Emergency Treatment for Clinically Unstable Patients with Pelvic Fracture and Haemorrhage

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A B S T R A C T

Unstable pelvic fractures very frequently occur with haemorrhage, not only from the broken pelvis but from the presacral venous plexus and/or iliac arterial or venous branches which may cause hypotension and increases the mortality rate. Very often this type of injury is concurrent with injuries in other organ systems. The compounded nature of these injuries makes it necessary for doctors who may encounter this type of patient to be educated in the techniques to effectively stabilise and treat the patient's complex injuries. After completing the international standard ATLS (Advanced Trauma Life Support) primary survey to identify a haemodinamically unstable patient with pelvic fracture, we discuss adequate replenishment of lost blood volume and standards of care for such a patient. The best diagnostics are described from transport immobilisation to the placement of external fixators or C-clamps. Likewise indication for intervention of pelvic angiography and therapeutic embolisation are also discussed. The direct surgical hemostasis method of pelvic packing is described in detail. All presented methods are mutually complementary in today's treatment of these patients.

***Key words**: bleeding pelvic fracture, pelvic fracture, pelvic packing, angiography embolisation, external fixation, c-clamps, haemorrhage*

Introduction

Pelvic fractures are especially difficult injuries and are indicators of multiple trauma. Fracturing the pelvis requires a great amount of force and when pelvic stability is compromised the patient may become haemodinamically unstable as well. Pelvic fractures account for approximately 3% of all skeletal injury after blunt trauma. It has been found that haemodinamically unstable pelvic fractures are frequently the result of motor vehicle crashes[1–7]. The common international protocol ATLS (Advanced Trauma Life Support) is standard in most emergency settings. ATLS teaches the acronym ABCDE concept for polytrauma patient care. In the ABCDE of the primary survey A stands for airway maintanence, B breathing and ventilation, C circulation and hemorrhage control, D is disability-Neuro, and E is exposure/environment control. However, injuries combining mechanically unstable pelvic fractures with haemodinamic instability are rare. These type of injuries comprise less than 10% of all pelvic fractures[3,7–9], mortality of patients with any pelvic fracture has been reported to be 5–10%[10–20]. Haemodinamically unstable pelvic fractures have a mortality rate of 40–60%[7,8,13,18,21,22]. The mortality rate in patients with open pelvic fractures is as high as 70%, this is because the self-tamponade effect is lost[20,23–26]. Haemorrhage from cancellous bone surfaces, the presacral venous plexus and/or iliac arterial or venous branches may cause hypotension. When excessive force, great enough to cause pelvic fractures, is applied to the human body the pelvic fracture is often associated with extra-pelvic haemorrhage from other injuries (chest 15%, intraabdominal 32%, long bones 40%) which complicates the initial work-up[27,28]. Mortality rates in excess of 40% are reported with exsanguinating haemorrhage identified as the major cause of death during the first 24 hours after injury, and with multiorgan failure (MOF) causing the majority of deaths thereafter[3,7–9,18,21,29,30–32]. This late mortality is most likely to be a direct result of what may be referred to as a »bloody vicious cycle« of continued haemorrhage and transfusion[7,21,33–37]. Thus, urgent identification and control of haemorrhage is paramount to patient survival.

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The bony structure of the pelvis is made up of three bones; the two inominate bones and the sacrum. To disrupt the integrity of the pelvic ring requires an instantaneous deceleration of approximately 30 miles *per* hour and as this energy dissipates, it often causes trauma to the head, chest, abdomen or extremities which adds to the over-all physiological burden of injury[6,7,28,38–40]. More than 80% of patients with unstable pelvic fractures will be found to have additional musculoskeletal injuries[20,21,38,41]. Only a small proportion of deaths are directly attributable to the pelvic fracture alone[7,42–44]. High-energy impact is needed to disrupt the pelvic ring and these high-energy transfers are absorbed by the rest of the body producing major injury to other critical organs. Up to 90% of patients with unstable pelvic fractures have associated injuries and 50% of patients have sources of major haemorrhage other than pelvic fractures[7,15,20,26,43]. If the patient is haemodinamically unstable without bleeding from the thorax, abdomen or any external haemorrhage and has an unstable pelvis, the pelvis must be stabilised. The weakest link in the pelvic ring supplying only 15% of the intrinsic pelvic stability is the pubic symphysis. Muscles and ligaments of the pelvic floor also contribute to pelvic stability; extensive disruption of this extraperitoneal compartment leads to loss of tamponade, and uncontrolled haemorrhage and exsanguination[7,8,30,45–47]. Significant disruption and displacement of one area of the pelvic ring are accompanied by the same in another and are usually the result of both bone and ligamentous disruption. Pelvic instability is defined as the inability of the pelvic ring to withstand physiological loading, and it is these high energy pelvic injuries, especially those involving posterior structures, that result in the greatest amount of blood loss[7,8,11,20,48,49].

The posterior pelvic venous plexus or bleeding cancellous bone surfaces are the primary source of haemorrhage in pelvic fracture[50,51]. Arterial haemorrhage is found in 10–15% of cases and its usual source is from named branches of the internal iliac system with pudendal (anterior) and superior gluteal (posterior) arteries being the most commonly identified at arteriography[7,45]. Occurring less than 1% of the time, posterior fracture along the sacroiliac joints may cause disruption of a main iliac trunk. Force vectors and fracture patterns are inconsistent predictors for those with arterial bleeding and need for subsequent angiography. This is most likely because radiographs can only capture the degree of displacement at the time of imaging, not that which was present at the time of impact[7]. Exsanguinating haemorrhage can and does occur in all fracture patterns, even simple rami fractures, and may in fact be independent of the bony injury pattern to the pelvis altogether[7,10,31,32,45,48,51–60]. Retroperitoneal haemorrhage should be assumed when a pelvic fracture is seen on the initial anteroposterior (AP) pelvic X-ray.

A reliable method to estimate the amount of haemorrhage in the retroperitoneal space or to ascertain the relative contribution of arterial *versus* venous bleeding to the overall pelvic haemorrhage has not been found. Therefore determination of the major cause of ongoing bleeding in pelvic fractures may often be a diagnosis of exclusion. Large transfusion requirement is not a reliable predictor for bleeding from the pelvis. Clinical assessment of haemodinamic instability with exclusion of other sources of haemorrhage is the best predictor of the need for haemostasis of the pelvis[10,15,17,20,56,61,62].

Management

When a patient presents with multiple injuries and a pelvic fracture is suspected the patient's airway is secured and resuscitation begun with intravenous crystalloid solutions while deliberate hypotension is maintained until all sources of haemorrhage have been identified and controlled[7,52,53,58]. The most important factor in the survival of patients with pelvic fracture is urgent haemostasis thus limiting the detrimental effects of shock and high volume resuscitation[8,31]. Since bleeding from associated injuries significantly influences patient survival, prompt identification and management of all life threatening injuries is essential to restoring normal haemodynamics[7,8,38,39]. There is a poor correlation between the severity of the pelvic fracture pattern and the need for emergent haemostasis[5,6,10,18,20,22,54,56,59,63–67]. Patients with haemodinamic instability due to haemorrhage should be initially resuscitated with 2 L of crystalloid followed by packed red blood cells (PRBC) and fresh frozen plasma (FFP) in a 1:1 ratio[20,68,69] and platelets ideally in a 1:1:1 (pack) ratio[10,20,58,69–74]. If the patients' systolic blood pressure remains less than 90 mmHg despite PRBC transfusion, the patient is considered as a »non-responder«, and requires more advanced treatment[6,7,10,20,21,31,56,59,68,75,76]. Haemoglobin and/or haematocrit levels measured within minutes of patient arrival in the trauma bay may be a reliable marker of ongoing haemorrhage and need for massive transfusion. An admission haematocrit of 30% or less has been shown to be a predictor of major pelvic haemorrhage[1,7,77]. However, haemoglobin and haematocrit are potentially spurious and should not be trusted to determine amount of blood lost. High base deficits and lactate levels have correlated with mortality in pelvic trauma and those with base deficits of 5 mmol/L on arrival were more likely to die[7,27,78]. Improvement in base deficit and blood lactate signals amelioration of oxygen debt and reversal of the shock state[7,79]. As a result of tissue damage/destruction and resultant hypoperfusion, trauma-induced coagulopathy may be present in 25% of patients upon Trauma Department admission and appears to increase linearly with injury severity scores and risk of death[7,80,81,82]. Crystalloid use is then significantly limited and should serve mainly as a carrier to keep lines open between blood products[83,84,85]. Early transfusion of platelets as six packs to keep platelet counts above 100,000/ mL during massive transfusion appears to provide a survival advantage[7,73,74,86,87]. Cryoprecipitate and recombinant factor VIIa (rFVIIa) may be used as adjuncts to haemostatic resuscitation especially in those patients who are coagulopathic as a result of delayed presentation or ongoing haemorrhage with tris-hydroxymethyl aminomethane (THAM) given to rapidly correct pH and acid base deficits[7,36,58,84,88,89,90,91]. It is important to maintain the patient at normothermia.

Direct compression and immobilisation of the pelvic ring and lower extremity can be achieved via pneumatic pressure using Military antishock trousers (MAST). The use of MAST was advocated in 1970s and 1980s to induce pelvic tamponade and increase venous return[11,13,14,20,92,93]. But the device is also associated with inherent complications, such as lower extremity ischemia/reperfusion, development of compartment syndrome, and skin necrosis[94–97]. Today, most prehospital care systems have discontinued using MAST[3,7,20,98–100]. MAST might still be an option however for haemodinamically unstable patients who would die because of prolonged transfer time. The simplest method to reduce the volume of an unstable pelvis is internal rotation of the legs. However, medical caregivers must also avoid the external rotation of the legs which increases the pelvic volume. Reduction of venous bleeding by stabilisation of pelvic ring injuries is most expeditiously accomplished with a longitudinally folded bed sheet wrapped circumferentially around the pelvis, placed between the iliac crests and greater trochanters, and secured anteriorly by clamping[101-103] or with simple commercially available devices. Commercial pelvic binders have been devised which permit tension adjustment from 140 to 200 N[2,20,104,105]. Their easy application, relative safety, cost-effectiveness, and non-invasive character make them an attractive option. The application of a pelvic binder should be considered as early as possible. Patients in the prehospital setting in particular, may benefit because maintaining the fractured pelvis' stability prevents disruption of haemostatic clots and consumption of clotting factors which can lead to coagulopathy[7,10,20,91,104,]. Pelvic binders or sheets should be considered as a temporary measure bridging acute injury towards more rigid stabilisation[7,20,102,104]. While binders and external fixators may decrease the pelvic volume of »open-book« injuries[106,107] (Figure 1), it is controversial whether they can create a tamponade effect, since the retroperitoneum is disrupted[7,46,108]. The »splinting« of pathological pelvic motion is more likely to be the mechanism that aids in haemostasis. Moreover, the reduction in volume of the true pelvis is much less than expected. A large pubic diastasis of 10 cm only corresponds to a 35% increase in pelvic volume (479 cm^3)[109].

Anterior external fixator application usually limits blood loss by direct compression of bleeding vessels at the fracture site or sacroiliac joint disruption for rotationally unstable pelvic fractures that involve partial disruption of the posterior elements. External fixators have been in use from the 1960s[1,7,44]. Unfortunately, stability and haemorrhage control for vertically unstable patterns with complete disruption of the posterior elements are limited[110]. An external fixator can be applied by an experienced orthopaedic surgeon in 15–20 min[16,20,95,96,97,111]. External fixation can be performed either by placing the pins in the iliac crest (Figure 2) under direct palpation without fluoroscopy or placing the pins in the supra-acetabular bones with fluoroscopy. None the less an experienced surgeon can feel the inferior anterior iliac spine, and can place supra-acetabular pins without fluoroscopy in 5–15 minutes. Biomechanical studies show that supra-acetabular pin placement has greater rigidity and pull-out strength[112]. Iliac crest placement is quicker and requires less equipment, but supra-acetabular pins are preferable for long term treatment. However supra-acetabular pins should only be applied in the stable patient. External fixation provides only a small volume change within the true pelvis even if applied to open-book pelvic fractures[7,20,46,113,114]. Thus, an external fixator is thought to contribute to haemostasis primarily by decreasing bony motion at the fracture site, re-opposing the cancellous bone surface, and allowing stable clot formation as well as maintaining a reduced pelvic volume[7,20,46,50,113]. The disadvantage of external fixators is they do not provide posterior stability and can potentially increase dis-

Fig. 1. Fractured pelvis.

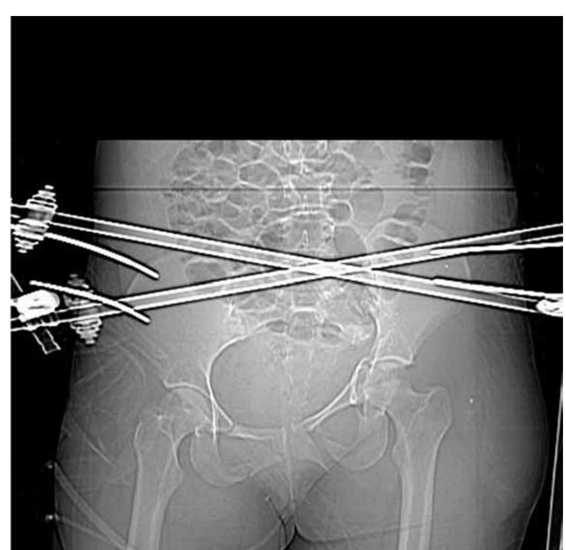

Fig. 2. Temporary external fixator for fractured pelvis.

placement of the fractured pelvis in a vertically unstable fracture configuration. Additionally, if pin sites become infected, they can compromise subsequent definitive open reduction and fixation. In general, we recommend simple external fixation placed quickly during resuscitation procedures, with conversion to definitive internal or more stable external fixation when the patient is haemodinamically stable. In those patients with posterior pelvic ring disruptions, the major source of bleeding is often from the cancellous bone and/or the presacral venous plexus[62]. In these injuries, rapid reduction and posterior stabilisation can be performed with the pelvic C-clamp, which consists of two pins applied to the ilium in the region of the sacroiliac joints. It may be applied in the emergency department, but it is preferable to place the device in the operating room under fluoroscopic control[110,115]. The anterior placement sites are supra and lateral acetabulum and can be used posteriorly for direct reduction of vertically and rotationally unstable fractures[116,117]. By inserting a wide pin bilaterally in the region of the sacroiliac joints, C-clamps offer a distinct biomechanical advantage over anterior external fixators because they can exert transverse compression directly across the sacroiliac joint with a significant force. C-clamps can be assembled and applied in 5 min[10,20,76,116,117]. They can provide prompt stabilisation of the posterior pelvic ring and can be effective in case of complete disruption of the posterior ring[7,10,20,30,31,76,116,118–122], and because the clamp can be rotated cephalad and caudad, access to the abdomen and perineum is not limited. The C-clamp can be applied for a haemodinamically unstable patient status based on an AP pelvic X–ray. However, it is not applicable in iliac fractures and transiliac fracture dislocations. Also, pelvic penetration or misplacement through the greater sciatic notch that caused iatrogenic nerve and vascular injuries has been reported[117]. A C-clamp or external fixator should be considered before or concomitantly with emergent laparotomy because the anterior abdominal wall contributes to limiting the degree of pubic diastasis through a tension band effect on the iliac wings, and the pelvic volume will increase if the pelvis is not stabilised prior to laparotomy[8,17,104,113].The application of these devices is also necessary when pelvic packing (Figure 3) is performed for the mechanically unstable pelvis because the fracture must be stabilised during this

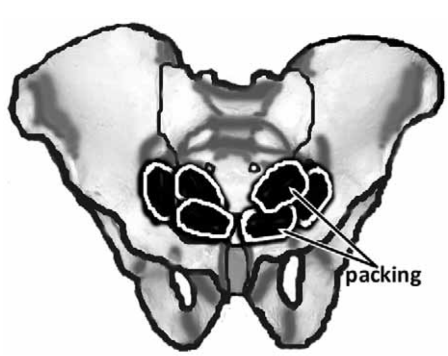

Fig. 3. Diagram showing pelvic packing.

procedure in order to provide a stable wall against which to pack[7,54]. Anterior injuries (pubic rami diastasis/fractures) are more easily identified than those affecting posterior structures, which may be missed in up to 22% of cases. Overall, AP films of the pelvis have a sensitivity of only 78% for identification of pelvic fractures in the acute trauma patient and may be the result of poor film quality or clinician inexperience[123,124,125,126]. Additionally, fracture pattern has inconsistently predicted blood loss and need for transcatheter arterial embolisation (TAE)[1,6,7,31,55,56,59,127].

Pelvic fractures with associated bleeding have the following signs: A palpable haematoma above the inguinal ligament, on the proximal thigh, and/or over the perineum (Destot sign), and ecchymosis about the flank (Grey Turner sign) which is associated with retroperitoneal haemorrhage[7]. Pelvic springing involves applying alternating compression and distortion over the iliac wings to detect pelvic ring instability however it is a poor predictor of the presence or absence of pelvic fracture. Pelvic springing also may dislodge adherent clot further exacerbating haemorrhage, is painful to the conscious patient and should therefore be avoided[7,27,128]. Bleeding from extra-pelvic sources occurs 30% of the time[20,21]. An AP chest X-ray should be obtained along with ultrasound evaluation of the pericardium to exclude intra-thoracic injury. Intraabdominal haemorrhage can be evaluated by ultrasound, diagnostic peritoneal lavage (DPL) and/or CT scanning. Abdominal ultrasound is a rapid and accurate means of diagnosing haemoperitoneum. DPL may be used in cases of equivocal ultrasound findings, which may be caused by anatomic distortions of the retroperitoneum from injury, or to differentiate haemoperitoneum from uroperitoneum, as between 4% and 8% of patients with pelvic fracture will have an associated bladder injury[129]. However DPL is associated with a high number of false positive results, non-therapeutic laparotomy and negative impact on outcome[8,38,130]. Direct ligation of bleeding pelvic vessels should not be attempted as results have been universally poor[131,132]. Though highly sensitive and specific for intra-abdominal bleeding, haemodinamic instability limits the use of CT scan in this patient population. Even so, pelvic CT angiography may be more sensitive for arterial injury than catheter based angiography[133,134]. Pelvic angiography with therapeutic embolisation was reported in 1972[135]. Embolisations were carried out initially with autologous blood clots, and later with gelatin sponge, rarely followed by metal coil placement[65]. This less-invasive procedure is a safe and efficacious substitute for direct surgical intervention[14,15,20,111,136]. Pelvic angiography consists of a non-selective injection of contrast medium just above the aortic bifurcation followed by selective injection of the branches of the internal iliac arteries. Branches of other arterial systems, such as the lumbar artery, median sacral artery, deep iliac circumflex artery, and corona mortis, are possible sources of bleeding, which may be amenable for selective catheterisation[20,22,64,65,67,137]. Angiographic evidence of extraluminal contrast extravasation indicates ongoing arterial bleeding and haemostasis is obtained by catheter embolisation with gelatin sponge and/or coils. Haemodinamically unstable patients after appropriate fluid resuscitation with PRBC and FFP and mechanical stabilisation of the pelvis, are possible candidates for pelvic angiography[13,112]. The other indications for pelvic angiography include the incidental discovery of extravasation of contrast medium on the arterial phase of computed tomography (CT) scans which is an indication of active arterial bleeding[19,20,138,139]. CT scans are also useful in gauging the amount and location of pelvic haemorrhage, both of which may predict arterial injuries[140,141]. Prevalence of patients with pelvic fractures who need embolisation is reported to be less than 10%[5,7,11,13–15,17,18,19,20,22,42,55,56,59,65,66,75,92,142]. Haemodinamically unstable patients have a potentially higher possibility of arterial extravasation by angiography. Some authors report that only 11.1% of their patients exhibited arterial bleeding[50]. In others this percentage is much higher as: 58.7%[8] or 57.1%[5] or 67.9%[59] and some even report as high as 75.3%[64] patients exhibit arterial bleeding[7]. If pelvic arterial haemorrhage embolisation is accomplished within 3 hours of arrival it resulted in a significantly greater survival rate[75], if accomplished 90 min after admission there was an improved mortality[61]. Angiography for pelvic fractures allows both selective embolisation of bleeding arteries and non-selective embolisation of bilateral internal iliac arteries. Selective is preferable, especially in patients who are haemodinamically stable following fluid resuscitation[14,17,20, 59,65,135,143]. Critically injured patients often have vasospasm of injured arteries, temporal clotting, and/or low perfusion secondary to hypotension. These factors can lead to intermittent bleeding distally due to changing coagulation status, blood pressure, and motion of fracture sites[20,62,137,144,145,146,147,148]. Non-selective bilateral internal iliac artery embolisation with a gelatin sponge has been advocated in patients with multiple bleeding sites from bilateral internal iliac artery branches[5,7,13,14,20,22,45, 55,56,62,64,66,67,75,111,137,144,148]. This is time-saving embolisation compared to non-selective. This technique is theoretically supported by the fact that there are generous collateral pathways and anastomoses between each artery and cross circulation from the contra lateral side. The collateral arteries may supply the ruptured arteries from the opposite side. These potential collateral vessels should be considered as multiple communicating channels and need to be embolised at their common trunk[13,20,111,137,148].

Even with aggressive resuscitation, mechanical stabilisation, and successful embolisation, mortality remains high. Some authors[92] reported that 88.9% of patients treated with embolisation eventually died. Several authors have reported that the mortality of patients treated with embolisation was around 50% despite successful control of arterial bleeding[7,20,23,56,59,63,65,75]. Arterial embolisation does not always stop bleeding due to pelvic fracture. It is still difficult to know the proportional contributions of arterial, fracture site and venous bleeding to the overall pelvic haemorrhage, and in which combinations. It has been found that the majority of patients who die with pelvic fractures, die of blood loss, without major arterial injury[20,26,43,50,51,149,150].

The retroperitoneum is considered a closed space that can provide a tamponade for bleeding from a pelvic fracture. Most bleeding from venous injuries arises from small- and medium-sized torn veins and can stop naturally[7,20,45,151,152]. Frequently 1.5 L, and 4–6 units of red blood cells transfused may be enough to tamponade venous bleeding within a stable or stabilised pelvic ring[7,20,45,113,114]. If the parapelvic fascia is disrupted tamponade ability is lost. This is significant with posterior displacement, such as sacroiliac dislocations, sacral fractures and sacroiliac fracture dislocations. Creating open-book pelvic fractures caused disruption of the pelvic floor, thereby allowing haemorrhage to escape into the perineum and thighs[46]. Haemorrhage from pelvic fracture is bleeding into a free space, without gaining sufficient pressure-dependent tamponade[54]. This can lead rapidly to the requirement of massive transfusion with the risk of exsanguination, despite an absence of arterial injury. In these patients, time spent in angiography can be life threatening. However, waiting for the tamponade effect may result in a waste of time and a waste of blood transfusion that can contribute to higher morbidity and mortality[20].

Venous injuries and bleeding are likely to occur more frequently than arterial injury[7,50,107]. This is because venous structures are more fragile to external trauma force than are arteries[28]. So that even when arterial bleeding is present, venous bleeding is probably close to 100%[7,20,30,107,150]. The iliac vein and its major branch injuries are believed to cause the high mortality rate[149]. Pelvic packing was developed as a direct haemostasis to control haemorrhage due to pelvic fractures during the 1960s[54]. It is important to remember that stabilisation of the pelvis must precede pelvic packing. This technique facilitates control of retroperitoneal bleeding through a small incision which does not violate the intraperitoneal space and leaves the peritoneum intact. First a simple external fixator or C-clamp is placed to stabilize the ring of packing then using an 8-cm midline incision of the lower ab-

Fig. 4. Internal osteosynthesis on fractured pelvis.

domen, direct access to the bleeding retroperitoneal space is possible and then presacral area and paravesicle space is packed with surgical lap packs usually 3 *per* side (Figure 3). The key of this manoeuvre is packing of the true pelvis, below the pelvic brim and not the false pelvis, above pelvic brim. Packing above the pelvic brim has minimal tamponade effect since the major venous bleeding occurs in the plexi of vessels located in the true pelvis. Afterwards, the skin incision is closed[25,32,121]. Total time for the packing procedure should be less than 20 min[32]. Packing can reduce unnecessary angiography[21,122] and reduce up to 1/3 of patients who have hypotension caused solely by venous bleeding. Disadvantages of packing are that it is a relatively invasive procedure, and the possibility of infection afterwards. Some authors have also reported abdominal compartment syndrome as a complication following pelvic packing[30,153]. In patients with significant haemodinamic instability, arterial bleeding may accompany venous and fracture site bleeding. Thus, angiography may be required following pelvic packing if there is persistent hypotension or ongoing haemorrhage is suspected[20,21,32,121]. It has been found that 54 to 80% of initially hypotensive patients due to pelvic haemorrhage are non-responders[7,8,59]. There has not been evidence demonstrating the effectiveness of any single technique for the controlling pelvic fracture haemorrhage. Pelvic packing followed by angiography is the logical protocol for haemodinamically unstable patients with pelvic fracture. After the patient's condition is no longer life threatening and bleeding has stopped, the external temporary fixator or C-clamp may be removed and internal osteosynthesis for the stabilization of the fractured pelvis may be placed (Figure 4).

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URGENTNO LIJEČENJE KLINIČKI NESTABILNOG BOLESNIKA S PRIJELOMOM ZDJELICE I PRIPADAJUĆIM KRVARENJEM

S A Ž E T A K

Nestabilni prijelomi zdjelice vrlo često su udruženi s masivnim krvarenjem, ne samo iz slomljenih zdjeličnih kostiju već i iz presakralnog venskog spleta i/ili iz ogranaka ilijačnih arterija i vena što uzrokuje hipotenziju i visoku smrtnost. Vrlo često su udružene i ozljede drugih organskih sustava. Zbog svega navedenog vrlo je važna edukacija liječnika koji dolazi u susret s takvim bolesnikom, da bih pružio sve što zahtijeva takva teška ozljeda. Nakon primarnog pregleda po međunarodnom standardu ATLS (Advanced Trauma Life Support) i prepoznavanja hemodinamski nestabilnog bolesnika s prijelomom zdjelice, u radu je opisana adekvatna nadoknada izgubljenog volumena i po kojim pravilima se ona vrši. Također je opisana nužna dijagnostika te postupci od transportne imobilizacije do postavljanja vanjskog fiksatora ili c-kliješta. Opisane su indikacije i postupak intervente pelvične angiografije i terapeutske embolizacije. U radu je detaljno opisan postupak direktne kirurške hemostaze metodom zdjeličnog »packinga«. Sve navedene metode imaju današnju primjenu u liječenju i međusobno se dopunjuju.