

# Management of Hemodynamic Unstable Patients “in extremis” with Pelvic Ring Fractures

Léčení extrémně hemodynamicky nestabilních pacientů s frakturou pánevního kruhu

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## SUMMARY

The hemodynamic status in patients with pelvic ring injuries is a major prognostic factor of an immediate mortality risk. Especially, patients “in extremis” are of high risk to die. This patient group is characterized by absent vital signs or being in severe shock with initial systolic blood pressure  $\leq 70$  mm Hg and/or requiring mechanical resuscitation or catecholamines despite  $>12$  blood transfusions within the first two hours after admission.

The sources of pelvic bleeding is in approximately 80-90% of venous origin and relevant arterial bleeding accounts for 10-20%.

Important parts of the initial treatment treatment concept include mechanical pelvic ring stabilization combined with hemorrhage control concepts.

Mechanical stabilization is performed non-invasively by pelvic binder application or invasively by classical anterior pelvic fixation or posterior pelvic C-clamp, depending on the local available resources.

In patients “in extremis” the concept of direct extraperitoneal pelvic packing is recommended, whereas in moderately unstable patients or in patients where persistent hemodynamic instability occurs despite shock therapy and mechanical stabilization and pelvic packing, arterial injury is ruled out by angiography followed by selected embolization of pelvic vessels.

## INTRODUCTION

The majority of pelvic ring injuries are „uncomplicated” and thus „easily” to be treated. The osteoligamentous reconstruction in these cases is the primary treatment aim as hemodynamic impairment is normally missing (71, 73). Several established stabilization methods are available resulting in a high rate of good and excellent primary and long-term results (102, 106).

A complex pelvic trauma, defined as a pelvic ring injury with a significant concomitant peripelvic soft-tissue or organ trauma (7), is a potential life-threatening injury of the pelvis with a mortality rate still as high as 20% (43).

As a subgroup of these injuries, hemodynamically and mechanically unstable pelvic ring injuries require a demanding primary management concept as exsanguinating hemorrhage is associated with a high mortality rate within the first 24 hours after trauma (21).

Several nationwide landmark papers are dealing with management recommendations in hemodynamic unstable trauma patients.

Rossaint et al. and Spahn et al. recommend immediate pelvic ring closure and stabilization in hemodynamical-

ly unstable patients with pelvic ring injuries followed by early preperitoneal pelvic packing, angiography embolisation and/or surgical bleeding control when hemodynamic instability persists (81, 94).

The Scandinavian guidelines for massive bleeding patients recommend a damage control pelvic approach, where extraperitoneal pelvic packing is favoured in patients in extremis and angiography for stable patients requiring  $\geq 4$  PRBCs/24 hours after exclusion of thoracic and/or abdominal bleeding sources after initial pelvic binder fixation (26).

Geeraerts et al. primarily proposed angiography with arterial embolization as the treatment of choice complemented by pelvic external fixation devices to additionally facilitate venous haemostasis, whereas in major retroperitoneal haematoma, damage control pelvic surgery by pelvic packing and pelvic C-clamps are effective options (33).

There are still several controversies regarding treatment of these patients. The definition of the subgroup of patients „in extremis”, the source of pelvic bleeding in unstable pelvic ring injuries and therefore the optimal treatment method remains unclear as practical risk factors are difficult to identify.

### Definition of life-threatening pelvic hemorrhage

The major problem in analyzing data of pelvic fracture patients is the different definition of hemodynamic instability. The Hannover group integrated complex pelvic trauma patients in their definition, as this special group of patients is still associated with a mortality rate of 20% (43).

Patients „in extremis” were defined by Pohlemann et al. as patients with a complex pelvic injury and an admission haemoglobin level of  $\leq 8$  g/dl (72). Tscherne et al. extended this definition to an additional admission systolic blood pressure  $\leq 70$  mm Hg (107).

Ertel et al. defined this group as having absent vital signs or being in severe shock requiring mechanical resuscitation or catecholamines despite  $>12$  blood transfusions within 2 hours post admission (20, 57).

Töttermann et al. defined patients in extremis as having a class III to IV hemorrhage according to ATLS concept. Systolic blood pressure has to be  $<90$  mm Hg, central venous pressure  $<5$  cm H<sub>2</sub>O and heart rate  $>100$ /min. In these cases they indicated pelvic packing (104).

In contrast, Cothren et al. indicated pelvic packing in patients with a persistent systolic blood pressure  $<90$  mm Hg despite transfusion of two units of PRBCs (13).

A more moderate indication was stated by Tai et al., who defined hemodynamic instability as a persistent systolic blood pressure  $<90$  mm Hg despite  $\geq 2000$  mL intravenous crystalloid and a negative FAST scan (98).

Considering the definition of hemodynamic instability in unstable patients by Ertel et al. which have a systolic blood pressure  $<90$  mm Hg, a heart rate of  $>100$  beats/minute, a central venous pressure  $<5$  cm H<sub>2</sub>O or a urine output  $<30$  ml/hour despite adequate fluid replacement and blood transfusion over a time period of 2 hours, the latter definition more correspond to unstable patients than to patients in extremis (20).

The incidence of patients in extremis is therefore difficult to state but seems to be between 1-4% of all patients with pelvic ring injuries (72, 98, 104, 107).

### Bleeding sources in unstable pelvic ring fractures

Exsanguinating haemorrhage is independent of the bony injury pattern in pelvic ring fractures (113).

In general, hemorrhage from pelvic ring fracture can be due to tear of branches or the main trunk of the internal iliac artery, injury to large veins, diffuse venous injury from the presacral and perivesical plexus and the pelvic floor and from fracture sites resulting in life-threatening retroperitoneal haematoma.

About 1-2% of all pelvic fractures are accompanied with life-threatening pelvic hemorrhage (30, 71, 74, 107).

The posterior pelvic region is the major source of hemorrhage (44), despite some significant anterior hemorrhage is also reported.

Venous bleeding is probably the most common bleeding source in hemodynamic unstable pelvic ring injuries.

Huittinen et al. in their early postmortem study analyzed 27 patients (44). In the majority of patients venous bleeding from pelvic fracture sites, from pelvic soft tissues and the pelvic floor was observed, whereas arterial injury shown by postmortem angiography was only seen in 11%. They found that the posterior pelvic venous plexus was disrupted especially in sacro-iliac disruption and sacral fractures and bleeding from posterior cancellous bone surfaces after sacral fractures were the main sources of hemorrhage in fatal pelvic injuries (44). These data are supported by present clinical studies. Ertel et al. found a rate of 70% venous bleeding from pelvic origin during laparotomy in patients „in extremis” (21). Comparable data were reported by Pohlemann et al. who found a 63% rate of diffuse venous bleeding in patients „in extremis” (72). These rates can be expected as venous structures are more fragile to trauma than arteries (5, 44). Even in the presence of arterial bleeding additional venous bleeding can be expected in close to 100% (97).

**Thus, the expected rate of major venous hemorrhage in patients „in extremis” is approximately 80%.**

The main venous trunks accompany its course to the major arteries. Additionally, large venous plexus are found directly anterior to the sacral surface and around the intrapelvic organs, especially around the bladder.

It is supposed that in unstable pelvic fractures a significant laceration of the pelvic floor ligaments occurs. Therefore, the pelvic compartment borders are often disrupted which can lead to life-threatening venous bleeding. A self-tamponade effect can not be expected (LIT Grimm, Trentz).

Major venous vascular injury is more uncommon than venous plexus injury, but can be significant. Analyzing the literature, Suzuki et al. stated, that fatal venous bleeding from major vessels is more frequent than generally acknowledged (97). Often it is associated with significant arterial injury but Rothenberger et al. found a doubled incidence of major venous vascular injury compared to arterial injury (83).

Baque et al. experimentally found in open-book injuries, that symphyseal widening of 5cm lead to a 60% rate of injury to the iliolumbar vein, without presence of arterial injuries (5). Kataoka et al. found that 9 of 25 haemodynamically unstable patients had major venous injuries despite successful embolisation (49).

**Overall, a main iliac vein trunk injury is supposed to occur in less than 1% (113), but is resulting in significant hemorrhage. Often these patients may present „in extremis” (49).**

Bleeding from cancellous bone can be significant especially in sacral fractures or the more uncommon iliac fractures. Hemostasis is possible by fracture reduction and tamponade. Gilliland et al., and Naam et al. stated that bleeding from the fracture zones can result in fatal pelvic hemorrhage (36, 64).

Overall, 80-90% of hemorrhage from pelvic fractures is expected to originate from the low-pressure venous system (2, 10, 21, 23, 31, 35, 44, 71, 75, 94, 98, 107).

Therefore, bleeding from venous plexus and fracture surfaces seems to be of the greatest importance, while arterial bleeding was found to be present in 18-27% in early reports (15, 63, 82).

At the posterior pelvic ring the common iliac artery and its division into the internal and external iliac artery are in risk, due to its close anatomical localization to the sacroiliac joint. Additionally, injury to major branches from the internal iliac artery can lead to significant bleeding. The difficult surgical inaccessibility to this area has led to a preference for the angiographic embolization.

More recent angiographic studies showed a rate of arterial hemorrhage in 65% (2, 11, 19, 52, 58, 70, 90) but the incidence of relevant arterial bleeding remains unclear.

The clinical relevant incidence of injury to the posterior pelvis with disruption of large arterial vessels is expected to be approximately 2-4%.

### Additional relevant parameters in assessing pelvic injuries

Important aspects in the primary assessment of patients with pelvic ring injuries are therefore the assessment of the accompanying shock state.

Various parameters such as systolic blood pressure, heart rate, the primary base deficit, primary lactate, the course of these parameters, the hemoglobin or hematocrit level at admission, the respiratory rate, the pulse pressure, the mental status, „capillary refill“ and the extent of urinary excretion are considered in determining the state of shock (3, 81, 91).

Hypotension in blunt trauma is usually defined as a sBP of  $\leq 90$  mmHg (3, 6, 18, 19, 41, 58, 81, 91, 95, 111), although no clear evidence exists for this threshold (18). In patients with pelvic injuries, Eastridge et al. found that with a sBP of 110 mm Hg a hypoperfusion of the soft-tissues already exists (18).

It is not known what HR value is really pathological. Different cut-off values are given in the literature (6, 9, 111). Brasel et al. showed sufficient specificity of  $>95\%$  in blunt trauma patients only at a HR of  $>120$ /min, whereas the specificity with a HR of 80-100/min was only 33.2% and the sensitivity was 75.4% (9). Comparable value were found by Blackmore et al., who identified a HR of  $\geq 130$ /min as a risk factor for pelvis-related bleeding (6).

Therefore, as single parameters, HR and sBP have no reliable predictive value estimating the shock state.

Victorino et al. tried to correlate both parameters (111). Disadvantage of their study was the integration of both blunt and penetrating trauma. Overall, tachycardia  $\geq 90$ /min was identified as a significant risk factor for hypotension (RR  $< 90$  mm Hg). However, 35% of patients had a relative bradycardia seen in combination with hypotension, which corresponds to experiences from other studies (17, 111).

Grimme et al. were able to confirm this relationship, according to a shock index of  $>1$  (HR/sBP). Especially the associated pelvic trauma could be identified as a risk factor of the pathological shock index (40).

Immediate analysis of hemoglobin and hematocrit concentrations should be judged with caution as a single parameter (94), as normal admission values can not exclude significant trauma (69).

In contrast, the primary base deficit and lactate levels are considered important parameters for shock-monitoring (16, 21, 56, 78, 86, 91, 94). Both parameters are important in assessing the „hidden“ shocks (1, 16).

A primary increased lactate level indicates significant injury severity (21, 55) and persistent increased values are associated with mortality (1, 45, 79).

The value of the primary base excess was extensively analysed by Rixen et al. (78, 80), who identified a threshold of -6 mmol/l as a prognostic worse indicator.

**Therefore, clinical and blood sample parameters available within 1 minute after admission (HR, sBP, lactate, base deficit, hematocrit, hemoglobin) should be integrated into decision algorithms.**

### Biomechanics of pelvic volume change in unstable injuries

There is a general consensus that an increase of the pelvic volume in C-type injuries or massive external rotation injuries (AP III according to Burgess) is associated with an increased rate of pelvic bleeding complications.

Moss et al. found that with every centimeter symphyseal displacement a 4.6% increase in pelvic volume and with every centimeter sacroiliac joint diastasis an increase of 3.1% can be expected. Diastases at both regions can be added. A 5 cm symphyseal diastasis was associated with an increase of pelvic volume of approximately 20% (61).

Similar results were reported by Bague et al. showing a 20.8% increase of pelvic volume with 5 cm of pubic diastasis. In this open-book injury model 60% venous lacerations of the ilio-lumbar vein were observed, but no arterial vessel injury or tension on the lumbo-sacral trunk or the obturator nerve (5).

A self-tamponating effect can not be expected as Grimm et al. showed experimentally that even with 20 liters of fluids (blood) infused into the true pelvis and retroperitoneum lead to an insufficient tamponade effect not reaching values of the intact pelvis. Applying an external fixator leads to a temporary immediate but reduced effect, while a laparotomy again reversed this effect (39). Similar data were found in a recent analysis (54).

Ghanayem et al. found similar results and pointed out that to reduce the risk of pelvic hemorrhage from a possibly necessary laparotomy mechanical stabilization, best by supraacetabular external fixation is postulated to reduce the additional instability of the pelvic-abdominal region (35).

Therefore, the proposed positive effect of external pelvic ring stabilization alone (50, 76) to control pelvic hemorrhage by „self-tamponade“ is only of moderate value as the potential tamponade effect is lost due to complete disruption of parapelvic fascia (gluteus medius, gluteus minimus, gluteus maximus, iliopsoas compartment). Thus, „haemorrhage from pelvic fracture is

essentially bleeding into a free space“ (97). This was proven clinically by Trentz et al. who described this effect as a „chimney effect“ in mechanically unstable, especially C-type pelvic ring injuries (105).

### Concepts of pelvic bleeding control

There is now general agreement that in pelvic ring injuries with concomitant hemodynamic instability, pelvic bleeding control is of major importance.

There are basically two key concepts: the mechanical stabilization of the pelvic ring (81) and vascular hemostasis by angiography/embolization and pelvic packing (26, 81, 94).

### The „first line of defence“ – mechanical stabilization of the pelvic ring

There is substantial agreement that immediate pelvic ring closure by external stabilization in hemodynamically unstable patients is the first treatment option (26, 33, 71, 76, 94, 106, 107).

Three principle methods for mechanical stabilization of the pelvis are available.

#### 1. Pelvic external fixation

Pelvic fixation with an external fixator is the most frequently available method, it is quickly applicable, allows bleeding control by compression of fracture sites but is biomechanically less sufficient in C-type injuries compared to the pelvic C-clamp (39, 71, 108, 116). The supraacetabular pin placement is biomechanically superior to the iliac crest placement (51, 65, 85).

#### 2. Pelvic C-clamp

The application of the pelvic C-clamp has a biomechanical advantage of the direct compressive effect on the posterior pelvic ring and thus constitutes the basis of pelvic tamponade (31, 73). This effect could be confirmed in several clinical studies (10, 21, 29, 72, 87, 89, 99-101, 114). Venous hemorrhage can be decreased and hemodynamic stabilization is gained if there are no arterial lesions (31).

The theoretical disadvantages of over-compression of sacral fractures and iliac perforation is of minor importance in the emergency situation (29).

#### 3. Pelvic binders/sheets

During the last decade stabilization by pelvic sheets or pelvic binders as non-invasive procedures became popular (8, 14, 34, 48, 53, 84, 92, 110).

They allow direct compression and adequate reduction of the pelvic ring with the disadvantage of a restricted approach to the small pelvis. Biomechanically, a comparable effect to pelvic C-clamps was observed, while the clinical effect is still under discussion.

Overall, external fixation should always be considered in hemodynamic unstable patients with pelvic fractures especially when laparotomy is indicated (8, 19, 35, 90).

### The „second line of defence“ – pelvic packing

The pelvic tamponade for hemostasis in visceral and gynecological operations is well described in the literature.

Riska et al. in 1979 first described a tamponade for treatment of traumatic pelvic bleeding in pelvic fractures (77). They describe the possibility of a retroperitoneal tamponade of the pelvic area via the Pfannenstiel approach or a paramedian and median infraumbilical incision. Furthermore, pelvic haemostasis can be performed through an access to the iliac fossa and the Kocher-Langenbeck approach in selected cases. They stated, that bleeding from fracture sites was insignificant.

Pohlemann et al. in 1995 described the technique of retroperitoneal pelvic packing in detail via an infraumbilical extraperitoneal approach (73) (Fig. 1). The indication performing pelvic packing was first reported in a severely injured group of 19 patients with C-type pelvic injuries. The pelvis was stabilized by pelvic C-clamp. The mean injury severity was 47.4 points (Hannover Polytrauma Scale) and the admission hemoglobin was 7.7 g/dl. Retroperitoneal pelvic packing was performed in 73.7% for controlling venous hemorrhage, which was present in about 70%. Additional abdominal injuries were frequent with a rate of 63%. Overall, in this group of patients, mortality was high with 58%.

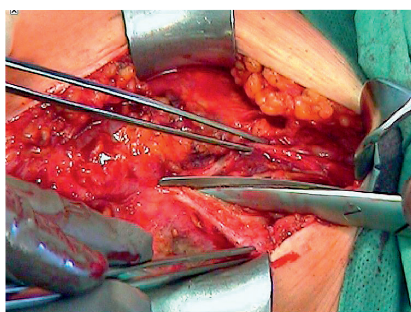
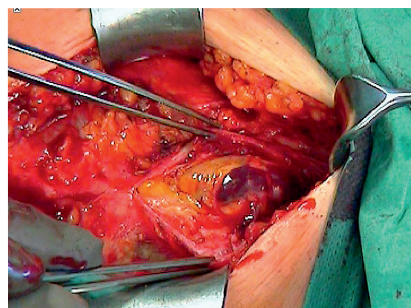
In a further analysis of 15 patients with C-type pelvic injuries and an initial hemoglobin level  $\leq 8$  g/dl pelvic packing was performed (107). This patient group additionally was severely injured with an ISS of 37.4 points, a mean systolic blood pressure at admission of 63 mm Hg, a mean hemoglobin level of 5.6 g/dl and a mean base deficit of -10.1 mmol/l. During the first hour of treatment a mean of 7.9 units of blood had to be transfused, and within 12 hours after admission a mean of 37.4 units were necessary. Concomitant abdominal injury was seen in 80%. Overall mortality was high with 66.6%.

Ertel et al. analyzed 41 patients in extremis defined as absent vital signs, severe shock requiring mechanical resuscitation or catecholamines despite transfusion of >12 units within 2 hours after admission (20). The mean ISS was 40.1 points. 19 of the 41 patients had C-type injuries of the pelvis and 12 B-type injuries. Additional abdominal injuries were frequent with a rate of 61%. Stabilization of the pelvis was performed by C-clamp in 2 patients with C-type injury (10.5%). An external fixator was applied in additional 26.3% of patients with C-type injuries. The overall rate of pelvic emergency stabilization in C-type injuries in patients in extremis therefore was 36.8%. Pelvic packing in the whole group was performed in 29.3%. The overall mortality rate was 90.2%. Two thirds (62%) of these patients died due to uncontrollable hemorrhage.

A further analysis by the same group on 16 patients with type C-injuries were treated with a pelvic C-clamp for mechanical pelvic stabilization followed by intraperitoneal pelvic packing in 10 cases. The mean ISS in this group was 38.5 with an overall mortality rate of 25%. Of these, 75% died due to uncontrollable hemorrhage (21).

Interestingly 11 patients were treated by crash-laparotomy, despite only two showed abdominal injury.



a|b|c  
d|e

*Fig. 1. A infraumbilical midline incision (a) is made in the lower abdomen and the abdominal fascia is opened (b), leaving the peritoneum intact. All parapelvic fascias are already disrupted and direct manual access through the right or left paravesical space down to the presacral region can be achieved without further soft tissue dissection (c). The presacral and paravesical regions are packed using standard surgical tamponades (d). When the acute bleeding is under control, the integrity of the bladder and urethra is inspected (e).*

Additionally they found that primary lactate levels were superior to hemoglobine or hematocrit identifying patients in extremis.

In a recent european analysis by Töttermann et al. 18 hemodynamic unstable patients with a mean systolic BP of 60 mm Hg, a heart rate of 119/minute, a base deficit of -6.6 mmol/l and a hemoglobin value of 8.8 g/dl were analyzed (104). 17 of these were polytraumatized and had additional injuries. The mean ISS was 48 and 28% of these patients died during further course. The mean time from injury to hospital admission was 63 minutes. After further 41 minutes extraperitoneal pelvic packing was performed in 13 patients with manifest shock signs. The overall time to packing was 134 minutes indicating an inhospital treatment window of 2.2 hours since injury. The pelvis was stabilized by pelvic sheeting or external fixation. 12 units of blood were transfused in average during this period (5,3 units/hour) followed by 0,71 units/hour during the following 24 hours. Stabilization of sBP was observed immediately after the procedure. Despite hemodynamic stabilization after pelvic packing, secondary angiography revealed arterial injury in 80% of these patients.

The disadvantage of this study was that beside seven type C-injuries, isolated acetabular fractures, type A- and type B-injuries were analyzed.

The complication rate was 11.1%. One patient developed infection as the swabs could not be removed earlier than 3 days post injury and in another patient septicaemia was due to accidentally left swabs.

As pelvic packing is a procedure which is presently not in widespread use, Bach et al. analysed teaching of this potentially simple procedure to be easy and clinical implementation was possible without major problems (4).

The value of this treatment concept has also been identified in the anglo-american area in recent years. Re-discovering this technique (28, 106) lead to a paradigm shift.

In a first report two cases were present by Smith et al. on two secondarily transferred patients which were treated by pelvic C-clamp and extraperitoneal pelvic packing (93). Both patients received transfusions prior to packing of approximately 2units/hour. From their hemodynamic status both were moderately hemodynamic unstable. A further case report was presented by Cothren et al. (12). A secondary transferred 6 year old child received 5 units of blood before pelvic packing. Angiography after pecking showed no arterial extravasation.

Cothren et al. then presented a study on 28 patients with type B- and C-injuries and a sBP < 90 mm Hg receiving two units of blood. The ISS was 55. The mean primary sBP was 77 mm Hg, the heart rate was 120/minute and the base deficit was 13mmol/l. Mechanical stabilization of the pelvis was performed by anterior external fixation or posterior pelvic C-clamp prior to pelvic packing. In average, 2.9 units of blood per hour were transfused during the initial period. Within 48 hours re-packing was necessary in 32% of these patients. Mortality rate was 25%. Infectious complications due to the procedure were found in one patient. They concluded, that pelvic packing more rapidly and directly addresses the primary source of bleeding with pelvic fractures, the venous and bone hemorrhage and pelvic packing was effective in reducing transfusion requirements (13).

The same group compared angiography/embolization vs. pelvic packing. Osborn et al. reported on 20 patients requiring pelvic packing after resuscitation with

2000 ml of intravenous (IV) crystalloids according to the ATLS protocol. When sBP was <90 mm Hg six hours after admission, despite receiving 2 units of blood packing was performed together with pelvic mechanical stabilization (66).

The mean ISS in the packing group was 54.7, higher than in the angiography group. The mean admission sBP and base deficit were comparable in both groups (packing vs. angiography) with 81.5 vs. 75.8 mm Hg and 12.7 vs. 13.2 mmol/l, respectively.

Packing was performed in median 45 minutes after admission. These patients received 11.8 PRBC units before completion of pelvic packing (median: 15.7 units/hour) in contrast to 2 units/hour in the angiography group (median: 4.2 units/hour). There was a trend that patients after pelvic packing had reduced transfusion requirements within 24 hours after this procedure compared to the angiography group (6.9 vs. 10.1 PRBC). Overall, the mortality rate was 25% vs. 30%, respectively.

In the Chinese literature Gao et al. reported on two patients with significant pelvic bleeding where pelvic packing was performed via a retroperitoneal approach and packing was supported by application of an external fixator. Both patients hemodynamically stabilized after the procedure (32).

A recent study by Tai et al. 11 patients receiving pelvic packing after a mean of 78.8 minutes in patients with a mean sBP at admission of 99 mm Hg (98). Two units of blood were transfused prior to packing in average (1,5 units/hour). After this procedure transfusion requirements were 0,37/hour within the next 24 hours. Overall mortality in this group 36.3%. Comparing these patients to a group where angiography and embolization was performed, showed a higher transfusion requirement prior to intervention (3,1 units/hour), a reduced transfusion rate within 24 hours after the procedure (0,21 units/hour) but a higher mortality rate of 69,2% after primary sBP of 61.9 mm Hg and a base deficit of -14.8 vs. -10,8 mmol/l. In the packing group 25% non-survivors died due to persistent hemorrhage compared to 33% in the angiography group.

Older age was found to be a worse prognostic indicator in patients requiring pelvic packing (13, 104).

Overall, pelvic packing leads to hemodynamic stabilization with an increase of systolic blood pressure (72, 104) and reduced transfusion requirements (66, 72, 98, 104) and seems to be effective in both venous and arterial bleeding (21).

### The „third line of defence“ – angiography/embolization

Significant arterial bleeding is only seen in 10-20% of cases (44, 72, 107), although arterial bleeding is found in up to 65% by angiography (2, 11, 19, 52, 58, 70, 90).

Recent data have shown that angiographic embolization is necessary in about 3% of cases (2, 58, 70, 90, 115) with a success rate as high as 95% (90, 96, 109, 115), despite an overall mortality rate in these patients of 1/3 of cases (2, 11, 22, 37, 59, 62, 68, 70, 90, 96, 115).

Again, the problem of angiographic data analysis are different definitions of hemodynamic instability such as 6 PRBCs/ 24 hours to 6 PRBCs/72 hours (67, 95) and the clinical definition of hemodynamic instability. An own analysis showed that patients where pelvic bleeding was treated by angiographic embolization averaged a need of 1.6 PRBCs/hour with embolization finished 17 hours after admission.

This indicates a mean blood loss on about 400 ml/hour (27), according to a grade I-II shock state according to the ATLS criteria (3).

Furthermore, it is known that the mortality rate increases significantly when the angiography/embolization is performed after >3 hours after admission (2) and frequently no active bleeding sites could be identified (2, 42). Additionally, angiography does not always decrease transfusion requirements (13).

Interestingly, more recent data show a much higher incidence of performed angiography/embolization up to 31% (24, 25, 38, 88, 103). Remarkable is, that it takes still 5.6 hours in average until angiography is started and the embolization procedure is finished in this summarized group of 320 embolized patients (24, 25, 46, 47, 60, 103, 112).

Therefore, this patient group represents most likely a moderately hemodynamic unstable group and angiography/embolization should therefore be the „third line of defence“.

### CONCLUSION

Patients with pelvic ring injuries should be hemodynamically defined as stable, unstable or in extremis as early as possible in the primary emergency management.

2-3% of these patients belong to the „in extremis“ group with potential significant pelvis-related hemorrhage. In this group excessive venous hemorrhage is frequent and can result in an immediate risk of death. Therefore, aggressive bleeding control should be performed by mechanical stabilization of the pelvic ring by pelvic binders/sheets or by external fixation with a supra-acetabular external fixator or the pelvic C-lamp. This should be followed by pelvic packing in all cases, where hemodynamic stabilization could not be achieved within 15 minutes after admission, despite adequate volume and transfusion replacement (Fig. 2). Angiography and embolization is the third option in these cases and it is recommended in patients with moderate hemodynamic instability, as it is still today a relative time-consuming procedure.

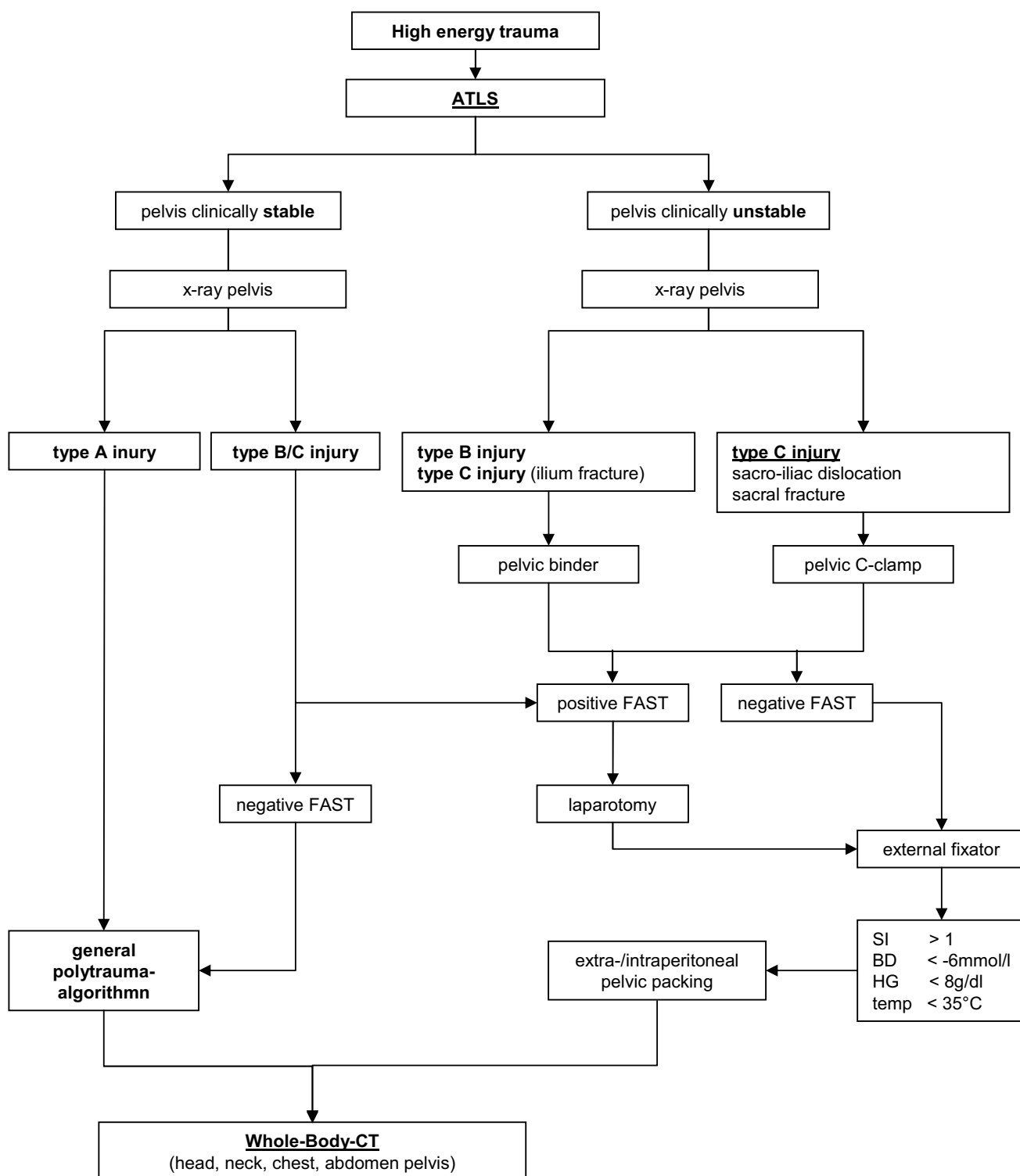


Fig. 2. Proposed emergency pelvic ring fracture algorithm with integration of different stabilization techniques and indication of pelvic packing depending on admission shock parameters. (BD = base deficit, HG = hemoglobine concentration, SI = shock index, temp = temperature).



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