Extra-peritoneal pressure packing without external pelvic fixation: A life-saving stand-alone surgical treatment

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ABSTRACT

Purpose: Traditional maneuvers aim to decrease retroperitoneal bleeding in hemodynamically unstable multi-trauma patients with unstable pelvic fractures, are reportedly successful in approximately only 50%. The life-saving effect of extra-peritoneal pressure packing (EPPP) is based on direct compression and control of both venous and arterial retroperitoneal bleeders. This study describes the safety and efficacy of emergent EPPP employment, as a stand-alone surgical treatment, that is, carried out without external pelvic fixation or emergent angiography. Materials and Methods: A retrospective chart review of all hemodynamic unstable, multi-trauma patients with mechanically unstable pelvic fractures treated by the EPPP technique at our medical center between the years 2005 and 2011. Survival rates, clinical, and physiological outcomes were followed prospectively. Results: Twenty-five of the 181 pelvic fracture patients had biomechanically unstable fractures that required surgical fixation. Fourteen of those 25 patients had deteriorating hemodynamic instability from massive pelvic bleeding which was resistant to resuscitation, and they underwent EPPP as a stand-alone treatment. The procedure successfully achieved hemodynamic stability in all 14 patients and obviated the early mortality associated with massive pelvic bleeding. Three of these patients eventually succumbed to their multiple injuries. Conclusion: Implementation of EPPP improved all measured physiological outcome parameters and survival rates of hemodynamically unstable multi-trauma patients with unstable pelvic fractures in our trauma center. It provided the unique advantage of directly compressing the life-threatening retroperitoneal bleeders by applying direct pressure and causing a tamponade effect to stanch venous and arterial pelvic blood flow and obviate the early mortality associated with massive pelvic bleeding.

Key Words: Extra-peritoneal packing, hemodynamic instability, multi-trauma, pelvic fractures, salvage procedure

INTRODUCTION

With a mortality rate >40%, management of multi-trauma patients presenting with exsanguinating pelvic fractures is a therapeutic challenge.¹ Mortality within the first 24 h is primarily due to complications of the bleeding itself,²,³ while associated coexisting cerebral injuries, thromboembolism,
and multiple organ failure account for most of the mortality afterward.\cite{6,7} These patients present with the life-threatening hemodynamic instability due to massive pelvic bleeding from the presacral vessels damaged by the unstable pelvic fractures. This massive intrapelvic bleeding is difficult to control, and traditional treatment is aimed at decreasing the retroperitoneal bleeding by the containment of the retroperitoneal hematoma using techniques for reducing the pelvic volume and stabilizing the pelvic fractures, together with emergent angiographic catheterization and arterial embolization of retroperitoneal bleeders.\cite{6,7} Despite widespread use of these approaches, mortality rates remain high (>40%),\cite{6,7} and concerns have been raised about the effectiveness of these life-saving efforts to contain the retroperitoneal hematoma and bleeding,\cite{1,6,8} including pelvic clamps, external fixation, or strapping maneuvers to reduce the pelvic volume and stabilize the pelvic fractures. Traditional methods that attempt to control bleeding in an indirect fashion, such as external pelvic fixation and arterial embolization, are time-consuming (30-90 min) and effective to varying degrees in 40-50% of cases at best,\cite{6,7} and may not be available in all hospital settings. Furthermore, it is difficult to contain bleeding into the pelvic retroperitoneal space even when stabilization of the pelvis has been successfully achieved, since this space is continuous with the abdominal retroperitoneal space as well as with the buttocks and thighs through the greater sciatic notch. In contrast, extra-peritoneal pressure packing (EPPP) enables immediate and direct application of pressure upon bleeding wounds and vessels, leading to the successful cessation of life-threatening exsanguination. Most of the retroperitoneal bleeding comes from the pelvic venous plexus and from the bone itself and not from the arterial plexus.\cite{8,9} The additive effect of angiographic catheterization and arterial embolization is limited to the bleeding iliac arteries and does nothing to stanch the flow from the venous retroperitoneal bleeders, which is the major cause of death.\cite{1,6-8}

Emergent surgical access to the presacral vessels and direct application of pressure packing onto the retroperitoneal bleeding vessels via EPPP has gained popularity following reports of its effectiveness and advantages over earlier approaches.\cite{1,6,8,10-12} Typically EPPP is employed in conjunction with the application of external fixation with the concept that the external fixation will counteract the forces associated with packing and insertion of multiple abdominal pads into the pelvis which increases the pelvic volume. It has not, however, been conclusively established whether EPPP is effective as an immediate stand-alone surgical treatment for multi-trauma patients, that is, carried out without external pelvic fixation or emergent angiography. In this study, EPPP was employed as a first-line sole surgical treatment without external fixator application in exsanguinating unstable patients.

The aim of this study is to describe the survival rates associated with prompt employment of the EPPP technique, as a stand-alone surgical treatment for multi-trauma patients and the clinical and physiological outcomes.

**MATERIALS AND METHODS**

A retrospective cohort study of prospectively collected data of all patients treated for traumatic pelvic fractures at our medical center between the years 2005 and 2011 that was approved by our Institutional Review Board. Multi-trauma patients who were exsanguinating from their pelvic fractures which were treated by the EPPP technique were prospectively followed for clinical and physiological outcomes and survival rates.

Inclusion criteria for a patient to be considered for emergent stand-alone EPPP included: Hemodynamic instability in multi-trauma patients (systolic blood pressure <90 mmHg and tachycardia) associated with unstable pelvic fractures, who continued to exhibit life-threatening deterioration of vital signs despite life-saving resuscitation efforts, unresponsive to fluids and at least 2 units of packed red blood cell (RBC) that had no other apparent source of major bleeding.

**Outcome measures**

The primary outcome measure was survival versus mortality. The secondary outcome measures included: Initial pelvic stabilization and additional surgical interventions. Other variables that were recorded and measured included: Time between injury and arrival to the Emergency Department and time until initiation of EPPP, the physiological parameters that were evaluated included blood pressure, heart rate, hemoglobin level, and mean number of blood packs given before and after EPPP. Patients’ characteristics were allocated from the hospital-based trauma registry and included age, gender, associated injuries, and cause of injury. All injuries were coded according to the Abbreviated Injury Scale\cite{13} for calculation of the Injury Severity Score (ISS).\cite{14} EPPP was considered successful if the patient was alive 30 days after the intervention, time, and cause of death in nonsurvivors will be depicted. We also monitored the improvement in the physiological parameters to further assess the effectiveness of the procedure.

**The procedure**

EPPP was developed in the early 90’s by trauma surgeons in Europe and usually followed exploratory laparotomy.\cite{10} We adopted this life-saving surgical procedure, which is usually performed in the operating room, but can also be performed in the angiography suite or even in the Emergency Department in the extreme situations. The patient is positioned supine on the table, and the abdomen is draped from the groin to the clavicles in order to reach the thorax and abdomen if emergent laparotomy or thoracotomy should be needed. Though access through a midline laparotomy like incision can be used, we find the Pfannenstiel low horizontal ~10-12 cm long incision allows better access when it is made just above the pubic rim ("bikini line"). The upper edge of the pubic bone
is palpated, a low transverse incision with detachment of the rectus muscles from their insertion on the rami pubic is made, and dissection is then carried out until the urinary bladder is identified. It should be noted that in these high-energy injuries we typically find that the rectus muscles are already partially detached from the injured/fractured pubis. Without opening the peritoneum, the urinary bladder is retracted to one side while blunt dissection is manually carried out onto the iliacus muscle. Identification of the extra-peritoneal bladder is critical as is a retraction of the urinary bladder to the contralateral side in order to directly approach the presacral vessels. Packing is directed downward and posteriorly while sliding down the urinary bladder directing the surgeon’s fingers posteriorly and deep into the pelvis ring, reaching posteriorly until the sacroiliac joint is palpated (and often the fracture fragments). Surgical abdominal pads are then firmly packed via this route down into the sacroiliac joint and its surroundings (preferably 5-7 pads are firmly packed on each side of the urinary bladder). The abdominal pads are directed toward the pelvic venous plexus and branches of the internal iliac artery, which are in close proximity to the sacrum and pelvic bones. Considerable pressure is mandatory in this packing maneuver, so that the abdominal pads firmly packed on the pelvic ring from the sacrum to the pelvic rim, thus creating pressure directly onto the presacral vessels [Figure 1]. The same maneuver is then repeated on the contralateral side of the bladder. Finally, superficial and lateral packing should be avoided preventing compression on the femoral vessels.

After controlling the pelvic bleeding and once the patient’s vital signs improve, the incision is closed with temporary sutures. If hemodynamic stability is not achieved within minutes of EPPP, the abdominal pads should be removed, and repeated packing performed as detailed above.

After successful EPPP assures hemodynamic control, the patient is transferred to the Intensive Care Unit and monitored for 24-48 h before returning to the operating theater for a second look and repacking procedure [Figures 1 and 2]. If arterial ooze is still suspected after 24-48 h (e.g., when there is a slow and mild decline in Hg level), the patient is taken nonemergently to the angiography suite where arterial access is first gained with a femoral artery standard angiography catheter. Under sterile conditions, the abdominal packs are then carefully removed allowing direct visualization of the vessels followed by angiography and embolization of any small bleeding arteries. The pads are removed 48-72 h later, and if they are dry, the wound can be irrigated with saline and closed by standard layered suturing. The external fixator was used at a later second stage, only after successfully controlling the bleeding via EPPP employment in a few selective cases in which the mechanical stabilization was needed.

Management protocol for blunt pelvic trauma
The protocol for the initial treatment of patients with blunt pelvic trauma employed at our regional trauma hospital is displayed in Figure 3.

Initial resuscitation
Patients suffering from high-energy injuries are managed according to the Advanced Trauma Life Support (ATLS) algorithm [15] until the sources of bleeding are identified and controlled, the patients are resuscitated according to the principle of deliberate permissive hypotensive fluid resuscitation.

RESULTS
Twenty-five of the 181 patients with significant pelvic fractures treated from 2005 to 2011 had biomechanically unstable fractures
that required surgical fixation. Fourteen of these 25 patients presented with deteriorating hemodynamic instability that was refractory to resuscitation despite multiple blood transfusions and fluids, therefore, they were promptly treated with the EPPP procedure. With EPPP as part of the initial life-saving procedures, hemodynamic stability was successfully achieved in 100% of these patients without the use of external fixation or emergent angiography as seen in Table 1, no additional surgical intervention was required. EPPP was successful already with the first packing attempt in 11 patients, while in 3 out of 14 patients repacking was performed in the OR due to ongoing oozing before hemodynamic and local control were achieved and the abdomen sutured. None of the patients died of massive pelvic bleeding associated with the unstable pelvic fracture [Table 2]. The mean time of arrival to the Emergency Department from the site of injury was 34.2 min, and the mean transfer time from arrival to the hospital until entering the operating room was 83.87 min.

**Patient characteristics [Table 3]**
The mean age was 42.2, 12 out of 14 were male. All the patients had other associated injuries (urinary bladder rupture, fractures of long bones, and intracranial bleeding, etc.) associated with the high-energy trauma. Motor vehicle accidents accounted for 60% of the injuries, and accidental falls from heights accounted for the remaining 40% [Table 3]. All study patients were involved in high-energy injuries, with an ISS score >15 (the median ISS score was 29, range: 17-38).

**Physiologic parameters [Table 1]**
Despite multiple transfusions of packed RBC units and life-saving resuscitation, the mean systolic blood pressure was 62.66 mmHg before EPPP and increased to 113.33 mmHg, after EPPP. All patients were therefore in shock Class 3-4 (according to the ATLS guidelines).[13] The mean number of RBC packs decreased significantly following EPPP (3.45 RBC units) compared with the rate before the procedure (12 RBC units).

**Mortality**
Three of the 14 study patients did not survive. None succumbed due to ongoing hemorrhage, but rather from other major associated injuries, including intracranial hemorrhage, and chest contusions with cardiac arrhythmias [Tables 2 and 4]. Two patients were died within 1-day of undergoing EPPP and the three patients were died 4 days later with intracranial hemorrhage being the presumed cause of death.

Apart from survival and mortality, not all parameters were available for all patients; therefore the number of patients with available data is indicated in parenthesis in the tables.

![Figure 3: Management algorithm for multi-trauma patients with suspected blunt pelvic injury](image)

**Table 1: Physiological parameters**

| Parameter                        | After EPPP | Prior to EPPP |
|----------------------------------|------------|--------------|
| Systolic blood pressure (mmHg)   | 113.33     | 62.66        |
| Number of blood units given      | 3.45       | 12.0         |
| Heart rate (beats per minute)    | 96         | 85.5         |
| Hemoglobin (g/dL)                | 9.54       | 10.31        |

RBC: Packed red blood cells (1 unit = 300 mL); EPPP: Extra-peritoneal pressure packing

**Table 2: Characteristics of the three nonsurvivors**

| Patient characteristics | Patient 1 | Patient 2 | Patient 3 |
|-------------------------|-----------|-----------|-----------|
| Age (years)             | 74        | 61        | 42        |
| Time of death*          | 28 h      | 3 h       | 4 days    |
| Primary cause of death  | Massive bleeding, intracerebral hemorrhage | Complications of cardiac and chest contusion that led to PEA | Multiple organ failure, intracerebral hemorrhage |
| ISS                     | 29        | 36        | 37        |
| Comorbidity             | CVA, Alzheimer | IHD, PTCA (past) | Hepatitis C |
| Pelvic injury primary cause of death | No | No | No |

*From admission to the trauma unit. PEA: Pulseless electric activity; IHD: Ischemic heart disease; CVA: Cerebrovascular accident; PTCA: Percutaneous transluminal coronary angioplasty; ISS: Injury Severity Score
DISCUSSION

Management of trauma patients with bleeding pelvic fractures depends on their hemodynamic stability upon arrival. In the majority of cases, bleedings stop after standard initial resuscitation. However, there is a subgroup of patients that present with the life-threatening retroperitoneal bleeding which does not respond to resuscitation efforts. Thus, the indication for EPPP employment was continuous life-threatening deterioration of hemodynamic status despite repeated resuscitative efforts in an exsanguinating patient with a known unstable pelvic fracture. The reported mortality rate of patients who present with massive pelvic bleeding associated with unstable pelvic fractures reportedly exceeds 40%.11

In the current study, EPPP was promptly instituted as a stand-alone initial surgical procedure in the initial phases of resuscitation due to life-threatening hemodynamic deterioration in patients that were refractory to multiple blood transfusions and resuscitation and despite external pelvic binders. As such, external pelvic fixators were not applied, nor were these patients emergently taken to the angiography suite upon arrival to the hospital. Abandoning the use of emergent angiography and application of external fixation became our practice after experiencing patient deaths in the angiography suite and realizing that it is both time-consuming and in our experience a less effective means, to stop the major cause of bleeding that occurs from pelvic veins. EPPP was shown to be very effective in stopping both bleeding pelvic presacral veins and arteries and can be achieved quickly by orthopedic and general surgeons who are readily available at all times, as opposed to the need to await for the angiography team to arrive and set up. The concept of employing EPPP as the initial and sole surgical therapeutic management is based on a paradigm shift in treatment rationale aimed at damage control. When bleeding is severe, and resuscitation efforts do not stabilize the patients’ hemodynamic status, it seems that one should direct all attention toward obtaining immediate surgical access to the bleeding presacral vessels and control of these venous and arterial bleeders via direct pressure packing. This is in contrast to the tradition of employing indirect trials to contain the bleeding via external pelvic stabilization or angiography with arterial embolization that do not fully succeed in stopping the venous presacral bleeding, that is, considered the major cause of bleeding and of hemodynamic instability.

This change in treatment sequence using EPPP first during the initial resuscitation while abandoning angiography and pelvic external fixation for a later stage brought about a dramatic change in patient survival and outcomes whereby initial resuscitation was successful and hemodynamic stabilization was achieved in all patients (i.e., none died from exsanguination). This 100% initial resuscitation success rate was followed by a 79% long-term survival rate and eventual discharge from rehabilitation.

Previous reports on EPPP recommended that the pelvis should be fixed before packing is performed.8,11 As mentioned, in this study external fixation was not used in the initial treatment and interestingly, the 79% survival rate with EPPP reported here (11 of 14 patients) is similar to that reported by Ertel et al.,16 who described a 71% survival rate in 10 of 14 patients with hemorrhagic shock after retroperitoneal pelvic packing and application of a C-clamp. Noteworthy, the addition of the external pelvic fixation reportedly does not seem to make a difference in patient survival.11,17,18 The results of the current study concur, and demonstrate that immediate external fixation of the pelvis is not needed in order to control the bleeding. Initial pelvic stabilization relies on the misconception that the pelvis is a closed contained space and that minimizing the volume of the fractured pelvis would, therefore, initiate a tamponade effect.19,20 However, intraoperative observation refutes this notion by showing that despite the use of external fixators, the bleeding retroperitoneal hematoma continues to expand into the abdominal retroperitoneal space above the pelvis, and through the sciatic notch into the gluteal space below the pelvis.11

Emergent angiographic embolization has been advocated in the control of life-threatening pelvic hemorrhage.16,21 However, the angiographic procedure may be time-consuming, with reported procedure times of 30-90 min,18 the severely hemodynamically unstable patient may not be able to sustain life for that long a period of time. Furthermore, angiographic services may not be available in all hospital settings at all times and may require awaiting the arrival of the angiography trained invasive radiology specialist. In contrast, EPPP can be accomplished efficiently and quickly (medium time of 30 min in our hands). Finally, Huittinen and Slätis showed that most of the bleeding comes from the presacral venous plexus and from the bone,21 whereupon angiographic arterial embolization would do nothing to stop the major cause of death, which is bleeding from the venous and intraosseous bleeding vessels.

### Table 3: Patient characteristics

| Patient characteristics | Survivors (n = 11) | Nonsurvivors (n = 3) | Unpaired t-test results |
|-------------------------|--------------------|---------------------|-------------------------|
| Age (years)             | 35                 | 59                  | t(12)=1.12, NS           |
| ISS                     | 30.71              | 27.33               | t(4)=2.77, NS            |
| Revised trauma score    | 9.22               | 5.101               | t(4)=0.6, NS             |
| Time from injury to admission (min) | 30               | 40.5                | t(4)=0.6, NS             |

*NS: Not significant; ISS: Injury Severity Score*
Our protocol presented here [Figure 3] emphasizes that the use of angiography should be reserved for later stages of treatment, that is, only after the patient’s hemodynamic and life-threatening conditions are addressed and stabilized by more immediate resuscitative measures. In other words, using damage control concepts, the multiple pads inserted during the immediate EPPP stop major bleeding by pressing directly upon all vessels and allow stabilizing the patients’ physiological status. Then, typically after 2–3 days of treatment in intensive care he/she can safely be transported to the angiography suite in an orderly scheduled manner. Our working scheme delegates the use of angiography to serving as an adjunct to intensive care treatment, only after the hemodynamically stable patient can be safely transported to the angiography suite. At this point, with the patient’s hemodynamic status well controlled, and with the angiography team ready and in place, arterial angiographic catheterization access through the femoral artery is initiated before the Pfannenstiel wound is re-opened and the abdominal pads of the EPPP are removed in a controlled manner. This allows both fluoroscopic visualizations by the angiographer and direct visualization of the now thrombosed bleeding vessels in the surgical wound by the surgeon. If any remaining arterial bleeding resumes after the pressure packing is removed, it can now be easily addressed by the angiography team that already has their catheters in place.

Limitations of this study are apparent and include a small patient group (fortunately these devastating injuries are rare) with only historic controls. Larger multi-centered trials may better enable subgroup assignment and analysis. Not all the physiological data was recorded in the patients files due to lack of reporting by the trauma teams at the time of emergent life-saving resuscitative efforts, therefore some of the data includes <14 patients as is noted in the tables where applicable. EPPP also has reported disadvantages. It is an invasive, open procedure done as a last resort life-saving procedure in extreme and emergent situations and carries a risk of infection. In our study, the infection rate was 35% (5/14), similar to a rate of 33% reported by Tötterman et al. All infections were aggressively treated with intravenous antibiotics as well as by repetitive irrigation and debridement with daily repacking as needed until the wounds were clean and could be closed with vacuum drains. None of the patients succumbed to infection, and none of them sustained an intra-abdominal abscess. Another disadvantage of EPPP is the need for repetitive surgical procedures for bandage exchanges and repacking, typically after 24–48 h, and until the wounds are clean and can be closed.

As in any surgical procedure strict adherence to technique is mandatory, emphasis must be placed on correctly directing the packing deep down into the pelvis and onto the presacral vessels while avoiding pressure packing onto the more lateral and superficial femoral arteries so as to maintain blood flow to the lower extremities.

Ertel et al. reported that 30% of the patients that were treated with pelvic packing developed abdominal compartment syndrome. Fortunately, none of the patients developed this complication, since the EPPP procedure is extra-peritoneal and does not violate the abdominal compartment.

CONCLUSION

The implementation of EPPP as part of the initial resuscitative treatment of life-threatening hemodynamically unstable multi-trauma patients with unstable pelvic fractures in our trauma center led to excellent early survival rates. EPPP effectively stabilized all patients that were refractory to initial resuscitative measures, and eliminated the early mortality associated with massive pelvic bleeding. EPPP was shown to be effective as a stand-alone surgical procedure while abandoning the use of emergent angiographic arterial embolization or early external pelvic fixation. EPPP enables a unique advantage of directly compressing the life-threatening retroperitoneal bleeders by applying direct pressure and causing a tamponade effect, effectively staunching both venous and arterial pelvic blood flow.

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Conflicts of interest

There are no conflicts of interest.

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