Anaesth Crit Care Pain Med 38 (2019) 199–207

Guidelines

Early management of severe pelvic injury (first 24 hours)

Pascal Incagnoli [a,*], Alain Puidupin [b], Sylvain Ausset [c], Jean Paul Beregi [d], Jacques Bessereau [e], Xavier Bobbia [f], Julien Brun [g], Elodie Brunel [h], Clément Buléon [i], Jacques Choukroun [j], Xavier Combes [k], Jean Stephane David [l], François-Régis Desfemmes [m], Delphine Garrigue [n], Jean-Luc Hanouz [i], Isabelle Plénier [o], Fréderic Rongieras [p], Benoit Vivien [q], Tobias Gauss [r], Anatole Harrois [s], Pierre Bouzat [g], Eric Kipnis [t]

[a] *Hospices Civils de Lyon, centre hospitalier Lyon Sud, service d'anesthésie-réanimation, 165, chemin du Grand-Revoyet, 69495 Pierre-Bénite, France*
[b] *Direction centrale du service de santé des armées, 60, boulevard du Général-Marcel-Valin, 75509 Paris, France*
[c] *Ecole du Val de Grâce, hôpital d'instruction des armées Percy, 1, rue du Lieutenant-Raoul-Batany, 92190 Clamart, France*
[d] *CHU de Nîmes, service de radiologie et d'imagerie médicale, place du Pr-Robert-Debré, 30029 Nimes, France*
[e] *Assistance publique des Hôpitaux de Marseille, SAMU 13, pôle RUSH, CHU de la Timone, 264, rue Saint-Pierre, 13385 Marseille, France*
[f] *CHU de Nîmes, division anesthésie-réanimation douleur urgences, 30029 Nimes, France*
[g] *Grenoble Alpes Trauma Centre, pôle anesthésie-réanimation, boulevard de la Chantourne, 38700 La Tronche, France*
[h] *CHU de Toulouse, service d'anesthésie-réanimation, hôpital Purpan, 1, place du Dr Balzac, 31300 Toulouse, France*
[i] *CHU de Caen, pôle réanimations-anesthésie-samu, avenue Côtes de Nacre, 14033 Caen, France*
[j] *Centre hospitalier du Mans, service des urgences, 194, avenue Rubillard, 72037 Le Mans, France*
[k] *CHU de la Réunion, hôpital Bellepierre, SAMU 974, 97405 Saint Denis, France*
[l] *Hospices Civils de Lyon, centre hospitalier Lyon Sud, service d'anesthésie-réanimation, faculté de médecine Lyon Est, Université de Lyon 1 Claude-Bernard, 165, chemin du Grand Revoyet, 69495 Pierre Bénite, France*
[m] *Hôpital d'instruction des Armées du Val de Grace, service de chirurgie urologique, 75005 Paris, France*
[n] *CHRU de Lille, service d'accueil des urgences vitales chirurgicales, 2, avenue Oscar-Lambret 59037 Lille, France*
[o] *CHRU de Lille, service de chirurgie de l'urgence, 2, avenue Oscar-Lambret 59037 Lille, France*
[p] *Hôpital d'instruction des armées Desgenettes, service de chirurgie orthopédique et traumatologique, 108, boulevard Pinel, 69003 Lyon, France*
[q] *Assistance publique des Hôpitaux Paris, CHU de Necker-Enfants Malades, SAMU de Paris et service d'anesthésie-réanimation, 149, rue de Sèvres, 75330 Paris, France*
[r] *Assistance publique des Hôpitaux Paris, hôpital Beaujon, servie d'anesthésie-réanimation, réanimation chirurgicale, hôpitaux universitaires Paris Nord Val de Seine, 92110 Clichy, France*
[s] *Assistance publique des Hôpitaux Paris, CHU de Bicêtre, service d'anesthésie-réanimation, reanimation chirurgicale, 78, rue du Général Leclerc, 94270 Le Kremlin-Bicêtre, France*
[t] *CHRU de Lille, réanimation chirurgicale, pôle d'anesthésie-réanimation, 2 avenue Oscar-Lambret 59037 Lille, France*

ARTICLE INFO

Historique de l'article :
Available online 21 December 2018

Keywords:
Pelvic trauma
Prehospital setting
Severity criteria
Trauma network
Arterial embolization

ABSTRACT

Objective: Pelvic fractures represent 5% of all traumatic fractures and 30% are isolated pelvic fractures. Pelvic fractures are found in 10 to 20% of severe trauma patients and their presence is highly correlated to increasing trauma severity scores. The high mortality of pelvic trauma, about 8 to 15%, is related to actively bleeding pelvic injuries and/or associated injuries to the head, abdomen or chest. Regardless of the severity of pelvic trauma, diagnosis and treatment must proceed according to a strategy that does not delay the management of the most severely injured patients. To date, in France, there are no guidelines issued by healthcare authorities or professional societies that address this subject.
Design: A consensus committee of 22 experts from the French Society of Anaesthesia and Intensive Care Medicine (*Société Française d'Anesthésie et de Réanimation*; SFAR) and the French Society of Emergency Medicine (*Société Française de Médecine d'Urgence*; SFMU) in collaboration with the French Society of Radiology (*Société Française de Radiologie*; SFR), French Defence Health Service (*Service de Santé des Armées*; SSA), French Society of Urology (*Association Française d'Urologie*; AFU), the French Society of Orthopaedic and Trauma Surgery (*Société Française de Chirurgie Orthopédique et Traumatologique*; SOCFCOT), and the French Society of Digestive Surgery (*Société Française de Chirurgie digestive*; SFCD) was convened. A formal conflict-of-interest (COI) policy was developed at the onset of the process and enforced throughout. The entire guidelines process was conducted independently from any industry

* Corresponding author: Hospices civils de Lyon, centre hospitalier Lyon Sud, service d'anesthésie-réanimation, 165, chemin du Grand Revoyet, 69495 Pierre Bénite, France.
E-mail address: pascal.incagnoli@chu-lyon.fr (P. Incagnoli).

https://doi.org/10.1016/j.accpm.2018.12.003

funding. The authors were advised to follow the principles of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system to guide assessment of quality of evidence. The potential drawbacks of making strong recommendations in the presence of low-quality evidence were emphasised.
Methods: Population, intervention, comparison, and outcomes (PICO) questions were reviewed and updated as needed, and evidence profiles were generated. The analysis of the literature and the recommendations were then conducted according to the GRADE® methodology.
Results: The SFAR Guideline panel provided 22 statements on prehospital and hospital management of the unstable patient with pelvic fracture. After three rounds of discussion and various amendments, a strong agreement was reached for 100% of recommendations. Of these recommendations, 11 have a high level of evidence (Grade 1 ±), 11 have a low level of evidence (Grade 2 ±).
Conclusions: Substantial agreement exists among experts regarding many strong recommendations for management of the unstable patient with pelvic fracture.

1. Introduction

Pelvic fractures are observed in 10% of severe trauma patients admitted to level 1 trauma centres [1]. Their severity is due to associated non-pelvic injuries and/or haemorrhagic pelvic injuries [2,3]. Pre-hospital and hospital management of severe pelvic trauma requires clear organisational and therapeutic strategies in order to control haemorrhage as rapidly as possible. These strategies involve both global approaches such as establishing a clearly identified regional trauma care network and local approaches such as a coordinated multidisciplinary team focused on trauma patient care. Prehospital management is a critical link within a trauma network and the trauma centres/teams. Every step of patient management must be carefully thought out and focused on haemorrhage control. While French guidelines concerning haemorrhagic shock due to trauma exist [4], there are no guidelines related to the management of patients with severe pelvic trauma. Furthermore, the abundant literature on the topic is heterogeneous includes many studies with major methodological weaknesses and few meta-analyses providing clear answers to the many issues in the field. These issues include the pre-hospital use of pelvic binders, appropriate imaging strategy, and appropriate use of surgical or interventional radiological control of bleeding. Establishing these guidelines is therefore necessary to provide clear strategies to all healthcare professionals involved in the management of patients with severe pelvic trauma.

2. Material and methods

These recommendations come from experts of the Société Française d'Anesthésie et de Réanimation (SFAR) and Société Française de Médecine d'Urgence (SFMU) in partnership with: Association Française d'Urologie, Société Française de Chirurgie Digestive, Société Française de Radiologie, Société Française de Chirurgie Orthopédique et Traumatologique, Service de Santé des Armées. As a first step, the organisation committee defined the questions under consideration according to the PICO format (Patients Intervention Comparison Outcome). The system used to elaborate their recommendations is the GRADE® method. After a quantitative analysis of the literature, this method allows firstly an assessment of the quality of evidence, such as a confidence estimation needed to analyse the effect of the quantitative intervention, and secondly provides a level of recommendation. The quality of evidence is distributed into four categories:

- high: further research is very unlikely to change the confidence in the estimate of the effect;
- moderate: further research is likely to have an impact on the confidence in the estimate of the effect and may change the estimate of the effect itself;
- low: further research is very likely to have an impact on the confidence in the estimate of the effect and is likely to change the estimate of the effect itself;
- very low: any estimate of the effect is very unlikely.

The analysis of the quality of evidence is completed for every study, then a global level of evidence is defined for a given question and criterion. The final formulation of recommendations will always be binary, positive or negative and strong or weak:

- strong: we recommend or we do not recommend (GRADE 1+ or 1−);
- weak: we suggest or we do not suggest (GRADE 2+ or 2−).

The strength of the recommendations is determined according to key factors, and validated by the experts after a vote, using the Delphi and GRADE Grid method, taking into account:

- the estimate of the effect;
- the global level of evidence; the higher the level of evidence, the stronger the recommendation;
- the balance between desirable and undesirable effects: the more favourable the balance, the stronger the recommendation;
- values and preferences: in case of uncertainty or large variability, the level of evidence of the recommendation is probably weak. Values and preferences must be more clearly obtained from persons affected (patient, physician, decision-maker);
- cost: the greater the costs or the use of resources, the weaker the recommendation;
- formulating a recommendation requires that 50% of participants should have an opinion and that less than 20% of participant prefer the opposite proposition;
- making a strong recommendation requires an agreement of at least 70% of participants.

The analysis of the early management of pelvic injuries has been assessed according to 2 headings: pre-hospital and hospital management. A total of 22 experts were divided into 4 working groups. Data had to have been published within the last 20 years to be selected. In the case of no data or a very low number of publications during the considered period, the timing of publications was extended to the last 25 years.

The experts were faced with three situations:

- for some questions with evidence from several trials or meta-analyses with an acceptable methodological quality, the GRADE® method was totally applicable and allowed recommendations to be made;
- when no meta-analysis was available to answer the question, a qualitative analysis by the experts following the GRADE® method was possible and a systematic review was performed;
- for some questions, the lack of any recent studies made recommendations impossible.

After collating all the work of the experts and implementing the GRADE® method, 22 recommendations were formally proposed by the organising committee. Of these, 11 were strong (Grade 1 ±), 11 were weak (Grade 2 ±), and for 9 questions the application of the GRADE1 method proved to be impossible. All the recommendations were submitted to a reviewing group for a Delphi method assessment. After three rounds of voting and evaluation and after various amendments, a strong agreement was reached for 100% of recommendations.

3. Prehospital management

3.1. What clinical signs should point to pelvic trauma upon initial prehospital management?

R1: A spontaneous pelvic pain must be assessed in conscious trauma patients in order to diagnose a pelvic fracture. We recommend all trauma patients with shock or altered consciousness be systematically considered as having pelvic trauma. (Grade 1+) Strong agreement

Clinical pelvic examination is often unreliable in the prehospital setting and has little or no impact on patient outcome. Many studies pool pelvic and non-pelvic trauma patients, most studies concern patients with a Glasgow Coma Score over 13. Only one meta-analysis is available, including 5.235 patients from 12 prospective and retrospective studies, among which 441 patients had pelvic fractures. Of these 441 patients with pelvic fractures, only 3 were missed by clinical examination. Despite the high methodological inhomogeneity of the studies included in the meta-analysis, the authors conclude that clinical examination by trained teams in conscious trauma patients without shock can detect pelvic fractures with a high sensitivity close to 100% [5].

3.2. How to clinically assess pelvic trauma severity in the prehospital setting?

R2: We suggest the open pelvic injury, associated major injury or major bleeding, be considered at risk of severe pelvic trauma. (Grade 2+) Strong agreement

The most frequent mechanisms causing severe pelvic trauma are falls from heights, motor vehicle crashes involving two-wheeled vehicles, and other less high-kinetic energy trauma in more vulnerable trauma victims such as those older than 65 years old. Severity criteria for trauma patient triage were proposed in 2002 by Riou et al. at the Vittel meeting [6]. Among the proposed criteria organised into categories (clinical, trauma kinetics, anatomical injury and underlying patient status), the presence of a single criterion identifies severe trauma. Mortality of patients with pelvic trauma increases when associated with severe traumatic brain injury (TBI) (OR = 4.57, CI 95% [1.95–10.73]) [7,8], thoracic trauma (OR = 2.8, CI 95% [1,3–6.1]) [9,10], severe abdominal trauma (OR = 5.54, CI 95% [1.61–18.37]) [11,12]. Likewise, haemorrhagic shock increases pelvic trauma mortality by a factor of 3 to 5 [8,12–17] and open pelvic injury increases pelvic trauma mortality by a factor of 3 to 4 [18–21]. In general, patients aged over 65 are considered at higher risk of death than younger patients following any given trauma [22].

3.3. When and how should pelvic stabilisation be performed in the prehospital setting?

R3a: We recommend external pelvic compression be applied as soon as possible in all patients with suspected severe pelvic trauma. (Grade 1+) Strong agreement

R3b: We suggest that pelvic binders, regardless of type (except sheet wrapping), be used to apply external pelvic compression. In order to be efficient (compared to surgical C-clamp compression), pelvic binders must be placed around the great trochanters. (Grade 2+) Strong agreement

External stabilisation of pelvic trauma is part of many trauma recommendations despite little or any evidence though methodologically sound trials. To date, there are no randomised controlled trials, only retrospective studies and case series. Two available systematic reviews suggest that pelvic binders may reduce transfusion requirements, and both ICU and hospital length-of-stay, while sheet wrapping yields no potential benefit [23]. The impact of pelvic binders on mortality remains to be determined given that all pertaining studies are of low level-of-evidence [24,25]. Among available studies, some are contradictory and suggest that external pelvic stabilisation might displace some fractures (B2–B3) and lead to cutaneous injury (particularly in men, thinner patients or the elderly) [26,27].

3.4. What facility should patients with severe pelvic trauma be initially transported to?

R4: All patients with severe pelvic trauma could be initially transported to a referral centre fully staffed and equipped to treat any aspect of trauma (''trauma centre''). (Grade 1+) Strong agreement

In France, the deployment of healthcare networks dedicated to trauma management (or trauma "systems") is still ongoing. Such networks encompass the care of trauma patients from pre-hospital management at the scene to admission to a trauma centre and definitive care. Pre-hospital medical care at the scene delivered by doctors, as is the case in the French healthcare system, has led to a 30% mortality rate decrease in severe trauma regardless of injury type [28] and the use of air emergency medical services (almost exclusively helicopters) led to a 15% increase in survival of patients with severe trauma in Europe as well as North America [29]. Trauma care systems have demonstrated their efficacy in the United-States in terms of reducing mortality and avoidable deaths and increasing quality of care [30,31]. Admission to a designated Trauma Centre leads to a 20% decrease in overall trauma mortality and a 30% decrease in severe trauma mortality [32–34]. An 8% decrease in motor vehicle crash related mortality was observed in the USA following the implementation of a severe Trauma network [35]. A meta-analysis of 14 studies assessing the efficacy of US trauma networks showed a resulting 15% decrease in

overall mortality [36]. Rapid transfer of severe trauma patients (including, but not limited to patients with severe pelvic trauma) to a referral Trauma Centre increases survival compared to transfer to the closest available non-specialised facility [37]. Data specifically focused on severe pelvic trauma are rare [38], but prehospital management and patient transfer strategies are the same as for severe trauma patients in general. Recently, a French study showed that within a regional trauma system, transfer of severe pelvic trauma patients to the referral Trauma Centre could decrease observed mortality to levels lower than predicted mortality [39].

4. Hospital management

4.1. Should a pelvic X-ray be obtained upon arrival to the trauma centre of a patient with suspected severe pelvic trauma?

R5a: We suggest getting a pelvic X-ray upon arrival to the trauma centre for patients who are haemodynamically unstable patients and/or require urgent intervention(s) to stabilise vital signs. (Grade 2+) Strong agreement

R5b: We do not suggest a pelvic X-ray upon arrival to the trauma centre for haemodynamically stable patients. A body (including pelvic) CT-scan with intravenous contrast should be performed. (GRADE 2-) Strong agreement

In haemodynamically unstable patients despite pre-hospital resuscitation efforts, the focus is on the control of bleeding. A definite diagnosis of the source of bleeding must be established as rapidly as possible in conditions of on-going resuscitation that do not allow performing a CT-scan. In this case, pelvic X-ray, as well as chest X-ray (CXR) and Extended Focused Assessment with Sonography for Trauma (E-FAST) are the only imaging workups compatible with both on-going resuscitation and the imperative to decide upon different bleeding control options, either surgical or radiological. The study of Peytel et al. on haemodynamically unstable patients reported 98% (CI 95%: 97%–99%) appropriate urgent intervention decisions (tube thoracostomy, emergency thoracotomy, pelvic angiography/embolization, emergency laparotomy) based on imaging alone [40]. When CXR and E-FAST rule out extra-pelvic causes of haemorrhagic shock, pelvic angiography has a high probability of visualising active arterial bleeding and the patient should undergo a body CT-scan with intravenous contrast followed by angiography/embolization. In rare cases of uncontrollable haemorrhagic shock, angiography/embolization can be performed immediately after CXR and E-FAST to rule out non-pelvic massive haemorrhage. When pelvic trauma is associated with hemoperitoneum, the decision algorithm is more difficult since the origin of active bleeding may depend on pelvic fracture stability. Indeed, the source of active bleeding is more often abdominal (70%) when hemoperitoneum is associated with stable pelvic fracture, and more often pelvic (56%) when associated with unstable fractures [41], albeit with remaining uncertainty in both cases. Other factors must be taken into account, such as abundance of hemoperitoneum, since massive hemoperitoneum suggests a massive intra-abdominal bleeding requiring surgical control. If angiographic embolization is decided for control of pelvis bleeding, it also allows control of concomitantly bleeding intra-abdominal sources of bleeding (due to hepatic, splenic and renal injuries). In this context, the usefulness of pelvic X-ray is therefore dependent on haemodynamic instability and extra-pelvic (mainly thoracic and/or abdominal) sources of bleeding. In haemodynamically stable patients, pelvic X-ray does not influence patient management since normal images only exclude pelvic injuries as sources of major bleeding and do not exclude pelvic fractures, which may be revealed by the CT-scan.

4.2. Should extended focus assessment with sonography for trauma (E-FAST) be performed in patients with suspected severe pelvic trauma?

R6: We suggest an E-FAST be performed in all patients with suspected severe trauma including patients with suspected severe pelvic trauma. (Grade 2+) Strong agreement

4.2.1. Rationale

E-FAST serves two purposes in severe pelvic trauma: it allows:

- the diagnosis of open-book pelvic fractures by measuring the pubic symphysis widening (the pelvic ring is open when symphysis widening $>$ 25 mm) [42] and;
- the diagnosis of associated injuries that may be responsible for or participate in haemodynamic instability.

E-FAST performance characteristics allow attributing bleeding to associated injuries and may therefore assist therapeutic decision-making particularly when severe pelvic trauma is associated with severe abdominal trauma. Rucholtz et al. find a PPV of 97% for the diagnosis of intra-abdominal bleeding through E-FAST detection of E-FAST in 31 patients presenting pelvic trauma associated with severe abdominal trauma allowing appropriate bleeding control through laparotomy [43]. Another study reports the importance of assessing the abundance of hemoperitoneum to increase the rate of appropriate laparotomies; abundant hemoperitoneum defined as 3 positive E-FAST screening sites was associated with 61% of appropriate laparotomies, while moderate hemoperitoneum defined as 2 positive E-FAST screening sites was associated with 26% [44]. The negative predictive value (NPV) of E-FAST must be taken into account in the management of severe pelvic trauma: Verbeek et al. fin an NPV of 97% in patients with shock [45]. Finally, E-FAST performance may be diminished by false positives such as suffusion of a hemoretroperitoneum or intra-peritoneal bladder rupture [43].

4.3. Should a thoraco-abdomino-pelvic CT-scan with contrast be performed before angiographic embolization in patients with severe pelvic trauma?

R7: We recommend performing a thoraco-abdomino-pelvic CT-scan with contrast before angiographic embolization in patients with severe pelvic trauma when allowed by the patient's haemodynamic status. (Grade 1+) Strong agreement

Access to imaging in patients with severe pelvic trauma is a priority in order to obtain a full survey of all injuries, and particularly, abdominal, pelvic and/or thoracic injuries and associations thereof. CT scanning with contrast agent allows complete inventory of injuries as well as the identification of active bleeding and provides information useful to deciding upon surgical or radiological interventional management of active bleeding. CT-scan must be performed as rapidly as possible and as briefly as possible in order to direct eventual subsequent embolization and avoid delays. If the CT-scan with contrast shows isolated pelvic injury without active bleeding and the patient is haemodynami-

cally unstable, angiography is warranted to detect active pelvic bleeding and perform selective embolization. In the recent publication by Hallinan et al., 51 patients with abdominal and/or pelvic trauma underwent a CT-scan with contrast followed by angiography. Predictive positive and negative values of CT-scan with contrast compared to angiography were respectively 93,9 %, 77.8%, 88.6% and 87.5% [46–53].

4.4. Should urethral and bladder opacification be performed in severe pelvic trauma patients?

R8a: We do not suggest systematically performing specific imaging workup for lower urinary tract injury (urethral and/or bladder opacification) in severe pelvic trauma patients. (Grade 2−) Strong agreement

R8b: We suggest performing a retrograde urethral and bladder opacification, ideally with a CT-scan in severe pelvic trauma patients with clinical symptoms of lower urinary tract injury (inability to urinate, gross haematuria, blood at the meatus, suprapubic tenderness and suprapubic penetrating wounds), particularly before attempting urinary catheterization in men. (Grade 2+) Strong agreement

Lower urinary tract injuries (mainly bladder and posterior urethral injuries) are classically associated with severe pelvic trauma. In civilian trauma, 60 to 90% of bladder injuries and 75% of posterior urethral injuries are due to pelvic fracture [54–56]. Bladder injuries are found in 3.5% of pelvic fractures [57], mostly extra peritoneal more frequently than intra-peritoneal ruptures. Traumas occurring on a full bladder, particularly in the setting of acute alcohol intoxication, represent a risk factor for bladder injury, particularly intraperitoneal rupture [51]. Posterior urethral injuries are found in 4 to 19% of pelvic fractures [58]. Unstable pelvic fractures, particularly those associating bilateral ischio-pubic rami and sacro-iliac dislocation are at the greatest risk of associated lower urinary tract injuries [55,56]. Associated urethral and bladder injuries are found in 4 to 15% of cases in this context [58]. However, anterior urethral injuries in men and urethral injuries in women are rare [58]. For these reasons, systematic dedicated imaging (urethracystography) to detect lower urinary tract injuries is not warranted. Indeed, these injuries never jeopardize patient outcome in the initial phase and their repair is never an emergency. However, the diagnosis of lower urinary tract injuries associated with pelvic fractures remains necessary to allow early drainage, and early surgical closure in case of intraperitoneal rupture, to limit complications and urinary sequelae. Contrast CT-scan of the abdomen and pelvis is the standard-of-care imaging workup in hemodynamically stable patients with severe pelvic trauma. While late excretion phase images will reveal ureteral injuries, they may miss bladder injuries, particularly intraperitoneal ruptures when a urinary catheter is already in place and unclamped [57]. Furthermore, contrast CT-scan does not allow visualisation of the urethra. Only specific retrograde contrast opacification coupled with CT-scan allow a complete survey of urethral and bladder injuries in case of evocative symptoms. In men, the recommended exam is retrograde urethrocystogram with contrast CT-scan. It is performed by introducing a urinary catheter in the anterior urethra and inflating the cuff to only 1 to 2 mL to allow opacification of the lower urinary tract with contrast agent up to 350 mL to visualise the posterior urethra and bladder. Coupled with CT-scan, it is the gold standard to diagnose bladder injuries [58–61]. "Classic" fluorometric retrograde urethrocystography in the radiology suite or operating room with lateral imaging to visualize the urethra and both frontal and lateral imaging for the bladder remain pertinent in male patients with severe pelvic trauma who are too unstable for CT-scanning or when CT-scan is inaccessible. Endoscopic retrograde urethrocystography remains an option when available particularly to allow concomitant realignment of a ruptured urethra. It is also recommended in case of suspected urethral trauma in women [56,58,62] given a short anatomical urethral length that precludes visualisation by retrograde opacification.

4.5. What are the radio-anatomical criteria of severe pelvic trauma?

R9: According to the Young-Burgess or Tile classifications, unstable pelvic fracture, particularly « open book » fractures and pelvic ring disruptions with posterior fractures or active extravasation of contrast agent during the arterial phase of the CT-scan or angiography, should probably be considered at radio-anatomical criteria of severe pelvic trauma. (Grade 2+) Strong agreement

According to the Tile classification, unstable fractures (type C fractures) [63] and pelvic ring fractures with posterior injuries are associated with significantly more frequent haemorrhagic pelvic vascular injuries [64] and greater blood product transfusion requirements than other types of fractures [65].

According to the Young-Burgess classification, unstable fractures [66] (types APC2, APC3, LC2, LC3, VS and combinations) are associated with significantly greater mortality than stable fractures (11.5% vs. 7.5%; $P < 0.05$) and greater blood product transfusion requirements [67,68]. Extravasation of contrast agent during the arterial phase of the CT-scan is related to arterial bleeding with a sensitivity that varies from 82% to 89% and specificities from 75% to 100% [69,70].

4.6. What is the optimal timing to perform bleeding control procedures in actively bleeding severe pelvic trauma?

R10a: We recommend bleeding control procedures be performed as soon as possible in actively bleeding severe pelvic trauma. In the setting of severe pelvic trauma, bleeding control procedures may be angiographic embolization or surgical pelvic pre-peritoneal packing by a trained proficient team. (Grade 1+) Strong agreement

R10b: We recommend that the time between admission to the hospital and bleeding control procedures, regardless of type, should not exceed 60 minutes. (Grade 1+) Strong agreement

Control of pelvic bleeding can be achieved by mechanical closure of the pelvic ring (pelvic binders or C-clamp), arteriographic embolization, or surgical rescue pelvic pre-peritoneal packing. Whatever the chosen method, studies all show that the most important factor is time-to-control-of-bleeding. Thus, in a recent randomised trial, there was no difference in survival between angiographic embolization and surgical pelvic pre-peritoneal packing [71].

When embolization is the chosen method, time-to-successful embolization is independently associated with mortality, which increases with duration [72]. Mortality increases from 16 to 64% if embolization requires more than 60 minutes [73]. It is estimated that mortality increases by 1% for every additional 3 minutes time required for embolization [74].

4.7. What type of embolization should be performed in patients with severe pelvic trauma?

R11: We recommend that a non-selective embolization through the common femoral artery be performed in unstable patients, stable patients who present multiple active bleeding targets on CT-scan and/or when attempted selective embolization fails. (Grade 1+) Strong agreement

Embolization should be performed in a vascular angiography suite that optimally comprises a vascular imaging C-arm unit coupled with the sliding table, digital substraction modes, "road maps" modes, image comparison modes and dynamic imaging rates of 3 to 6images per second [75–80]. The operator must be trained and proficient in embolization procedures and must be familiar with different types of embolization, equipment and catheters (particularly, 4F or micro-catheters). Arterial access is chosen according to accessibility of common femoral arteries, which is the preferred route either uni- or bilateral [80–82]. If pelvic injuries are too extensive to allow femoral access, the humeral route is recommended. The first step of the procedure is a full frontal aortography obtained from the catheter in place at the sub-renal aorta, allowing angiographic diagnosis of active bleeding. The next step is selective catheterization of internal iliac arteries, sometimes the external iliac and lumbar arteries due to collaterality. The most commonly observed sign of active bleeding is irregular contrast extravasation at the level of small arterioles. Other findings suggestive of vascular injury include arterial occlusion due to vasospasm, arteriovenous fistula, pseudoaneurysm and diffuse abnormal blush. The choice of embolizing agents and exact embolization strategy depend on angiographic data, vascular anatomy and haemodynamic stability [75,81–84]. Whenever possible, embolization if performed with temporary material. In haemodynamically unstable patients and in case of multiple bilateral bleeding targets, non-selective bilateral embolization of the internal iliac arteries should be performed [85]. Non-selective unilateral internal iliac artery embolization is necessary in case of multiple unilateral bleeding targets or in case of failed attempts at selective embolization [85]. Selective embolization should be performed in hemodynamically stable patients with one or few bleeding targets identified on the CT-scan or angiography. Embolization is performed with pelvic closure in place (binding, C-clamp) or even with Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in place. Once embolization has been performed, prudent pelvic decompression (or REBOA deflation) is attempted allowing angiographic verification of bleeding control and additional embolization if required [81,82]. The arterial access port with anti-reflux valve should be kept in place 24 h to allow angiographic embolization in case of haemorrhage recurrence. Additionally, if an arterial line for monitoring was not placed prior to embolization, the arterial access allows invasive blood pressure monitoring while it is in place.

4.8. Should secondary angiographic verification be performed systematically in severe pelvic trauma patients having undergone angiographic embolization initially?

R12: We suggest not performing a secondary systematic angiographic verification in severe pelvic trauma patients having undergone initial angiographic embolization. (Grade 2-) Strong agreement

Secondary angiographic verification is only warranted in case of doubt concerning haemorrhage recurrence and should optimally be considered after contrast CT-scan [86,87]. Contrast CT-scan will confirm recurrence and/or may identify another bleeding target. Recurrence is due to the many collateral vessels and anastomoses of the pelvic vasculature, which is also the rationale for bilateral embolization of haemodynamically unstable patients even when the fracture is unilateral. Recurring haemorrhage can also be due to the reopening of injured vessels initially subject to vasospasm due to the low blood flow in haemorrhagic shock. With resuscitation and haemodynamic stabilization, reopening of these injured vessels leads to new active bleeding. Additional embolization may therefore be required depending on patient status and CT-scan verification. In case of suspected ureteral or bladder injury, CT-scan after embolization is indicated to diagnose these injuries that require intervention after control of bleeding [88,89].

4.9. Should surgical pelvic trauma packing be proposed for severe pelvic trauma patients?

R13: We suggest performing a surgical pre-peritoneal pelvic packing in association with an external fixation in the case of haemodynamic instability when impossible to:
Transfer the patient to the CT-scan or/and for embolization
Perform an embolization in less than 60 minutes once the diagnosis has been made.
(Grade 2+) Strong agreement

In the case of severe haemodynamic instability making it impossible to transfer the patient to the CT-scan and to perform the angioembolization in less than 60 minutes once the diagnosis is made, pre-peritoneal pelvic packing is a complementary method which aims to achieve temporary haemostasis until definite haemostasis is done in severe pelvic trauma patients with an uncontrolled haemorrhagic shock. The fast and easy realisation of this method, demands however a surgical training and a multidisciplinary discussion. Once the method is mastered, a significant haemostasis is achieved [90] and in a small series of patients, has permitted haemodynamic stability allowing transfer to the angiography procedure room for embolization. This method is not aimed to be a substitute to embolization even if it seems to be sufficient to control the haemorrhage [91]. An extensive injury assessment must follow the use of this method. To achieve better results, it is recommended to combine the use of an external fixation (pelvic ring, external fixation or C-clamp).

4.10. When should external surgical pelvic fixation be proposed for severe pelvic trauma patients?

R14a: We recommend performing an early external fixation of the pelvis in patients with a severe pelvic trauma with haemodynamic instability to limit the expansion of the pelvic haematoma. External fixation can be performed by a Ganz clamp or an anterior pelvic external fixator. (Grade 1+) Strong agreement
R14b: We recommend using the Ganz clamp for Tile C fractures essentially, after a heavy traction of the ascended lower limb (15% of the patient's weight). Trained operators can set it up in the emergency room. (Grade 1+) Strong agreement
R14c: We recommend using an external fixator for pelvic stabilisation of Tile C fractures and to reduce the ring disruption in Tile B1 and B3 fractures. It must be placed anteriorly and inferiorly in order to be able to perform a laparotomy. (Grade 1+) Strong agreement

External fixation of the pelvis is set up either right away or in relay of an external pelvic stabilisation device [92]. It can also be

set up after embolization in case of persistence of haemodynamic instability linked to a venous bleeding; the order of these actions depends on the team's experience and availability. Either way, reducing the ring disruption limits the expansion of the pelvic haematoma [93]. The setup of a Ganz Clamp is possible in the emergency room [94,95]. It requires a trained operator. The Ganz Clamp allows posterior reduction and is indicated mainly in Tile C fractures after reduction by traction of the ascended lower limb (15% of the patient's weight). The Ganz clamp allows the secondary accomplishment of an embolization, laparotomy or pelvic packing [96]. External fixation is indicated in tile B1 fractures to reduce ring disruption. It is performed either right away or in relay of an external compression. An external fixator can also be set up in tile B3 fractures. In tile C fractures, it must be associated with traction of the homolateral limb to the ascended hemi pelvis to control vertical instability. Anterior fixation is performed in the operating room with an anterior iliac crest fixation or with an external fixation of the pelvic girdle with a trapezoid compression frame. This set up must allow vascular access in case of secondary embolization, retroperitoneal packing and laparotomy [97,98]. Definitive fixation is realised on stabilised patients in the days following the trauma and is made of different steps depending on the type of lesions: posterior fixation followed by an anterior fixation by various osteosynthesis methods adapted to the type of pelvic instability and at the localisation of the pelvic ring fractures [99]. Open pelvic fractures have a more pejorative prognosis and can require a definitive treatment by an external fixator with a higher risk of functional negative outcome [100,101].

4.11. What are the particularities in the management of severe open pelvic trauma?

R15a: We suggest taking care of severe open pelvic trauma in referral centres because open pelvic lesions are rare, their management is complex and demands a multidisciplinary approach. (Grade 2+) Strong agreement

R15b: We recommend considering the bleeding control and the perineal contamination as primary objectives in the management of severe open pelvic trauma. (Grade 1+) Strong agreement

Open pelvic fractures are rarely observed. Therefore, in a review of 3053 pelvic fractures, only 52 were open, representing 1,7% [102]. However, they have poor prognosis because mortality can exceed more than 50% [103,104]. Prognosis is initially conditioned by the bleeding control and secondarily by the infection [105]. Usually, functional consequences are important. Their management obeys to 4 priorities:

- bleeding control;
- cleaning and debridement of the wound;
- identification and treatment of associated lesions, either pelvic and extra pelvic;
- treatment of the pelvic fracture [106].

Open pelvic fracture diagnosis is essentially clinical. The CT-scan allows a comprehensive diagnosis of pelvic lesions, including bone lesions. Delayed sequences, performed when haemodynamically possible, analysis of the iodine contrast excretion in order to make the diagnosis of suspected urinary lesions. It also allows the diagnosis of prospective extra-pelvic lesions. A sigmoidoscopy is also carried out to rule out a digestive lesion. Treatment of these lesions is usually complicated and appeals to surgical and interventional radiology techniques. These traumas combine bone, visceral, genital and sometimes vascular lesions that can increase the complexity of their management and dictates a multidisciplinary work. Treatment of the bleeding must be performed in priority because bleeding is usually significant and difficult to control considering its localisation. Surgical gestures are complex, involving for the most part a temporary stoma; the setting up of an external pelvic fixator and exceptionally a hemipelvectomy is necessary [107,108]. Embolization can be used in addition to the surgery to allow lesion haemostasis. In light of the complexity of these lesions, their rarity and the need of a multidisciplinary team, these lesions must be taken care of in experienced centres.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgments

The authors would like to thank Pr Lionel Velly and Dr James Apperry for their contribution

References

[1] Giannoudis PV, Grotz MR, Tzioupis C, Dinopoulos H, Wells GE, Bouamra O, Lecky F. Prevalence of pelvic fractures, associated injuries, and mortality: the United Kingdom perspective. J Trauma 2007;63:875–83.
[2] Poole GV, Ward EF, Muakkassa FF, Hsu HS, Griswold JA, Rhodes RS. Pelvic fracture from major blunt trauma. Outcome is determined by associated injuries. Ann Surg 1991;213:532–8.
[3] White CE, Hsu JR, Holcomb JB. Haemodynamically unstable pelvic fractures. Injury 2009;40:1023–30.
[4] Duranteau J, Asehnoune K, Pierre S, Ozier Y, Lefrant JY, et al. Guidelines on the treatment of hemorrhagic shock. Anesth Reanim 2015;1:62–74.
[5] Sauerland S, Bouillon B, Rixen D, Raum MR, Koy T, Neugebauer EA. The reliability of clinical examination in detecting pelvic fractures in blunt trauma patients: a meta-analysis. Arch Orthop Trauma Surg 2004;124:123–8.
[6] Riou B, Thicoïpé M, Atain-Kouadio P, et al. Comment évaluer la gravité?In: Samu de France. Actualités en réanimation préhospitalière: la traumatisé grave. Paris: SFEM Editions; 2002. p. 115–28.
[7] Ooi CK, Goh HK, Tay SY, Phua DH. Patients with pelvic fracture: what factors are associated with mortality? Int J Emerg Med 2010;3:299–304.
[8] Giannoudis PV, Grotz MR, Tzioupis C, Dinopoulos H, Wells GE, Bouamra O, et al. Prevalence of pelvic fractures, associated injuries, and mortality: the United Kingdom perspective. J Trauma 2007;63:875–83.
[9] Gabbe BJ, De Steiger R, Esser M, Bucknill A, Russ MK, Cameron P. Predictors of mortality following severe pelvic ring fracture: Results of a population-based study. Injury 201;42:985-991.
[10] Gustavo Parreira J, Coimbra R, Rasslan S, Oliveira A, Fregoneze M, Mercadante M. The role of associated injuries on outcome of blunt trauma patients sustaining pelvic fractures. Injury 2000;31:677–82.
[11] Ustundag M, Aldemir M, Orak M, Guloglu C. Predictors of mortality in blunt multi-trauma patients: a retrospective review. J Emerg Med 2010;17:471–6.
[12] Palmcrantz J, Hardcastle TC, Naidoo SR, Muckart DJ, Ahlm K, Eriksson A. Pelvic fractures at a new level 1 trauma centre: who dies from pelvic trauma? The Inkosi Albert Luthuli Central Hospital experience. Orthop Surg 2012;4:216–21.
[13] Sathy AK, Starr AJ, Smith WR, Elliott A, Agudelo J, Reinert CM, et al. The effect of pelvic fracture on mortality after trauma: an analysis of 63,000 trauma patients. J Bone Joint Surg Am 2009;91:2803–10.
[14] Starr AJ, Griffin DR, Reinert CM, Frawley WH, Walker J, Whitlock SN, et al. Pelvic ring disruptions: prediction of associated injuries, transfusion requirement, pelvic arteriography, complications, and mortality. J Orthop Trauma 2002;16:553–61.
[15] Arroyo W, Nelson KJ, Belmont PJ, Bader JO, Schoenfeld AJ. Pelvic trauma: what are the predictors of mortality and cardiac, venous thrombo-embolic and infectious complications following injury? Injury 2013;44:1745–9.
[16] Toth L, King KL, McGrath B, Balogh ZJ. Factors associated with Pelvic fracture-related arterial bleeding during trauma resuscitation: a prospective clinical study. J Orthop Trauma 2014;28:489–96.
[17] Blackmore CC, Cummings P, Jurkovich GJ, Linnau KF, Hoffer EK, Rivara FP. Predicting major hemorrhage in patients with pelvic fracture. J Trauma 2006;61:346–52.
[18] Sartorius D, Le Manach Y, David J-S, Rancurel E, Smail N, Thicoïpé M, et al. Mechanism, glasgow coma scale, age, and arterial pressure (MGAP): a new simple prehospital triage score to predict mortality in trauma patients. Crit Care Med 2010;38:831–7.
[19] Yoshihara H, Yoneoka D. Demographic epidemiology of unstable pelvic fracture in the United States from 2000 to 2009: trends and in-hospital mortality. J Trauma Acute Care Surg 2014;76:380–5.

[20] Poole GV, Ward EF. Causes of mortality in patients with pelvic fractures. Orthopedics 1994;17:691–6.
[21] Fox MA, Mangiante EC, Fabian TC, Voeller GR, Kudsk KA. Pelvic fractures: an analysis of factors affecting prehospital triage and patient outcome. South Med J 1990;83:785–8.
[22] Ricard-Hibon A, Duchateau F-X, Vivien B. Out-of-hospital management of elderly patients for trauma injury. Ann Fr Anesth Reanim 2012;31:e7–10.
[23] Pizanis A, Pohlemann T, Burkhardt M, Aghayev E, Holstein JH. Emergency stabilization of the pelvic ring: clinical comparison between three different techniques. Injury 2013;44:1760–4.
[24] Spanjersberg WR, Knops SP, Schep NWL, Van Lieshout EMM. Effectiveness and complications of pelvic circumferential compression devices with unstable pelvic fractures: a systematic review of the literature. Injury 2009;40:1031–5.
[25] Stewart M. Pelvic circumferential compression devices for haemorrhage control: panacea or myth? Emerg Med J 2013;30:425–6.
[26] Jowett AJL, Bowyer GW. Pressure characteristics of pelvic binders. Injury 2007;38:118–21.
[27] Knops SP, Van Lieshout EMM, Spanjersberg WR, Patka P, Schipper IB. Randomised clinical trial comparing pressure characteristics of pelvic circumferential compression devices in healthy volunteers. Injury 2001;42:1020–6.
[28] Botker MT, Bakke SA, Christensen EF. A systematic review of controlled studies : Do physicians increase survical with prehospital treatment? Scand J Trauma Resusc Emerg Med 2009;17:2.
[29] Galvagno SM, Haut ER, Zafar SN, Millin MG, Efron DT, Koenig GJ. Association between helicopter vs ground emergency medical services and survival for adults with major trauma. JAMA 2012;307:1602–10.
[30] Esposito TJ, Sanddal TL, Reynolds SA, Sanddal ND. Effect of a voluntary trauma system on preventable death and inapropriate care in a rural state. J Trauma 2003;54:663–9.
[31] Demetriades D, Martin M, Salim A, Rhee P, Brown C, Chan L. The effect of trauma center designation and trauma volume on outcome in specific severe injuries. Ann Surg 2005;242:512–7.
[32] MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med 2006;354:366–7.
[33] Marx WH, Simon R, O'Neill P, Shapiro MJ, Cooper AC, Farrell LS, et al. The relationship between annual hospital volume of trauma patients and in-hospital mortality in New York State. J Trauma 2011;71:339–45.
[34] Nathens AB, Jurkovich GJ, Maier RV, Grossman DC, MacKenzie EJ, Moore M, et al. Relationship between trauma center volume and outcomes. Jama 2001;285:1164–71.
[35] Nathens AB, Jurkovich GJ, Cummings P, Rivara FP, Maier RV. The effect of organized system of trauma care on motor vehicle crash mortality. JAMA 2000;283:1990–4.
[36] Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, et al. A systematic review and méta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishement of trauma systems. J Trauma 2006;60:371–8.
[37] Garwe T, Cowan LD, Neas B, Cathey T, Danford BC, Greenawalt P. Survival benefit of transfer to tertiary trauma centers for major trauma patients initially presenting to nontertiary trauma centers. Acad Emerg Med 2010;17:1223–32.
[38] Morshed S, Knops S, Jurkovich GJ, Wang J, MacKenzie E, Rivara FP. The impact of trauma-center care on mortality and function following pelvic ring and acetabular injuries. J Bone Joint Surg Am 2015;97:265–72.
[39] Bouzat P, Broux C, Ageron FX, Gros I, Levrat A, Thouret JM, et al. Impact of a trauma network on mortality in patient with sévère pelvic trauma. Ann Fr Anest Reanim 2013;32:827–32.
[40] Peytel E, Menegaux F, Cluzel P, Langeron O, Coriat P, Riou B. Initial imaging assessment of severe blunt trauma. Intensive Care Med 2001;27:1756–61.
[41] Eastridge BJ, Starr A, Minei JP, O'Keefe GE, Scalea TM. The importance of fracture pattern in guiding therapeutic décision-making in patients with hemorrhagic shock and pelvic ring disruptions. J Trauma 2002;53:446–50.
[42] Bauman M, Marinaro J, Tawil I, Crandall C, Rosenbaum L, Paul I. Ultrasonic determination of pubic symphyseal widening in trauma: the FAST-PS study. J Emerg Med 2011;40:528–33.
[43] Ruchholtz S, Waydhas C, Lewan U, Pehle B, Taeger G, Kühne C, et al. Free abdominal fluid on US in instable pelvic ring fracture is laparotomy always necessary. J Trauma 2004;57:278–85.
[44] Charbit J, Millet I, Martinez O, Roustan JP, Merigeaud S, Taourel P, et al. Does the size of the hemoperitoneum help to discriminate the bleeding source and guide therapeutic decisions in blunt trauma patients with pelvic ring fracture? Trauma Acute Care Surg 2012;73:117–25.
[45] Verbeek DO, Zijlstra IA, van der Leij C, Ponsen KJ, van Delden OM, Goslings JC. The utility of FAST for initial abdominal screening of major pelvic fracture patients. World J Surg 2014;38:1719–25.
[46] Anderson SW, Soto JA, Lucey BC, Burke PA, Hirsch EF, Rhea JT. Blunt Trauma Feasibility and clinical utility of pelvic CT angiography performed with 64 CT. Radiology 2008;246:410–9.
[47] Cerva DS, Jr, Mirvis SE, Shanmuganathan K, Kelly IM, Pais SO. Detection of bleeding in patient with major pelvic fractures. A JR Am J Roentgenol 1996;166:131–5.
[48] Pereira SJ, O'Brien DP, Luchette FA, Choe KA, Lim E, Davis JRK, et al. Dynamic helical CT scan accurately detects hemorrhage in patients with pelvic fracture. Surgery 2000;128:678–85.
[49] Domagen JB, Tötterman A, Roise O, Sandvik L, Klow NE. Efficacy of plain radiography and computer tomography in localizing the site of pelvic arterial bleeding in trauma patients. Acta Radiol 2010;51:107–16.
[50] Pinto A, Niola R, Tortora G, Ponticiello G, Russo G, Di Nuzzo L, et al. Role of multidetector row CT in assessing the source of arterial heamorrhage in patients with pelvic vascular trauma. Comparaison with angiography. Radiol Med 2010;115:648–67.
[51] Brasel KJ, Pham K, Yang H, Christensen R, Weigelt JA. Signification of contrast extravasation in patients with pelvic fracture. J Trauma 2007;62:1149–52.
[52] Hallinan JT, Tan CH, Pua U. The role of multidetector computed tomography versus digital subtraction angiography in triaging care and management in abdominopelvic trauma. Singapore Med J 2016;57(9):497. http://dx.doi.org/10.11622/smedj.2015179.
[53] Lerardi AM, Duka E, Lucchina N, Floridi C, De Martino A, Donat D, et al. The role of interventional radiology in abdominopelvic trauma. Br J Radiol 2016;89:1–16 [20150866].
[54] Figler BD, Hoffler CE, Reisman W, Carney KJ, Moore T, Feliciano D, et al. Multidisciplinary update on pelvic fracture associated blader and urethral injuries. Injury 2012;43:1242–9.
[55] Gomez RG, Ceballos L, Coburn M, Corriere JN, Dixon CM, Lobel B, et al. Consensus statement on bladder injuries. BJU Int 2004;94:27–32.
[56] Chapple C, Barbagli G, Jordan G, Mundy AR, Rodrigues-Netto N, Pansadoro V, et al. Consensus statement on urethral trauma. BJU Int 2004;93:1195–202.
[57] Bjurlin MA, Fantus RJ, Mellett MM, Goble SM. Genitourinary injuries in pelvic fracture morbidity and mortality using the National Trauma Data Bank. J Trauma 2009;67:1033–9.
[58] Lumen N, Kuehhas FE, Djakovic N, Kitrey ND, Serafetinidis E, Sharma DM, et al. Review of the current management of lower urinary tract injuries by the EAU Trauma Guidelines Panel. Eur Urol 2015;67:925–9.
[59] Koraitim MM, Marzouk ME, Atta MA, Orabi SS. Risk factors and mechanism of urethral injury in pelvic fractures. Br J Urol 1996;77:876–80.
[60] Basta AM, Blackmore CC, Wessells H. Predicting urethral injury from pelvic fracture patterns in male patients with blunt trauma. J Urol 2007;177:571–5.
[61] Quagliano PV, Delair SM, Malhotra AK. Diagnosis of blunt bladder injury: a prospective comparative study of computed tomography cystography and conventional retrograde cystography. J Trauma 2006;61:410–21.
[62] Kielb SJ, Voeltz ZL, Wolf JS. Evaluation and management of traumatic posterior urethral disruption with flexible cystourethroscopy. J Trauma 2001;50:36–40.
[63] Pennal GF, Tile M, Waddell JP, Garside H. Pelvic disruption: assessment and classification. Clin Orthop Relat Res 1980;151:12–21.
[64] Ruatti S, Guillot S, Brun J, Thony F, Bouzat P, Payen JF, et al. Which pelvic ring fractures are potentially lethal? Injury 2015;46:1059–63.
[65] Osterhoff G, Scheyerer MJ, Fritz Y, Bouaicha S, Wanner GA, Simmen HP, et al. Comparing the predictive value of the pelvic ring injury classification systems by Tile and by Young and Burgess. Injury 2014;45:742–7.
[66] Young JW, Burgess AR, Brumback RJ, Poka A. Pelvic fractures: value of plain radiography in early assesment and management. Radiology 1986;160:445–51.
[67] Manson T, O'Toole RV, Whitney A, Duggan B, Sciadini M, Nascone J. Young-Burgess. Classification of pelvic ring fractures: does it predict mortality, transfusion requirements, and non-orthopaedic injuries? J Orthop Trauma 2010;603–9.
[68] Verbeek DOF, Zijlstra IAJ, van der Leij C, Ponsen KJ, van Delden OM, Goslings JC. Management of pelvic ring fracture patients with a pelvic "blush" on early computed tomography. J Trauma Acute Care Surg 2014;76:374–9.
[69] Fu CY, Wang SY, Liao CH, Kang SC, Hsu YP, Lin BC, et al. Computed tomography angiography provides limited benefit in the evaluation of patients with pelvic fractures. Am J Emerg Med 2014;32:1220–4.
[70] Mohseni S, Talving P, Kobayashi L, Lam L, Inaba K, Branco BC, et al. The diagnostic accuracy of 64-slice computed tomography in detecting clinically significant arterial bleeding after pelvic fractures. Am Surg 2011;77:1176–82.
[71] Li Q, Dong J, Yang Y, Wang G, Wang Y, Liu P, et al. Retroperitoneal packing or angioembolization for haemorrhage control of pelvic fractures-Quasi-randomized clinical trial of 56 haemodynamically unstable patients with Injury Severity Score ≥33. Injury 2016;47:395–401.
[72] Howell GM, Peitzman AB, Nirula R, Rosengart MR, Alarcon LH, Billiar TR, et al. Delay to therapeutic interventional radiology postinjury: time is of the essence. J Trauma 2010;68:1296–300.
[73] Shinsuke T, Shigenobu M, Hideyuki M, Makoto S, Hideya N, Hiroshi I. Time to pelvic embolization for hemodynamically unstable pelvic fractures may affect the survival for delays up to 60 min. Injury 2014;45:738–41.
[74] Clarke JR, Trooskin SZ, Doshi PJ, Greenwald L, Mode CJ. Time to laparotomy for intra-abdominal bleeding from trauma does affect survival for delays up to 90 minutes. J Trauma 2002;52:420–5.
[75] Fu CY, Wang YC, Wu SC, Chen RJ, Hsieh CH, Huang JC, et al. Angioembolization provides benefits in patients concomitant unstable pelvic fracture and unstable hemodynamics. Am J Emerg Med 2012;30:207–2013.
[76] Niola R, Pinto A, Sparano A, Ignarra R, Romano L, Maglione F. Arterial bleeding in pelvic trauma priorities in angiographic embolization. Curr Probl Diagn Radiol 2012;41:93–101.
[77] Costantini TW, Bosarge PL, Fortlage D, Bansal V, Coimbra R. Arterial embolization for pelvic fractures after blunt trauma: are we all talk. Am J Surg 2010;200:752–7.

[78] Brun J, Guillot S, Bouzat P, Broux C, Thony F, Genty C, et al. Detecting active pelvic arterial haemorrhage on admission following serious pelvic fracture in multiple trauma patients. Injury 2014;45:101–6.
[79] Tanizaki S, Maeda S, Hayashi H, Matano H, Ishida H, Yoshikawa J, et al. Early embolization without external fixation in pelvic trauma. Am J Emerg Med 2012;30:342–6.
[80] Teo LT, Punamiya S, Chai CY, Go KT, Yeo YT, Wong D, et al. Emergency angio embolisation in the operating theatre for trauma patients using the C-Arm digital substraction angiography. Injury 2012;43:1492–6.
[81] Cherry RA, Goodspeed DC, Lynch FC, Delgado J, Reid SJ. Intraoperative angioembolization in management of pelvic-fracture related hemodynamic instability. J Trauma Manag Outcomes 2011;13(5):6.
[82] Shapiro M, McDonald AA, Knight D, Johannigman JA, Cuschieri J. The role of repeat angiography in management of pelvic fractures. J Trauma 2005;58:227–31.
[83] Lopez PP. Unstable pelvic fracture the use of angiography in controlling arterial hemorrhage. J Trauma 2007;62:S30–1.
[84] Hagiwara A, Murata A, Matsuda T, Shimazaki S. Usefulness of transcatheter arterial embolization for patients with blunt polytrauma showing transient response to fluid resuscitation. J Trauma 2004;57:271–6.
[85] Velmahos GC, Chahwan S, Hanks SE, Murray JA, Berne TV, Asensio J, et al. Angiographic embolization of bilateral internal iliac arteries to control life-threatening hemorrhage after blunt trauma to the pelvis. Am Surg 2000;66:858–62.
[86] Chabrot P, Boyer L. Embolisation. Société Française d'imagerie Cardiaque et Vasculaire. 2012. Springer.
[87] Pilleul F, De Queiros M, Durieux M, Milot L, Monneuse O, Floccard B, Allaouchiche B. Radiological management of vascular lesions secondary to pelvic injuries. J Radiol 2007;88:639–46.
[88] Gross JA, Lehnert BE, Linnau KF, Voelzke BB, Sandstrom CK. Imaging of Urinary System. Trauma Radiol Clin North Am 2015;53:773–88.
[89] Berko NS, Dym RJ. Computed tomographic imaging of renal and ureteral emergencies. Curr Probl Diagn Radiol 2015;44:207–20.
[90] Cothren CC, Osborn PM, Moore EE, Morgan SJ, Johnson JL, Smith WR. Pre-peritonal pelvic packing for hemodynamically unstable pelvic fractures: a paradigm shift. J Trauma 2007;62:834–42.
[91] Osborn PM, Smith WR, Moore EE, Cothren CC, Morgan SJ, Williams AE, et al. Direct retroperitoneal pelvic packing versus pelvic angiography: A comparaison of two management protocols for haemodynamically unstable pelvic fracture. Injury 2009;40:54–60.
[92] Martin AC, Magnotti LJ, Savage SA, Wood GW. Emergent pelvic fixation in patients with exsanguinating pelvic fractures. J Am Coll Surg 2007;204:935–42.
[93] Moss MC, Bircher MD. Volume changes within the true pelvis during disruption of the pelvic ring - Where does the haemorrhage go? Injury 1996;27(Suppl1) [S-A21].
[94] Ganz R, Krushell RJ, Jakob RP, Kuffer J. The antishock pelvic clamp. Clin Orthop Relat Res 1991;267:71–8.
[95] Pohlemann T, Braune C, Gansslen A, Hüfner T, Partenheimer A. Pelvic Emergency Clamps: anatomic landmarks for safe primary application. J Orthop Trauma 2004;18:102–5.
[96] Tonetti J. Management of recent unstable fractures of the pelvic ring. An update Conference supported by the Club Bassin Cotyle. (Pelvis-Acetabulum Club). Orthop Traumatol Surg Res 2013;99:S77–86.
[97] Bircher M. Indications and techniques of external fixation of the injured pelvis. Injury 1996;27:3–19.
[98] Slätis P, Karaharju EO. External fixation of the pelvic girdle with a trapezoid compression frame. Injury 1975;7:53–6.
[99] Katsoulis E, Giannoudis PV. Impact of timing of pelvic fixation on functional outcome. Injury 2006;37:1133–42.
[100] Halawi MJ. Pelvic ring injuries: surgical management and long-term outcomes. J Clin Orthop Trauma 2016;7:1–6.
[101] Trikha V, Gupta H. Current management of pelvic fractures. J Clin Orthop Trauma 2011;2:12–8.
[102] Black EA, Lawson CM, Smith S, Daley BJ. Open pelvic fractures: the university of Tennesse Medical Center at Knoxville, experience over ten years. Iowa Orthop J 2011;31:193–8.
[103] Cannada LK, Taylor RM, Reddix R, Mullis B, Moghadamian E, Erickson M. Southeastern Fracture Consortium. The Jones-Powell classification of open pelvic fractures: a multicenter study evaluationg mortality rates. J Trauma Acute Care Surg 2013;74:901–6.
[104] Sinnott R, Rhodes M, Brader A. Open pelvic fracture: an injury for trauma centers. Am J Surg 1992;163(3):283–7.
[105] Dong JL, Zhou DS. Management and outcome of open pelvic fractures: a rétrospective study. Injury 2011;42(10):1003–7.
[106] Scalea TM, Burgess AR. Pelvic Fractures. In: Trauma 5th ed, New York: McGraw Hill; 2004. p. 779–807.
[107] Ramasamy A, Evan S, Kendrew JM, Cooper J. The open blast pelvis: the significant burden of management. J Bone Joint Surg Br 2012;94(6):829–35.
[108] Govaert G, Siriwardhane M, Malisano L, Schuetz M. Prevention of pelvic sepsis in major open pelviperineal injury. Injury 2012;43:533–6.