

# The role of interventional angiography and embolisation in the management of high-energy pelvic ring injuries with uncontrolled haemorrhage

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## Abstract

**Background:** The availability of and advances in interventional angiography and embolisation for the management of high-energy pelvic ring injuries with uncontrolled haemorrhage have expanded considerably during the last decade. Its routine use, however, still remains controversial. The delay in performing angiography is often cited as a major limitation for this intervention.

**Purpose of the study:** We aim to determine the mean time to interventional angiography and embolisation and report on the success rate thereof in patients with pelvic ring injuries and associated haemorrhage in a Level 1 Trauma Unit.

**Methodology:** Between 1997 and 2012, we identified a total of seven patients who were managed with interventional angiography for the treatment of pelvic ring injuries associated with massive haemorrhage that did not respond to fluids and blood products resuscitation alone. Data was collected retrospectively, with respect to the injury pattern, resuscitative parameters, survival rates and efficacy of the angiography.

**Results:** All seven patients presented with high energy injuries and had rotationally as well as vertically unstable pelvic fractures. The average systolic blood pressure on admission was 80 mmHg (range 60–140). On average 8.75 (range 2–21) units of packed red blood cells were transfused per patient. Three patients required a laparotomy for associated intra-abdominal injuries. The time from admission to an emergency laparotomy was 4.5 h (range 2–12). The time from admission to angiography was 14 h (range 4–24). Three of the seven patients had a successful pelvic angio-embolisation. Six patients survived until discharge and one patient demised due to multi-organ failure on day 14 after embolisation.

**Discussion:** Only seven patients with pelvic ring injuries were managed with angiography and embolisation in a period of 15 years, suggesting that we seldom use this modality for haemorrhage control. The delay from admission to angiography was 14 hours (range 4–24). An arterial bleed was successfully identified and embolised in three patients (43%).

**Conclusion:** While it is used with greater frequency in other centres, in our hospital setting angiography in the management of haemorrhage in pelvic ring injuries is rarely used. Our success rate with this intervention is fair.

**Key words:** pelvis fracture, unstable, resuscitation, angiography, embolisation.

## Introduction

Patients who are haemodynamically unstable as a result of the presence of a pelvis fracture have a mortality rate of 40–60%, with haemorrhage being the leading cause of death.<sup>1,2</sup> In patients who present *in extremis* the mortality rate is even higher.<sup>3</sup> The routine use of angiography and embolisation in the resuscitation of this patient group remains controversial. The initial management involves the application of a circumferential pelvic binder to effect tamponade within the pelvis and offer stability to the pelvic ring. Various intervention modalities have been advocated for the initial treatment of these injuries including external fixation, C-clamp stabilisation, extraperitoneal pelvic packing and angiography plus embolisation.<sup>4</sup> Angio-embolisation is directed at arterial bleeding, usually from branches of the internal iliac artery. This source of bleeding was identified as the cause of bleeding in 85% of patients who had died from a pelvis fracture in an autopsy study by Huittinen.<sup>5</sup> Clear indications for angio-embolisation and patient selection criteria remain unclear, especially when compared to direct extraperitoneal pelvic packing.<sup>1</sup> Acceptable advantages of angio-embolisation are that it is selective as it is directed at the identified bleeding vessel and therefore has less access morbidity. Multiple active bleeders can also be targeted with this technique. The disadvantages are that it is not widely available and requires the presence of an experienced interventional radiologist to perform the procedure, who is often not immediately available. It also necessitates transfer of a potentially unstable patient away from the resuscitation bay to the angiography suite. Anandakumar *et al.* overcome this by performing angiography in the operating theatre with an anaesthetist present in case the patient deteriorates and requires a laparotomy.<sup>6</sup> Complications related to angiography and embolisation include ulceration at the entry point, skin necrosis, perineal or buttock paraparesis and thigh claudication.<sup>7</sup>

Extraperitoneal pelvic packing is more widely available and is technically easier, but it is associated with a higher risk of infection as well as associated access morbidity.<sup>7</sup> It also necessitates a second surgical procedure to remove the packs.

With this study, we aim to report on our own experience with and to determine the mean time to interventional angiography and embolisation, and the success rate thereof in patients with pelvic ring injuries and associated haemorrhage in a Level 1 Trauma Unit.

## Methods

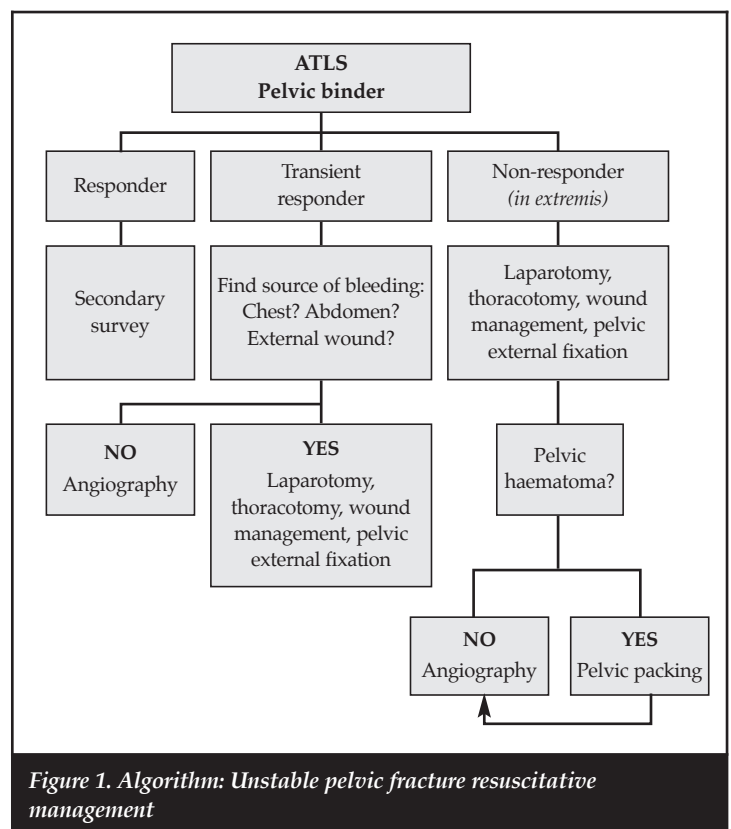
We retrospectively reviewed our trauma unit database for clinical and radiological data of all patients who presented with a pelvis fracture between 1997 and 2012. Out of this group we identified seven patients who underwent angiography for a pelvis fracture-associated haemorrhage.

The indications for this procedure was extensive bleeding that could not be controlled after the pelvis was stabilised in a circumferential binder; extrapelvic haemorrhage was adequately managed; and the patients were receiving ongoing fluid resuscitation. All data was scrutinised for patient demographics, mechanism of injury, fracture pattern, various resuscitative parameters, survival rates, time to angio-embolisation, as well as efficacy of the embolisation procedure. Patients admitted to our facility were managed according to a standardised institutional algorithm (*Figure 1*).

Ethics clearance was obtained from our institution's ethics committee.

## Results

During the study period seven patients with a mean age of 29 years (range 17–52) were identified as having undergone angiography after sustaining high-energy injuries with a consequent unstable pelvic injury. The average systolic blood pressure on admission was 80 mmHg (range 60–140). On average 8.75 (range 2–21) units of packed red cells were transfused per patient. Three of the patients required an explorative laparotomy for associated intra-abdominal injuries. The laparotomy was performed before angiography in all three cases. The median time from admission to emergency laparotomy was 4.5 hours (range 2–12). The median time from admission to angiography was 14 hours (range 4–24).



**Figure 1. Algorithm: Unstable pelvic fracture resuscitative management**

Angiography and embolisation were performed in a dedicated angiography suite by qualified interventional radiologists. Of the seven patients who underwent angiography, three had a successful embolisation of a bleeding pelvic arterial lesion. We defined embolisation success as the absence of contrast leak after coiling of the bleeding vessel. In the remaining patients, no active pelvic arterial bleeding was identified and embolisation was not performed. Of the seven patients who underwent angiographic embolisation, six survived until discharge and one demised on day 14 from multi-organ failure.

## Discussion

Three pelvic causes of haemorrhage (arterial, venous and osseous) and three remote sources (abdomen, chest and long bone fractures) may contribute to haemorrhage in pelvic ring disruption.<sup>8</sup> The major blood vessels which lie on the inner wall of the pelvis are the common iliac arteries, dividing into external and internal iliac arteries. The internal iliac artery lies over the pelvic brim and its branches are the most commonly affected artery in pelvic ring injuries.<sup>9</sup> Most bleeding from venous injuries arises from small- and medium-sized torn veins and usually ceases naturally.<sup>1</sup>

Various classification systems exist to describe pelvic fractures. In this study the AO/OTA and Young and Burgess classification system of pelvic fractures were both used, as they closely correlate with resuscitation needs, patterns of associated injuries and mortality.<sup>10</sup> Death due to massive pelvic haemorrhage is most commonly associated with high grade antero-posterior-compression (APC) injuries as branches of the internal iliac vessels are in close juxtaposition with the disrupted anterior sacroiliac joint.<sup>11</sup>

Lateral compression (LC) injury results from a lateral impact to the pelvis, rotating the affected hemipelvis away from the side of the impact towards the midline. The internal iliac vessels are shortened in Grade I and Grade II LC injuries but can be subjected to tensile forces in Grade III LC injuries when a 'windshield wiper mechanism' causes an opening of the iliosacral joint of the contralateral hemipelvis.<sup>12</sup> In this group, head injuries have been reported to be the most common cause of death.<sup>13</sup> Vertical shear (VS) injuries are distinguished by vertical translation of the affected hemipelvis. Displacement of the hemipelvis may be accompanied by severe local vascular injury. The combined mechanism (CM) injury pattern includes high-energy pelvic fractures as a result of a combination of two separate force vectors.<sup>14</sup> In a series of 210 consecutive patients by Burgess *et al.* the overall mortality rate was 8 per cent.<sup>12</sup> A higher mortality rate was seen in the APC (20%) and CM (18%) patterns than in the LC (7%) and VS (30%) patterns.<sup>15</sup> It is interesting to note that we used angiographic embolisation in only high grade displacements as in our cohort of patients, four (57%) had a APC III injury pattern and three (43%) had a LC III injury pattern (Table I).

**Table I: Mechanism of injury and pelvic fracture pattern according to Young and Burgess<sup>12</sup> in the study group**

Mechanism of injury	Fracture pattern
MVA pedestrian	LC III
MVA driver	LC III
MVA driver	LC III
MVA pedestrian	APC III
MVA pedestrian	APC III
MVA pedestrian	APC III
Train accident	APC III

MVA=motor vehicle accident; LC=lateral compression;  
APC=anteroposterior compression

Pelvic binders, external skeletal fixation, immediate open reduction and internal fixation and angiographic embolisation have all been used with variable success in controlling blood loss either alone or in combination.<sup>16</sup> Pelvic angiographic embolisation is applicable only in a minority of pelvic disruptions and only when the source of bleeding is from a small- or medium-sized artery.<sup>1</sup> Angiography and embolisation are not effective in controlling bleeding from venous injuries and bony sites, yet venous bleeding is the source of haemorrhage in 90% of high energy pelvic fractures.<sup>2</sup>

The question of whether angio-embolisation should be performed before or after a laparotomy is the subject of ongoing debate. According to Hak *et al.* angio-embolisation should only be considered in patients with continued blood loss despite pelvic fracture stabilisation and aggressive fluid management.<sup>2</sup> In previous studies the overall prevalence of patients with pelvic fractures who require embolisation is reported to be less than 10 per cent.<sup>2</sup> A delay to angiography is one of the main factors influencing the outcome in these studies as an embolisation within 1–3 hours of arrival resulted in a significantly greater survival rate.<sup>17,18,19</sup> Successful embolisation rates for arterial injuries have been reported to be 85–100%.<sup>1</sup> In our study the delay from admission to angio-embolisation was considerably longer with a mean of 14 hours (range 4–24). Additionally, the success rate of identifying an arterial bleeder and safely embolising it in our hospital was fair and comparable to available literature. Of the seven patients who underwent angiography, three (42%) had a successful embolisation of a bleeding pelvic arterial lesion. In the other four patients, no arterial bleed was identified. The transfusion requirements in our study averaged 9.8 units of red packed cells (RPC) and is lower than in most other studies to date (Table II).

However, even with aggressive resuscitation, mechanical stabilisation and successful embolisation, mortality remains high and is reported to reach up to 55% (Table II).

Table II: Comparison of various study results including successful embolisation

Study	N	Time to embolisation (h)	Transfusion before embolisation (units)	Mortality (%)	Time to laparotomy (h)
Our study	7	14 (3–36)	9.8	14 (1/7)	4 (0.5–12)
Chafour <i>et al.</i> <sup>16</sup>	9	17.8	13.9	11.1	
Grabewogger <i>et al.</i> <sup>20</sup>	6	–	24	50	
Holting <i>et al.</i> <sup>21</sup>	20	13.5	28	55	
Piotin <i>et al.</i> <sup>8</sup>	6	44	11.3	0	
Perez <i>et al.</i> <sup>13</sup>	8	5.7	10.6	25	
Hamill <i>et al.</i> <sup>22</sup>	20	5	2.8	45	
Cook <i>et al.</i> <sup>23</sup>	23	3.7	–	43	
Conclusion	92	10.6	18.3	39.1	

This number varies markedly when comparing previous studies (between 0% and 55%) as it is greatly influenced by the selection criteria for angio-embolisation.<sup>19</sup> In our algorithm (Figure 1), transient responders are selected for angio-embolisation once other sources of bleeding have been excluded. Furthermore, non-responders who presented *in extremis* are chosen to undergo angio-embolisation after the application of an external fixator and pelvic packing have been performed and ongoing bleeding from the pelvis is evident from the presence of a pelvis haematoma. With these indications for embolisation the mortality rate was 14% (one of seven patients).

Our algorithm differs to that of Metsemakers in that application of an external fixator does not form a primary part of our resuscitative intervention.<sup>4</sup> High-energy pelvis injuries with haemodynamic instability are known to be rare injuries and our study is in keeping with this trend. Anandakumar *et al.* identified 11 patients over a 5-year period who underwent angio-embolisation and their selection criteria are more liberal than ours.<sup>6</sup>

The retrospective nature of our series and the low patient numbers reflect limitations of our study.

## Conclusion

In our hospital setting, angiography in the management of haemorrhage associated with pelvic ring injuries is seldom used as there is a prolonged time delay to the procedure being performed. The average time to angio-embolisation was 14 h and this delay discourages its use before laparotomy in patients who are *in extremis*. It does play a role in patients who have ongoing surgical bleeding despite skeletal stabilisation and adequate fluid resuscitation.

Conclusive recommendations are difficult to draw due to the paucity of high level evidence studies addressing these injuries. Each unit should have a treatment algorithm that takes into account available local resources.

## Compliance with Ethics Guidelines

All authors confirm that no benefits of any form have been received from a commercial party related directly or indirectly to the subject of this article.

Ethics clearance was obtained from our institution's ethics committee.

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