Controlling hemorrhage in exsanguinating pelvic fractures: Utility of extraperitoneal pelvic packing as a damage control procedure

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ABSTRACT

Introduction: Exsanguinating pelvic fractures are still associated with a significant mortality rate of 28-60%. Extraperitoneal pelvic packing (EPP) has been proposed as an optimal method of early haemorrhage control. The aim of this study was to determine the effect of EPP compared with angioembolization as a primary intervention for patients with exsanguinating pelvic fracture.

Method: A prospective observational trial was performed at Westmead Hospital between September 2011 and May 2014. Adult patients with exsanguinating pelvic fracture were allocated into one of two treatment groups determined by the primary/initial haemorrhage control technique: 1. EPP followed by angioembolization or 2. Angioembolization alone. The intervention was determined by the on-call surgeon’s proficiency with EPP. Demographic, clinical and laboratory data were collected. Univariate analysis of the two groups was performed with Student’s t-test, Mann-Whitney-U test and Fisher’s exact test.

Results: 24 exsanguinating pelvic fracture cases were included. 14 underwent EPP while 10 underwent angioembolization as the primary intervention. Although not statistically significant, the EPP group was more severely injured (Injury Severity Score 32 vs. 23), more acidic (base deficit 7.9 vs. 6.2), and more hypotensive (Systolic Blood Pressure 74.2 vs. 84.3). Despite these differences, mortality was reduced (7.1% vs. 30%, not significant). Time to EPP compared with angioembolization was reduced (67.6 vs. 130.2 minutes, P = 0.017). Pre-angioembolization transfusion requirement was also reduced with EPP (0.032 vs. 0.052 units/min, P = 0.04). Arterial injury was found in 51% of the EPP group. There were no significant differences in complication rates between the groups.

Conclusion: EPP appears to be a safe and efficient technique for primary haemorrhage control in exsanguinating pelvic fractures. Given the high rate of associated arterial injury, EPP should be considered as the first part of a “damage control” approach for exsanguinating pelvic fractures.

Key Words: Damage control, pelvic fracture, shock

INTRODUCTION

Pelvic fractures occur in approximately 10% of blunt trauma patients.¹ 10% of pelvic fractures are associated with hemorrhagic shock.² It is in this small subset of patients, where mortality is high, ranging from 28% to 60%.[2-10] Deaths occur within 24 h from exsanguination, and after 24 h from multi-organ failure.[2-10] The likely...
cause of this late mortality is a direct result of the “bloody vicious cycle” associated with a delay to definitive hemorrhage control and associated massive blood product transfusion. Therefore, therapeutic interventions for patients exsanguinating from a pelvic fracture have been aimed at prompt hemorrhage control.

Anatomically, bleeding in the pelvis originates from three potential sources including the fractured cancellous bone surface, posterior pelvic venous plexus, and named branches of the internal iliac artery(ies). Irrespective of the source, pelvic bleeding associated with fractures, usually manifests as a retroperitoneal hematoma. Hemostatic techniques have included any combination of skeletal stabilization (both noninvasive and invasive), angioembolization (ANGIO) or packing. Although it is recognized that a combination of techniques is required to arrest significant pelvic bleeding, controversy exists over the correct sequence of interventions. Most contemporary algorithms for exsanguinating pelvic fracture management include early ANGIO, as this intervention been associated with improved survival. However, timely access to ANGIO is a significant problem. This is compounded by the apparent lack of resources out-of-hours, even in a Level I trauma center.

Extraperitoneal pelvic packing (EPP) is a technique that may be a valuable tool in the management of exsanguinating pelvic fractures. The main potential advantage with EPP is earlier hemorrhage control, by overcoming the delay in accessing ANGIO. It is likely to be a component of “damage control” for these severely injured patients.

At present, there is no prospective comparison between EPP and ANGIO as the primary intervention for patients with exsanguinating pelvic fracture. Therefore, the aim of this present study was to determine the utility of EPP in controlling hemorrhage from exsanguinating pelvic fractures.

**METHODS**

**Setting**
Westmead Hospital is the adult Major Trauma Centre for Western Sydney and the Western part of the state of New South Wales, Australia, and services a population of approximately 1.5 million people. Approximately, 1500 patients are admitted to the Trauma Service per year, of which 450 have an Injury Severity Score (ISS) of >12.

The study was approved by the Western Sydney Local Health District Ethics Committee.

**Study population**
All adult (age > 15 years) patients between September 2011 and May 2014 presenting with an exsanguinating pelvic fracture were included in this prospective cohort study. Exsanguinating pelvic fracture was defined as the presence of a pelvic fracture (as per Young and Burgess classification, i.e., lateral compression, anterior-posterior compression, or vertical shear) on pelvic X-ray and hemodynamic instability (sustained systolic blood pressure [SBP] < 90 mmHg and/or initial base deficit > 5).

Exclusion criteria included death before arrival, or death in resuscitation room before determination of primary intervention for the pelvic fracture. Included patients were treated with a standard protocol and allocation to the EPP group or ANGIO group determined by the on-call trauma surgeon’s proficiency with the EPP technique [Figure 1 for protocol and allocation method]. This pragmatic experimental design was required due to state restrictions on delayed consent, therefore impeding the ability to perform a randomized control trial in this severely injured cohort.

**Extraperitoneal pelvic packing and angioembolization technique**
EPP was performed as described by Pohlemann et al. For patients requiring concomitant laparotomy, the peritoneum was preserved below the umbilicus to facilitate packing into the extraperitoneal pelvic space. ANGIO was performed via a 5 French sheath inserted into the common femoral artery. Evidence of bleeding was defined as the presence of contrast extravasation, pseudoaneurysm, or acute vessel truncation. Embolization method (gelfoam or coils) was determined by the interventional radiologist performing the procedure.

**Statistical analysis**
Demographic, clinical, and injury-related variables were collected prospectively. All relevant variables were imported and/or entered into Microsoft Office Excel 2011 (Microsoft Corp., Redmond, WA, USA). Selected clinical variables included Emergency Department (ED) lowest SBP, highest pulse rate (PR), Glasgow Coma Score. SBP and PR post-intervention were also recorded. Laboratory variables included initial pH, base deficit, and hemoglobin. Injury variables included mechanism of injury and ISS. Outcome variables included time to primary intervention, pre-ANGIO packed red blood cell (PRBC) requirement, time to definitive orthopedic fixation, postoperative complications, Intensive Care Unit (ICU) length of stay (LOS), total hospital LOS and mortality.

All statistical analyses were performed using SPSS PASW version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous data are presented as means and standard deviation or medians and interquartile range (IQR, range from the 25th to the 75th percentile). Chi-square test or Fisher’s exact tests were used to compare proportions and to test for trends. The Student’s t-test and Mann–Whitney U-test was used to compare
RESULTS

Twenty-four patients were included during the study. All patients were severely injured, with exsanguinating pelvic fracture [Table 1]. Fourteen patients underwent EPP, and ten patients underwent ANGIO as the primary intervention. The EPP group was younger, more severely injured, and physiologically deranged than the ANGIO Group, although this was not significant [Table 2]. The ANGIO Group received significantly more ED RBC transfusion (6.6 ± 3.4 vs. 3.7 ± 3.2, P = 0.04). Time to primary procedure was significantly shorter in the EPP Group, as was the total time to ANGIO [Table 3]. The pre-ANGIO transfusion rate was also significantly less in the EPP Group [Table 3]. Although mortality was decreased, both ICU LOS and total hospital LOS were significantly increased in the EPP Group [Table 3].

In the EPP Group, a mean of 8 ± 4 packs was used. All patients undergoing EPP subsequently underwent angiography, with 8 out of the 14 patients requiring embolization of arterial bleeding. SBP was significantly unpaired groups of continuous data. Univariate analysis identified any significant differences. For all analyses, actual P values were reported and where possible, 95% confidence intervals presented. All tests were two-tailed. Differences were considered to be statistically significant at a P < 0.05 level.

Table 1: Exsanguinating pelvic fracture cohort

| Variable                        | EPP (n = 14) | ANGIO (n = 10) | Significance |
|---------------------------------|--------------|----------------|--------------|
| Age (years)                     | 54 ± 20      |                |              |
| Male (%)                        | 20 (83.3)    |                |              |
| Lateral compression fracture (%)| 3 (12.5)     |                |              |
| Anterior posterior compression fracture (%) | 11 (45.8)   |                |              |
| Vertical shear fracture (%)     | 10 (41.7)    |                |              |
| Lowest SBP in ED (mmHg)         | 78 ± 20      |                |              |
| Highest PR in ED (bpm)          | 112 ± 25     |                |              |
| Base deficit in ED              | 7.2 ± 5      |                |              |
| ICU LOS (days) (IQR)            | 6 (0–15)     |                |              |
| Hospital LOS (days) (IQR)       | 24.5 (11–86) |                |              |
| Injury severity score           | 28.5 ± 11.1  |                |              |
| Mortality (%)                   | 4 (16.7)     |                |              |

SBP = systolic blood pressure, ED = Emergency department, PR = Pulse rate, ICU = Intensive Care Unit, LOS = length of stay, IQR = Interquartile range

Table 2: Clinical features between extraperitoneal pelvic packing and angioembolization

| Variable                        | EPP (n = 14) | ANGIO (n = 10) | Significance |
|---------------------------------|--------------|----------------|--------------|
| Age (years)                     | 49.9 ± 17.5  | 60.3 ± 23.5    | NS           |
| Injury severity score           | 32.0 ± 6.7   | 23.8 ± 12.7    | NS           |
| Lowest SBP in ED (mmHg)         | 74.2 ± 22.3  | 84.3 ± 16.2    | NS           |
| Highest PR in ED (bpm)          | 119.9 ± 22.4 | 102.5 ± 26.8   | NS           |
| pH in ED                        | 7.19 ± 0.14  | 7.23 ± 0.16    | NS           |
| Base deficit in ED              | 7.9 ± 4.7    | 6.2 ± 6.3      | NS           |
| Lactate in ED (mmol/L)          | 5.2 ± 2.9    | 4.8 ± 4.3      | NS           |
| Laparotomy performed (%)        | 10 (71)      | 1 (10)         | P = 0.005    |

SBP = systolic blood pressure, ED = Emergency department, PR = Pulse rate, EPP = Extraperitoneal pelvic packing.
Table 3: Outcomes from extraperitoneal pelvic packing and angioembolization

|                          | EPP (n = 14)  | ANGIO (n = 10) | Significance |
|--------------------------|---------------|----------------|--------------|
| ICU LOS (days) (IQR)     | 11.5 (6–16)   | 0 (0)          | P = 0.002    |
| LOS (days) (IQR)         | 58 (26–165)   | 11 (6–21)      | P = 0.003    |
| Mortality (%)            | 1 (7.1)       | 3 (30)         | NS           |
| Time to primary procedure (min) | 67.6 ± 54.9  | 130.2 ± 63.2   | P = 0.017    |
| Time to ANGIO (min)      | 166.2 ± 104.4 | 130.2 ± 63.2   | NS           |
| Pre-ANGIO PRBC transfusion rate (units/min) | 0.032 ± 0.019 | 0.052 ± 0.026 | P = 0.04    |
| 24 h PRBC transfusion (units) | 12.6 ± 9.5   | 11.3 ± 2.3     | NS           |

ICU = Intensive Care Unit, LOS = length of stay, IQR = Interquartile range, EPP = Extraperitoneal pelvic packing

increased after EPP (74 mmHg vs. 83 mmHg, P = 0.03), with a corresponding decrease in PR (120 bpm vs. 111 bpm, P = 0.026). There were 3 wound complications associated with EPP (21%), but otherwise no significant difference in overall complications between EPP and ANGIO Groups.

The single death in the EPP Group occurred in a 59-year-old male pedestrian versus train. He had evidence of multicaudity bleeding and required a thoracotomy, laparotomy, and EPP; however, hemorrhage control was unable to be obtained, and he died in the operating room, without receiving ANGIO.

There were three deaths in the ANGIO Group. Two deaths in the ANGIO Group occurred in the Interventional Radiology suite. The time to ANGIO for these two cases was 80 min. One death was due to pelvic hemorrhage. The 2nd death in the Interventional Radiology suite was due to intraabdominal hemorrhage, i.e., pelvic hemorrhage was thought to be the main source of bleeding in the resuscitation room due to a reported negative FAST. The additional death in the ANGIO Group was an 80-year-old male pedestrian versus truck. Time to ANGIO was 100 min. He subsequently died in the ICU from multi-organ failure.

**DISCUSSION**

Exsanguinating pelvic fractures are an uncommon problem but are associated with a significant risk of death from hemorrhage. Multiple modalities of hemorrhage control must be utilized to ensure an optimal outcome.

ANGIO is the current choice of hemorrhage control in most pelvic fracture guidelines/algorithms. Although effective, delay to embolization has been shown to increase mortality.[22,24] In this study, time to ANGIO was almost twice as long as time to the operating room. The mortalities in the ANGIO Group can be directly attributed to pelvic hemorrhage or incorrect choice at the critical decision node of abdominal versus pelvic hemorrhage. It is important to recognize that operative management of the retroperitoneal pelvic hematoma has been controversial. Historically, opening the retroperitoneal hematoma in an attempt to control bleeding from the internal iliac arteries has resulted in catastrophic failure.[13,14,25-27] Packing from within the abdominal cavity was so ineffective, as to result in recommendations for massive transfusion as being the optimal management of exsanguinating pelvic fractures. A recent report from a Level I trauma center, revisiting bilateral internal iliac ligation for bleeding pelvic fractures, demonstrated a mortality rate of 64.3%. Therefore, the longstanding surgical dogma of “never opening a pelvic/retroperitoneal hematoma” seems to hold true.

EPP does not violate the retroperitoneum and applies hemostasis through direct pressure onto the sacral plexus of veins, as well as onto the iliac vessels. Time to operative intervention was significantly faster in this study and is consistent with reports by Tai et al.[29] and Osborn et al.[30] Although there is no difference in 24-h PRBC transfusion requirements between the groups, the transfusion rate was lower in the EPP Group before ANGIO, suggesting that bleeding had slowed after packing. This is also supported by the improvement in physiological signs after packing. 57% of the EPP Group demonstrated an arterial injury requiring embolization, supporting the statement that EPP is not a replacement for ANGIO. When considering the faster time to the operating room, EPP seems well placed as a damage control procedure, while angiographic resources are being mobilized. The findings in this study are consistent with those reported by Tötterman et al.[28] and Tai et al.[29] where time to the operating room was significantly shorter, and arterial injury found in >50% of case undergoing EPP.

Limitations of this study are mostly related to the relative small sample size. In addition, the overall mortality in this study is lower than previously reported (16.7% compared with >40%). This may reduce the ability to distinguish significant differences. The current study did not reach the target accrual to detect a 30% difference in mortality between groups. The incidence of severe pelvic injury was low (ten patients per year), and therefore an additional 3 years of enrollment would be required. Institutional change in clinical management occurred after this analysis when it was concluded that there was sufficient evidence to perform EPP primarily as a bridge to ANGIO. Although enrolled prospectively, potential bias exists with the treating surgeon. It is not known if the trauma surgeons were more comfortable...
with using ANGIO for those patients perceived as less severely injured. This bias may explain the difference in baseline groups. Furthermore, the time of day may have influenced the therapeutic decision, as consultant surgeons are off-site after hours.

The final limitation of this study is that EPP has not been proven to be more effective than ANGIO at controlling hemorrhage. The data would not support replacing ANGIO with pelvic packing. The procedure could be interpreted as a method of avoiding a system issue, namely, the inefficient access to ANGIO services at all hours.

CONCLUSIONS

EPP has been demonstrated to be a valid technique with improvement in time to definitive hemorrhage control. Mortality might be improved in the EPP Group, despite the EPP Group appearing to be more significantly injured than the ANGIO Group.

Therefore, EPP should be considered a part of all general surgical/orthopedic surgeons skillset in the management of exsanguinating pelvic fracture, but as damage control component. This may have relevance to the rural/regional setting, where efficient access to ANGIO services is not readily available.

Although this study was unable to reveal a statistically significant difference in mortality when comparing EPP to ANGIO, it forms the basis for further investigation in a multicenter, prospective randomized trial.

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Conflicts of interest
There are no conflicts of interest.

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