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Journal of Acute Disease
journal homepage: www.jadweb.org

Original article http://dx.doi.org/10.1016/j.joad.2015.11.004

Research on relation of mortality and hemodynamics in patients with an acute pelvic ring fracture

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ARTICLE INFO

Article history:
Received 26 Feb 2015
Received in revised form 21 Sep 2015
Accepted 5 Nov 2015
Available online 8 Jan 2016

Keywords:
Pelvic fracture
Mortality
Hemorrhage
Treatment

ABSTRACT

Objective: To study the treatment pathway of hemodynamic unstable patients with a pelvic ring fracture and analyze the causes of death in this group.
Methods: Retrospectively, all data of hemodynamic unstable patients with a pelvic ring fracture in the period 1 January 2003 till 1 June 2010 were analyzed. For all patients the treatment protocol was assessed and compared with our protocol.
Results: The data of 268 patients were analyzed. Among them, 89 cases presented as hemodynamic unstable. A total of 22/89 patients died (25%). Seven patients died because of an isolated circulatory problem, 1 of an isolated neurotrauma. Fourteen patients died because of a combination of vital injuries, in which 11 sustained extensive hemorrhage. Hemorrhage contributed to mortality in 18/22 patients (82%). In 12 of the 22 patients who died, the treatment protocol was not followed. This was significantly higher than in the group survivors ($P < 0.01$).
Conclusions: Mortality in patients with a pelvic fracture is most often caused by hemorrhage or sequelae from hemorrhage. A standardized treatment protocol reduces mortality.

1. Introduction

Injury to the bony pelvis with disruption of the pelvic ring represents a serious clinical problem. In the majority of cases the cause is a high-energy motor vehicle accident; other typical traumas are a fall from height or local compression by high forces[1]. Because of the massive energy transfer involved in such trauma, many patients sustain multiple injuries. Mechanical instability of the pelvic ring occurs in 13%–17% of all fractures[2]. A complication frequently seen in this type of injury is life-threatening hemorrhage with an overall reported mortality rate of 5%–50%[3,4].

Exsanguination is a leading cause of early and late mortality in this patient group. Anatomically external blood loss, chest, abdominal, pelvic and extremity injury or a combination of those contribute to the hypovolemic shock. Mortality exclusively due to pelvic hemorrhage is rarely seen and occurs usually do so within the first 24 h of injury. Late deaths are caused by multisystem organ failure and sepsis[5]. Rapid diagnostic work-up and efficient treatment of pelvic hemorrhage is critical for patient survival[6].

Pelvic bleeding can originate from the fracture surfaces, or from involved arteries or veins. Notorious is the presacral venous plexus, which can cause massive blood loss if ruptured. Venous and fracture bleeding sites constitute 85% of all cases[7]. Early stabilization of the fracture is important to stop venous bleeding or bleeding from fracture surfaces[8]. This can be combined with peripelvic packing during open stabilization of the pelvis. Arterial bleeding, accounting for 15% of all cases, can be treated using ligation, packing, or angiography and selective embolization[5].

Fortunately, mortality associated with a pelvic fracture has steadily decreased in most series over the last 20 years with the introduction of a multidisciplinary team approach and improved protocols such as damage control orthopedics.

In this study we reviewed the medical care given to patients with an unstable pelvic ring fracture, presenting with hemorrhagic shock, and analyzed the causes of death and effects of our clinical pathway.

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Peer review under responsibility of Hainan Medical College.

2. Materials and methods

The data of adult patients (aged 15 years or older) who arrived alive at the Emergency Department of the Radboud University Medical Center in the period 1 January 2003 to 1 June 2010 were analyzed. Only patients with a partially or complete unstable pelvic ring fracture (Tile type B or C) and signs of hemodynamic instability (shock class 2, 3 or 4 according to ATLS®[9]) were included. Excluded were patients who were initially treated in another hospital and referred to the Radboud University Medical Center for definitive pelvic fracture treatment. Furthermore, patients who died later than one month after initial trauma were excluded because the cause of death was considered not to be related to the primary injury of the pelvis itself.

The following data were collected of each patient: gender, age, mechanism of injury, pulse rate, blood pressure, revised trauma score (RTS)[10], abbreviated injury scale (AIS)[11] for each body area, injury severity score (ISS)[12], tile classification[13], concomitant injuries, acute treatment given, cause and time of death. If available, autopsy data were included as well. Autopsy in trauma related mortality is not mandatory by law in the Netherlands. The data were collected from medical registration systems of our hospital.

Death was classified as related directly to the pelvic fracture if the patient required massive transfusions, died within the first 24 h of admission and had no other body area injury with AIS $\geq$ 4 responsible for persistent hemorrhagic shock.

For all patients the clinical pathway was assessed. Specific attention was paid to differences related to the decision between acute surgery (damage control) versus diagnostic work-up with CT-scan as well as procedures related to acute stabilization of the pelvic ring and packing.

A patient was considered to have followed the standardized treatment protocol (Figure 1) in the following cases:

Emergency Room (ER): Hypovolemic shock and receiving IV fluid therapy and/or transfusion in the primary survey;

ER: Primary adjuncts X thorax, X-pelvis, FAST completed;

ER: Stabilization by pelvic sling or C-clamp device in class 3 of 4 shock;

Operation Room (OR): Damage control surgery (DCS) in class 3 or 4 shock; non- or poor responders;

CT-scan: Including spine, thorax, abdomen and pelvis. Selective embolization on indication in shock class 2 or class 3/4 responders.

3. Results

In total, the data of 268 patients with pelvic ring fractures were reviewed. We encountered 63 Tile type A fracture (23%), 79 type B fractures (30%) and 126 type C fractures (47.0%).

In our Emergency Department 31/79 patients with a type B fracture and 58/126 with a type C injury presented with signs of hypovolemic shock were included in our analysis. Of these 89 patients 55 were male. The mean age was 42 years (range 17–85) with a mean ISS of 31 (range 4–66). A total of 22/89 patients died (25%) within 30 days post injury.

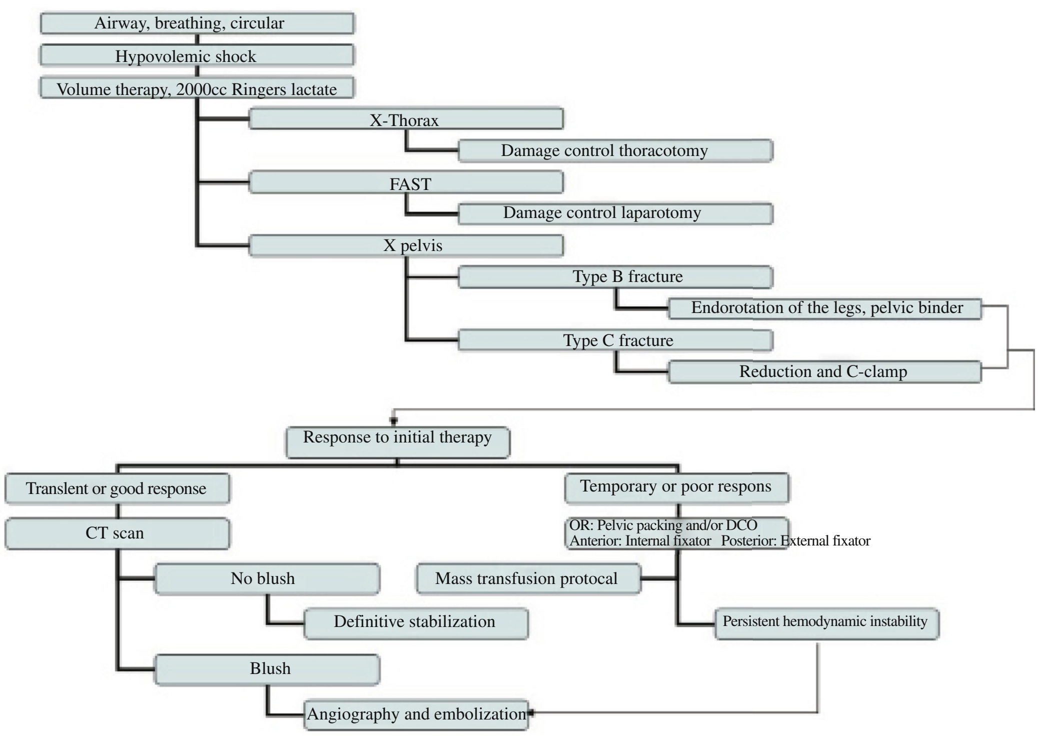

Figure 1. Treatment pathway, adapted from Van Vugt *et al.*[2].

Patient and fracture specifics are listed in Table 1. Non-survivors were significantly older ($P < 0.05$), had a higher ISS ($P < 0.01$) and showed a higher shock classification ($P < 0.01$) and lower RTS on admission ($P < 0.01$).

Table 1

Patient and fracture specifics.

		Survivors (n = 67)	Non-survivors (n = 22)	P value
Cause of injury	NS			
	Motor vehicle accident	44(66%)	12(55%)	
	FFH	14(21%)	7(32%)	
	Crush	9(13%)	3(13%)	
Age (mean)		36	50	$P < 0.05$
Male		43(64%)	12(55%)	NS
RTS	12	39(58%)	6(27%)	$P < 0.01$
	9–11	23(34%)	7(32%)	
	8	5(8%)	9(41%)	
ISS (mean)		36	50	$P < 0.01$
Shock classification	II	45(67%)	8(36%)	$P < 0.01$
	III/IV	22(33%)	14(64%)	
Type of fracture	AP compression	22(33%)	7(32%)	NS
	Lat compression	5(4%)	3(14%)	
	Vertical shear	21(30%)	8(36%)	
	Complex type	19 (27%)	4(18%)	
	Compound fracture	9(13%)	1(5%)	NS

3.1. Acute therapy pre-hospitally and in the shockroom

Table 2 lists the shock classification. All patients received IV fluids in the primary survey. Eighteen non-survivors (82%) and 32 survivors (48%) needed transfusion with packed red blood cells (PRBCs) ($P < 0.01$).

Table 2

Shock class in relation with fracture type.

Shock class	Survivors type B fracture	Non-survivors type B fracture	Survivors type C fracture	Non-survivors type C fracture	Total
II	17	3	28	5	53
III	5	1	14	6	26
IV	2	3	1	4	10
Total	24	7	43	15	89
Mortality		23%		26%	25%

Patient with a class IV shock all received PRBCs as well as the transient or non-responders in shock class III.

All patients had a chest X-ray, pelvic X-ray and an abdominal ultrasound within 15 min after arrival.

Acute stabilization of the pelvic ring in the ER was carried out 48 times. A pelvic binding device was used in 37 cases, a C-clamp device in 11 patients. The use of acute stabilization related to the initial shock classification and fracture classification is demonstrated in Table 3.

Table 3

Pre-hospital treatment and shock class.

	Shock	Open book B1		Vertical shear C	
		Survivors	†	Survivors	†
Pelvic binder	II	5	2	13	2
	III	3	0	6	2
	IV	0	0	1	2
Total		8	2	20	6
C-clamp	II	0	0	1	1
	III	0	0	6	1
	IV	0	0	0	2
Total		0	0	7	4
Total (PB and C-clamp)		8	2	27	10
					12/47 = 26%
No ER Fix	II	12	1	15	3
	III	2	1	8	4
	IV	2	3	0	2
Total		16	5	23	9
					14/53 = 26%

Twenty-two patients were not treated according to our protocol because they received no form of pelvic binder or C-clamp and had a class 3–4 shock; 10/22 of this group of patients died. Of 23 patients who received a binder according to protocol, 7 died ($P = 0.30$).

3.2. Routing and treatment

3.2.1. Non-survivors (n = 22)

Table 4 lists the routing of all patients. Five patients died in the ER. A shock class III/IV non responders was seen without exception. All patients received transfusion with PRBCs. Three patients had an unstable pelvic fracture; only in 1 patient with a type C fracture a pelvic binder was applied. In 2 patients an emergency thoracotomy was performed on the ER with fatal outcome.

Table 4

Routing patients and shock class.

Shock class	Survivors (n = 67)	Non-survivors (n = 22)	
		Number	Percentage
Died in ER	0	5	5/5 (100%)
II		0	
III/IV		5	
OR	11	7	7/18 (39%)
II	4	0	
III/IV	7	7	
CT–OR	43	8	8/51 (16%)
II	29	6	
III/IV	14	2	
CT-ICU	13	2	2/15 (13%)
II	12	2	
III/IV	1	0	

Ten patients underwent a CT-scan after primary survey; 2 patients sustained a shock class of III/IV and were therefore not treated according to our protocol which dictated acute surgery. Of these 10 patients, 8 were brought up directly to the OR for operative treatment. Two patients were transferred tot the ICU for further treatment.

Seven patients were transferred directly to the operating room (OR) for DCS for a diversity of injuries. Their shock class was III/IV nonresponding, unanimously. Two patients remained hemodynamic unstable after DCS. They were transferred to the angiosuite, according to protocol.

Of the 17 patients that were treated operatively, a damage control laparotomy was performed in 10 patients. Those patients had significant intraabdominal bleeding demonstrated on FAST and/or CT. In two patients no fixation of the pelvis could be applied, because of fatal outcome due to uncontrollable intraabdominal bleeding. In 4 patients the C-clamp which was already placed on the ER was left in place and only a laparotomy was performed. In 4 patients the laparotomy was combined with operative stabilization of the pelvic fracture and peripelvic packing. All had plate fixation of the ruptured symphysis.

In five patients acute stabilization of the pelvic ring was carried out as only procedure. An anterior external fixator was applied twice. One patient had plate fixation of the ruptured symphysis. In two patients definitive stabilization was carried out by the means of symphyseal plating and percutaneous sacroiliac screws (early total care). Both procedures were carried out within 95 min. These patients sustained a shock class II. Both patients died on the ICU within 2 weeks of severe inflammatory response syndrome.

The two remaining patients that underwent acute surgery had external fixation of femoral fractures and an endovascular device were placed for a traumatic rupture of the aorta. Fixation for the diagnosed type B2 fracture of the pelvis was not required. Reviewing the treatment protocol, only 2 patients were not treated according to our protocol.

3.2.2. Survivors (n = 67)

In 56 patients a CT scan was performed. Thirteen out of 56 patients were brought to the ICU after CT. Six of them were treated with open reduction and internal fixation of the pelvic fracture within one week; 7 patients were treated non-operatively for the pelvic fracture, mainly due to neurological problems.

Forty-three out of 56 patients were treated operatively after CT. Twenty-two patients underwent laparotomy, of which in 9 patients this was the only performed procedure in the acute phase. In 3 patients, a peripelvic packing was done.

In 34 patients the pelvic fracture was stabilized. In 2 patients with a shock class III/IV an external fixator was placed. The remaining patients all had open reduction and internal fixation and 16/32 patients were treated with plate fixation of the anterior ring combined with SI-screws.

Eleven patients were directly transferred to the OR for DCS; shock classification was II in 4/11 patients. Therefore these patients were not treated according to protocol. In 3 of these patients, urgent surgery was performed because of the need of fracture stabilization of compound fractures to the lower extremity. In 1 patient a laparotomy was performed due to evisceration of the small bowel.

3.2.3. Causes of death (n = 22)

Eleven patients died within 24 h, and the other 11 patients died 2–30 days after the initial trauma.

According to ATLS®-principles classification of (potential) lethal injuries was made in airway, breathing, circulation and disability (Table 4). Autopsy was not performed in any or our patients.

We lost no patients solely due to an airway or breathing problem. Circulation was the death cause in 7 patients (32%) who died due to exsanguination. Disability resulted in one fatal case (5%) which was related to an isolated major head trauma.

In the remaining 14 patients (63%) there was a combination of fatal factors. Four patients died due to a combination of breathing and circulation problems, a combination of circulation and disability problems was seen 6 times. One patient died due to a combination of breathing, circulation and disability injuries. The remaining 3 patients died because of a combined breathing and disability problem without signs of shock.

In conclusion, hemorrhagic shock (circulation) contributed to mortality in 18 out of 22 patients (82%). In 8 of these 22 cases the unstable pelvic ring fracture contributed to the fatal outcome due to hypovolemic shock.

In the 7 patients who died due to exsanguination as a single cause, all had massive hemorrhage in the pelvis combined with other major bleeding sources (AIS 4) in chest (4 cases), abdomen (5 cases) or extremities (6 cases). Only one patient, who sustained a pelvic crush injury type Tile B, the pelvic fracture, was the only bleeding source. The symphyseolysis was fixated with a symphyseal plate. Also the lesser pelvis was packed with gauzes. After initial stabilization, the patient rapidly detoriated and died while going to the operating theater for a second look. Fatal outcome occurred within the first 24 h after admission. Therefore, this patient's death was classified directly related to the pelvic fracture.

3.3. Mortality in relation with the treatment protocol

In 12/22 (55%) patients that died, the treatment pathway was not followed according to our protocol. This was mainly due to the lack of use of a pelvic binding device on the ER. In 11/67 (16%) survivors the treatment given was not according to our protocol. This was a significant difference between the two groups ($P < 0.01$).

4. Discussion

Hemorrhage causing hypovolemic shock remains the key complication in pelvic ring injuries. In our study, hemorrhagic shock is the leading cause of deaths (82%). Therefore, rapid detection and treatment is essential. Treatment of hemorrhagic shock and prevention of further deterioration should start in the field by applying a pelvic binding device next to IV fluid substitution[14–17]. Some authors promote prophylactic use of a pelvic binder even if a pelvic fracture is not clinically evident[18,19]. Similar to posterior injuries of the pelvic ring, a C-clamp, which can be applied in the ER, has proven to be effective in reducing excessive blood loss[20–22].

In this study, a pelvic binder was used in 54% of patients. Despite the absence of level I and II evidence for the clinical effectiveness of pelvic binding devices, papers so far report that pelvic binding devices are effective in reducing fractures and associated hemorrhage[23].

The exact treatment pathway of hemodynamic unstable patients with an unstable pelvic ring fracture remains controversial and is often dictated by hospital facilities. Some authors promote embolization before surgical therapy[24,25]. Arguments supporting this strategy are the frequent concomitant injuries to liver and spleen (which can be treated with selective embolization as well), the easy access to the femoral artery, even if a pelvic binder is in place, and the presence of a false aneurysm or a total transection of a vessel on CT-angiography (which is a risk factor for late onset or new hemorrhage)[26]. Arguments against this strategy are the length of the procedure, inhibition of simultaneous treatment of other injuries and the availability of an experienced intervention radiologist[27,28]. Also, bleeding injuries coming from other than liver, spleen or kidney are not addressed.

In our hospital, fixation before embolization is preferred as seen in our treatment algorithm. Mortality of hemodynamic unstable patients with an unstable pelvic ring fracture is reported as high as 40%[29]. In our study, we observed a mortality rate of 25%.

Early total care in a hemodynamic unstable patient is often not the method of choice[5,8,30]. Complete open stabilization of the pelvic ring is time-consuming and enhances the chance of post-operative complications such as severe inflammatory response syndrome[31,32]. However, stabilization of the anterior ring with symphyseal plating is a relatively easy, fast procedure[33]. In specific patients, with good response to volume therapy, early definitive stabilization of the pelvic ring with *i.e.*, SI screws, can be performed in a relatively short time if the surgeon is familiar with this technique[34,35]. To ensure good outcome continuous evaluation of the patient's condition by the surgeon and anesthesiologist is necessary. In our study, in 23 patients the entire pelvic ring was stabilized. Two patients died on the ICU after several days. It is questionable if these deaths could have been prevented when only DCO had been performed.

In 4 out of 22 (18%) patients who died, the routing was not according to the treatment protocol. Both patients with a class III shock died directly after the CT-scan. Both patients seemed to be good responders on IV fluid therapy, but collapsed during the CT scan. Resuscitation in the ER was not successful; 1 patient had an emergency laparotomy in the ER. It is uncertain if these patients would have survived if immediately DCS had been performed. The 2 other patients were treated with definitive stabilization and were discussed earlier.

Exsanguination entirely due to an unstable pelvic ring fracture is uncommon. In the literature the incidence of this condition varies between 0.8% and 1.4%[36]. In our study only one patient died of exsanguination from an isolated pelvic ring fracture.

This retrospective study shows that although the mortality of pelvic ring fractures as an isolated injury is low, the combination with other major injuries, leads to a high mortality. Death is most often caused by hemorrhage or sequelae from hemorrhage. Since pelvic fractures are a major bleeding source, these injuries contribute considerably in hemorrhage as a cause of death. Definitive fracture stabilization, when performed by an experienced surgeon, is possible in selected patients.

Also we believe that a treatment algorithm for this complex type of injury reduces mortality.

The weakness of our study is its retrospective set-up and the great heterogeneity of our patient group resulting in the wide variety of injuries all patients suffered. However, most studies regarding pelvic fractures have great heterogeneity in the patient population because most patients with pelvic fractures are polytraumatized. Further studies which address optimal treatment strategies in a prospective way are in progress.

Conflict of interest statement

The authors report no conflict of interest.

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