery or an anastomosis between the external iliac artery and the obturator artery in the obturator foramen. This is a common uni- or bilateral anatomical variant (29% of cases reported by Smith [40]).

The bleeds or arterial injuries seen in pelvic trauma mostly involve branches of the internal iliac artery although branches arising from the aorta (lumbar and median sacral arteries) or external iliac artery (inferior epigastric artery, corona mortis artery, circumflex iliac artery) may be involved through injury of either these arteries or their anastomoses with the internal iliac artery territory.

CT appearances of active bleeding and vascular injuries

These should be known by radiologists [41] (Fig. 4).

Active arterial bleeding is characterized by extravasation of contrast medium with a density at least equal to that of the aortic lumen in the arterial phase and increased volume and density compared to that of the aortic lumen in the venous phase, within a retroperitoneal effusion or hematoma.

An active venous bleed is characterized by extravasation of contrast medium in the venous phase (which is not visible in the arterial phase) within a retroperitoneal effusion or hematoma.

A pseudoaneurysm appears as rounded structure with low attenuation attached to the wall of the aorta with the same opacification kinetics to those of the arteries.

An arterio-venous shunt produces early opacification of a vein in the arterial phase.

Irregularities in arterial diameter may indicate spasm or traumatic injury (dissection with a non-circulating false lumen). Abrupt cessation of opacification of an artery indicates arterial injury with obstruction of the lumen by a thrombus and may be the source of delayed bleeding due to mobilization of the thrombus.

A bone fragment does not exhibit any change in shape or density in any phase and is located close to a fracture.

Opacified urine outside of the bladder is only seen in cases of urinary injury in the excretory phase or following retrograde injection of contrast medium into a bladder catheter.
CT mapping of the arterial territories of the pelvis

Identification of arteries, which have been damaged or involve active bleeding, is based on the anatomy of the branches of the internal iliac artery. The use of a CT reading method described by Hallinan et al. which distinguishes the arterial territories can prevent laborious monitoring of the arteries and saves time in making a topographic diagnosis of active bleeding or an arterial injury [42] (Fig. 5).

Indication for instrumentalized hemostasis

Identification of active arterial bleeding or vascular injury on the CT assessment of injuries is an indication for arterial embolization.

Some patients, however, have active arterial bleeding or a vascular injury but are not liable to exsanguinate [35]. The decision to carry out arterial embolization is multidisciplinary and should incorporate several factors:

- the patient’s clinical and laboratory state: the presence of clinical features of bleeding — stabilized hemorrhagic shock, tachycardia of over 120 bpm, systolic hypotension of under 90 mmHg, raised blood lactate, reduced blood bicarbonate, reduced hemoglobin, the need for fluid resuscitation or transfusion;
- the CT features of the bleeding: volume of contrast medium extravasation, change in volume of the extravasation between the arterial, portal and late phases, topography of the active arterial bleed and whether or not auto-tamponade is possible [41];
- factors supporting the bleeding: those related to the injury (sites and number of bleeds or vascular injuries), the consequences of the injury (consumption coagulopathy, hypothermia and acidosis) and factors relating to the patient (comorbidities, anti-platelet therapy and/or anti-coagulants and whether or not these can be stopped).

Hypotension is a sensitive sign for hypovolemia in conscious patients. Although a normal blood pressure is not in itself reassuring, this does not exclude active bleeding. Blood pressure is preserved for a long period of time by regulatory mechanisms until these are exhausted and collapse occurs suddenly [43].

Arterial embolization: why? How?

Rationale

The aim of arterial embolization is to obtain hemostasis (by reducing arterial flow, obstructing the arteries responsible for the bleed by thrombosis distal to the arterial and arteriolar collateral supply) without causing ischemic tissue necrosis (by obstructing the artery involved proximal to the pre-capillary collaterals) [44].

Arterial embolization performed too proximally (proximal to the arterial collaterals), carries a risk of failing in terms of stopping the bleeding.

Excessively distal arterial embolization (distal to the pre-capillary collaterals) will cause ischemic tissue necrosis.

Arterial embolization is highly effective in controlling bleeding (close to 100%) [6], and therefore, justifies readily
available access to this technique (24/24 hours, 7/7 days) in all level I multiple injury care centers.

Specific features of patients with multiple injuries

Healthy arteries (in young people), which are of normal diameter or reduced diameter due to collapse, are difficult to puncture. They also tend to spasm, causing catheterization difficulties.

Hypovolemia due to exsanguination causes an increased cardiac output requiring large volumes of iodinated contrast medium for angiographic diagnostic purposes.

Coagulopathy [45] (as a result of consumption of coagulation factors, hypothermia and acidosis due to hypoperfusion and administration of red cells without plasma) causes a reduction in the thrombogenic effectiveness of coils and maintains the bleeding complications related to the access site.

Methods

The femoral approach is preferable, on the accessible side (without fixation materials or deformity from the injury). If a femoral approach is impossible, a humeral approach is used. The puncture should be ultrasound guided if the pulse cannot be felt (bradycardia or collapse). A Seldinger allows a 5F valve introducer to be inserted, which is left in place for at least 48 h [46].

Diagnostic arteriography

Digital subtracted angiography (DSA) can identify targets and anatomical variants.

The abnormalities, which represent embolization targets, include active bleeds (extravasation of iodine contrast medium without washout in the venous phase) and/or vascular injuries (slow flow, irregularity in diameter, obstruction,
arterial dissection, pseudoaneurysm and arterio-venous shunt).

Routine aortography is of debatable utility. Normal images do not exclude an active bleed or vascular injury (an intermittent bleed which is not seen as collapse or diffuse arterial spasm which may recur when hemodynamics are restored). This should be performed if there is no CT assessment of the injury or if the branches of the aorta are suspected of contributing to the bleeding, using a 5F multi-perforated pigtail catheter, the distal tip of which is projecting over L1, with an injection of 25 mL to 18 mL/s and 3 images/s postero-anterior acquisition.

Catheterization of the contralateral internal iliac artery to the approach side is possible via an iliac crossover and is performed using a 5F catheter (Cobra, Simmons or UF) and a 0.035 guide.

The ipsilateral internal artery to the approach side can be catheterized by withdrawing the catheter or creating a Waltmann loop (which involves pushing the Cobra catheter when its distal tip is in the internal iliac artery in order to change the shape of the catheter into an equivalent to a Simmons).

The recurrent branches of the external iliac artery (inferior epigastric, circumflex iliac and corona mortis arteries) are catheterized with a 5F catheter.

Angiography of the common iliac arteries and the iliac bifurcation is performed in a contralateral oblique view at 35° to the artery being examined. Angiography of the internal iliac arteries is performed in an ipsilateral oblique view at 35° to the artery examined and angiography of the femoral artery and its branches is performed on an ipsilateral oblique view at 45° to the artery examined.

The injection can be manual (time saving) or automatic (20 mL at 12 mL/s). The image acquisition frequency can be increased particularly for arterio-venous shunts to 7 or 15 images/s.

The bilateral symmetrical cavernous blush, which is median at the base of the penis, is a distal capillary blush from the internal pudendal artery and should not be interpreted as active bleeding.

**Therapeutic arteriography**

**Embolization agents**

There are three types of embolization agents [47, 48]:

- Resorbable gelatin sponge provides temporary proximal mechanical thrombotic obstruction and are delivered through a catheter or micro-catheter. The ideal embolic agent is gelatin sponge, which is mixed with contrast material, resulting in a thick mixture. The mixture should only be passed through a 3-way tap a limited number of times in order to prevent gelatin microparticle formation which results in capillary embolization distal to all collaterals and therefore causes ischemic necrosis;

- Coils provide permanent thrombotic obstruction (or even mechanical if the packaging is dense). The use of fibrous or active coils improves the thrombogenic effectiveness of the implantable device. The method of delivery (flushable or controlled release) is left to the operator’s discretion. Their diameter should be at least (up to 130%) that of the artery containing the target, which is to be embolized.

Using catheters and micro-catheters of internal lumen, which are consistent with those of the coil (stated in the instructions for use), prevents the risk of blockage (jamming) of the coil within the catheter;

- Liquid agents provide permanent mechanical obstruction. Their effectiveness is independent of the presence or absence of coagulopathy although they carry a risk of distal embolization. They can be used for non-selective embolization of in extremis patients if hemostasis using resorbable gelatin has failed and in patients who are eligible for selective embolization with a target which is inaccessible to selective catheterization particularly if the patient is at high risk of rebleeding from anastomoses.

Adhesive liquid agents, the glues are conditioned and delivered rapidly and can be used for in extremis patients. The non-adhesive liquid agent ONYX (Ethylene vinyl alcohol copolymer [EVOH]) dissolved in dimethylsulfoxide (DMSO) requires preparation and slow delivery and cannot be used for in extremis patients.

**Embolization methods**

Non-selective embolization (Fig. 6) is indicated in unstable patients [49], in patients who are stable with multiple targets identified on CT or angiography and if selective embolization has failed.

Embolization is carried out using a thick mixture of resorbable gelatin in a sponge, cut coarsely and contrast medium. This involves bilateral obstruction of the internal iliac artery trunks in an unstable injury victim and one with multiple bilateral targets or unilateral obstruction of an iliac artery trunk for multiple unilateral targets or if selective embolization has failed.

If unstable hemodynamics persist on the angiography table patients should be investigated for recanalization of the internal iliac arteries (as a result of release of spasm and restoration of normal volemia) and where appropriate further embolization of the internal iliac arteries should be performed [46].

If the internal iliac arteries have not recanized, patients should be investigated for arterial bleed from another territory (branches of the external iliac artery and aorta) using dedicated angiography [46].

If no arterial target is found, a venous or bone bleed should be considered and an alternative instrumentedized hemostasis method used (PPP).

Selective embolization (Fig. 7) is indicated in stable patients with one or more target(s) identified on CT or angiography.

Catheterization is guided by CT mapping of the arterial territories and embolization is performed depending on the target and its site by resorbable gelatin, coils or a liquid agent:

- Pseudoaneurysms require the artery to be sacrificed by embolizing both the proximal and distal arteries to the pseudoaneurysm ("sandwich" packing), so as to prevent back door bleeding (which occurs when the front door alone has been treated). Distal pseudoaneurysms, however, can be treated by obstructing the feeding artery, proximal to the pseudoaneurysm only. Recurrent bleeding through vertical and horizontal anastomoses must be excluded with contralateral (internal iliac artery) and
bilateral non-selective embolization of the internal iliac artery trunks with resorbable gelatin: a: postero-anterior aortography. No active arterial bleeding or vascular injury; b and d: left and right internal iliac artery trunk angiography, ipsilateral oblique view (35°). No active arterial bleeding or vascular injury; c and e: post-embolization control. Slowing of flow in the internal iliac arteries and reflux of contrast medium into the external iliac arteries.

selective embolization of an active arterial bleed from the left obturator artery: a: active arterial bleeding (arrow) fed by the anterior branch of the obturator artery; b and c: exclusion of the anterior branch of the obturator artery by flushable fibrous coils (arrowhead). Sequestration of contrast medium in the pelvic hematoma (arrows).

ipsilateral (branches of the aorta and external iliac artery) diagnostic arteriography;
• damage to the large arterial and venous trunks is rare and carries a high mortality rate. These are managed specifically (obstruction balloon along the injury/sandwich packing pending repair or coated stent bypass) [50,51];
• a target identified in the obturator territory requires external iliac artery angiography to look for a corona mortis artery if internal iliac arteriography is normal.

Complications
The incidence of complications cannot be estimated reliably [6] and is based mostly on case reports.

Non-specific complications
Rarely, the arterial puncture may be complicated by hematoma or vascular injury (i.e., dissection/occlusion/
pseudoaneurysm and arterio-venous malformations) which are predisposed to by the context of injury.

The use of iodine contrast medium carries a risk of nephropathy due to acute tubular necrosis predisposed to by the context of injury (the use of iodine contrast medium for CT assessment of the lesion and for embolization; renal hypoperfusion due to shock) [52, 53] and to anaphylaxis.

Specific complications
Distal embolization may cause ischemic necrosis of the internal iliac artery territories characterized by:

- sciatic nerve paralysis due to embolization of either the lateral sacral artery (radicular arterial branches) or of the sciatic nerve artery feeding the nerve trunk and arising from the inferior gluteal artery [54];
- crural nerve paralysis by embolization of the ilio-lumbar artery (radicular and trunk branches) [54];
- muscle necrosis with necrotizing cellulitis due to embolization of parietal arteries (gluteal arteries) [55, 56];
- bladder, uterine or rectal wall necrosis due to embolization of the visceral arteries (superior or inferior vesicle arteries, uterine arteries, middle rectal arteries) [57–59].

These complications should be interpreted alongside the complications of the injury itself. Sciatic nerve trunk or femoral nerve trunk paralysis may be due to a traumatic injury or nerve compression and muscle necrosis may be due to a compartment syndrome as a result of edema, contusion or intramuscular hematoma.

Non-target embolization, as a result of reflux of the emboligenic agent or its passing through arterial anastomoses with other territories may involve:
- lower limb arteries through the external iliac artery. This may be responsible for acute lower limb ischemia [59];
- Adamkiewicz’s artery, possible as a result of embolization of the lumbar artery or of an ilio-lumbar or a lateral sacral artery, which has vertical anastomoses with the lumbar arteries. This may cause spinal cord arterial ischemia [59].

Influence of embolization methods on the incidence of ischemic complications
Ischemic complications mostly occur in non-selective and particularly in bilateral embolizations. Muscle necrosis with necrotizing cellulitis is only seen with bilateral non-selective embolization [60]. Notwithstanding the incidence of complications of bilateral non-selective embolization, it is both effective and fast to perform particularly in unstable injury victims.

Figure 8. Pelvic CT: a, b and c: axial sections without and then with contrast enhancement in the arterial and venous phases; d: Maximal Intensity Projection (MIP) oblique axial reconstruction in the arterial phase.
Influence of the choice of emboligenic agent on the incidence of ischemic complications

Microparticles, which produce distal embolization downstream from the pre-capillary collaterals, must be avoided. Liquid agents carry a risk of distal embolization but should be considered in some situations. The reversible nature of arterial obstruction with gelatin does not in itself provide reassurance. Arterial recanalization develops between 48 h and several weeks or months after the procedure [48], whereas muscle and nerve injuries due to arterial ischemia become irreversible over 4 to 6 hours [61]. Off-target embolization is prevented by distal catheterization, using a catheter without side holes (end hole) and continuous radioscopy monitoring of the embolization, slow embolization with an “end point” aiming for an obvious flow reduction (removal of contrast medium in 5 heartbeats).

Take-home messages
- Exsanguination is the leading cause of death within the first 24 hours of treatment of pelvic ring trauma victims.
- Coagulation, hypothermia, acidosis, anti-platelet therapy and anticoagulants maintain the bleeding.
- Hemodynamic instability and/or unstable pelvic ring injuries are associated with a high mortality rate and a high likelihood of arterial bleeding.
- Ninety per cent of patients have a concomitant extra-pelvic lesion which may be life threatening.
- Hemostatic laparotomy should take priority over pelvic instrumentalized hemostasis for a hemoperitoneum in an unstable injury victim.
- The CT injury assessment both provides the indication for and guides arterial embolization in a stable injury victim.
- Pelvic embolization should achieve hemostasis without ischemic complications.
- Non-selective embolization is the only possible method for unstable injury victims: each minute counts.
- Selective embolization carries a high risk of rebleeding.
- Knowledge of arterial anastamoses can prevent, identify and treat rebleeds.
- The choice of emboligenic agent and continuous monitoring of embolization prevent ischemic complications.

Figure 9. Digital angiography with and without subtraction: a and b: pre-embolization; c and d: post-embolization.
Clinical case

This 80-year-old woman is on D2 after a stable pelvic injury (Young LC1). During her hospitalization, she developed progressive clinical features of hemorrhage without exteriorization with a fall in her hemoglobin requiring transfusion of 2 Units of packed red blood cells. A CT is performed (Fig. 8).

Questions

1. Describe the abnormality and give its location.
2. What further information is needed from the clinician in order to establish whether arterial embolization (AE) is indicated?
3. In light of the CT findings, are you surprised that the target is not seen on internal iliac arteriography (not shown)?
4. Justify the use of a liquid agent for embolization.

Answers

1. Arterial pseudoaneurysm in the left obturator territory (Fig. 8 a–c: arrow)
2. Identification of a target is in itself an indication for AE. The decision, however, should incorporate clinical and laboratory findings (clinical consequences of the bleeding – tachycardia, dyspnea, chest pain, hypotension, shock – the need to continue transfusions to maintain a constant hemoglobin concentration or fall in hemoglobin despite transfusions) and factors maintaining the bleeding (coagulopathy, receipt of anti-platelet therapy or anticoagulants, whether or not it is possible to stop these and antagonize their effects – mechanical valve, high risk of venous thromboembolic disease, recent stent insertion, particularly if coated).
3. CT shows a corona mortis artery arising from a common trunk with the inferior epigastric artery providing exclusive arterial vascularity to the obturator territory (Fig. 8d: arrowheads). Only external iliac arteriography can identify the vascular abnormality.
4. The proximal pseudoaneurysm can be resupplied through the output point if this is not treated. Because of catheterization difficulties (tortuous and small diameter artery), it was not possible to position the micro-catheter distal to the output point in order to achieve sandwich packing with coils. The use of a liquid agent is beneficial in this situation.

Fig. 8 illustrates the arterial embolization. The pseudoaneurysm (arrow) is fed by an obturator artery arising from a common trunk with the inferior epigastric artery: the corona mortis artery (Fig. 9a–b arrowheads). Embolization (Fig. 9c–d) is performed with a non-adhesive liquid agent and excludes the target.

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Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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