Therapeutical Strategies and Outcome of Polytraumatized Patients with Pelvic Injuries

A Six-Year Experience

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Abstract

The combination of multiple injuries and pelvic ring disruption often represents a devastating injury pattern. This study evaluates therapeutical strategies and the outcome of 174 severely traumatized patients with pelvic ring injury (ISS: 32.1 ± 11.1 patients) over a 6-year period. Patients were divided into 3 groups according to their hemodynamic status at admission. Forty-one patients in extremis (group A; ISS: 40.1 ± 11.1 patients) which required the highest resuscitation efforts revealed a mortality rate of 90%. Many of these patients underwent crash laparotomy (44%)/thoracotomy (22%), aortic clamping (22%), and pelvic packing (44%). Patients with persistent hemodynamic instability (group B; n = 39; ISS: 34.2 ± 9.6 patients) had a mortality rate of 26% ($p < 0.05$ versus group A) with 14 patients (36%) undergoing emergency laparotomy. Mortality rate (5%) markedly ($p < 0.05$) decreased in patients with stable hemodynamics despite a relatively high ISS (group C; n = 94; ISS: 27.6 ± 9.4 patients). Hemorrhage could be controlled in all patients of group B and C, while 23 out of 41 patients (56%) in extremis died due to exsanguination during the first 24 hours after injury. Thus, treatment of patients in extremis must be focused on aggressive resuscitation and surgical intervention without extensive diagnostic procedures to effectively control lethal hemorrhage.

Key Words
Multiple injury · Pelvic injury · Hemorrhage

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Introduction

Multiple injuries in combination with severe pelvic ring disruption represent a serious life-threatening trauma pattern. Though isolated pelvic injury exhibits a mortality rate between 8% and 50% dependent on the type of pelvic disruption [1–3], associated injuries further aggravate the outcome of these patients. While infection and multiple organ dysfunction syndrome (MODS) are the major complications during the late posttraumatic course, exsanguinating hemorrhage represents the predominant lethal factor during the first 24 hours [4–13].

Most treatment concepts previously reported [14–18] have focused on isolated pelvic ring disruptions. They are widely accepted and include a rapid evaluation, identification, and control of the source of major blood loss, as well as reduction and primary fixation of the pelvis. Because additional injuries require a more variable scheme of diagnostic and therapeutical approaches, the order of emergent treatments, the procedures of bleeding control, and the time point of pelvic fixation in multiple injured patients have been controversially discussed in the past [11, 14–32]. Furthermore, the multidisciplinary approach which is used in many centers worldwide, may even increase the disagreements rather than providing a clear strategy to approach those patients.

This article reviews the management of 174 patients with multiple injuries combined with pelvic trauma over a 6-year period in an institution exclusively run by trauma surgeons. It identifies the major factors which significantly influence the outcome of those patients and provides a simple and clear protocol to effectively control severe hemorrhage during the acute period after injury.

Patients and Methods

From January 1, 1991 until December 31, 1996, 174 patients with multiple trauma including pelvic ring injuries were admitted to the emergency room of the University Hospital Zurich, a level-I trauma center. Severe injury was defined as at least 2 different system injuries one of these being one life-threatening [33], an injury severity score (ISS) >16 points [34], a systemic trauma response reflecting systemic inflammatory response syndrome (SIRS), and the need of postoperative intensive care. Excluded were multiple injured patients with isolated acetabular fractures and patients who were referred to our hospital more than 3 days after the accident occurred. Patients' charts and ICU-protocols from 1991 up to 1993 were reviewed retrospectively for mechanisms of injury, age, sex, blood loss, transfusion requirements, incidence of shock, SIRS, adult respiratory distress syndrome (ARDS), multiple organ dysfunction syndrome (MODS), and treatment modality. From 1994 up to 1996, these parameters were recorded prospectively. Hemodynamic, respiratory, laboratory, and radiological data were collected over a surveillance time of 30 days on the ICU or until discharge from the ICU.

Definitions

Pelvic fractures were classified according to the scheme of Tile and Pennal [35]. Fracture classification was obtained by a supine anterior-posterior radiograph and by inlet and outlet views, respectively. In 91 out of 174 patients (52.0%) CT-scan was additionally used for classification.

Patients were divided into 3 groups according to their hemodynamic status at admission: Group A included patients in extremis, with either absent vital signs or with severe shock due to torrential hemorrhage which needed mechanical resuscitation or repeatedly catecholamines despite complete blood volume replacement within 120 minutes (>12 blood transfusions/2 hours) [8]. Group B included patients not able to maintain a systolic blood pressure of >90 mm Hg, a pulse of <100 beats/minute, a central venous pressure (CVP) >5 cmH_2O, or a urine output >30 ml/hour despite adequate fluid replacement and blood transfusion over a time period of 2 hours. Group C consisted of patients with stable hemodynamics and absence of clinical signs of shock.

The incidence of shock, SIRS, sepsis, ARDS, and MODS was recorded using retrospective analysis of data files. The presence of shock was evaluated upon arrival of patients in the emergency room and was given if patients showed the following clinical signs: 1) hypotension <90 mm Hg systolic blood pressure, 2) tachycardia >100 beats/minute, and 3) the requirement of catecholamin. SIRS was present if 2 or more of the following conditions were met: 1) temperature >38 °C or <36 °C, 2) heart rate >90 beats per minute, 3) respiratory rate >20 breaths per minute or $PaCO_2$ >32 mm Hg, 4) white blood cell count >12,000/mm^3, <4,000/mm^3, or >10% immature band forms [36]. Sepsis was diagnosed, if all criteria of SIRS were fulfilled in combination with a positive focus or a positive blood culture [37]. ARDS was defined according to the criteria of Murray et al. [38] with a score >2.5 points. The presence of MODS was evaluated according to the criteria of Goris et al. [39] including our modifications during at least 3 days running [33].

Management

Evaluation of trauma pattern and resuscitation were carried out in the emergency room following ATLS (Advanced Trauma Life Support) guidelines.

Ultrasound of the abdomen and the chest were performed in the emergency room upon arrival by the trauma surgeon. Further assessment of the patient included plain X-ray of skull, chest, pelvis, cervical and thoraco-lumbar spine. Most of the patients who showed unstable (Type B or C) pelvic injuries were further evaluated by pelvic CT-scan except those in extremis or with persistent hemorrhagic shock. In most patients pelvic CT-scans were carried out as part of the CT-scan for evaluation of concomitant brain, chest, and/or abdominal injuries. Scans of the pelvis were obtained at 10 mm intervals throughout the abdomen and total pelvis.

The widely variable injury pattern required a flexible therapeutical approach. The operation schedule was individually adjusted to the hemodynamic and pulmonary status of the patient and the constellation of associated injuries as well as the particular fracture pattern. Only unstable displaced (>10 mm) pelvic ring injuries were stabilized either through external fixation or open reduction and internal fixation (ORIF) dependent on the patient's hemodynamic status. Additionally, fractures of long bones as well as unstable large joints were externally fixed or definitively stabilized as "day-1 surgery" [33]. Indications for emergency angiography were 1) chest X-ray suspicious for traumatic aortic rupture or 2) persistent blood loss after external stabilization of the pelvis in the presence of a negative abdominal ultrasound and massive fluid requirements or a large retroperitoneal hematoma seen on the CT-scan.

Patients in extremis (group A) with exsanguinating hemorrhage due to abdominal and/or pelvic injuries underwent crash laparotomy or even resuscitative thoracotomy without further diagnostic procedures. In some of those patients, hemodynamic stabilization was attempted by subdiaphragmatic clamping of the aorta or balloon occlusion of the aorta followed by packing of the 4 quadrants and the retroperitoneum. Disruption and dislocation of the pelvic ring were reduced and maintained either by external fixation (external fixator, pelvic anti-shock clamp) or were internally reduced and fixed at the end of damage-control laparotomy.

Patients with persistent hemodynamic instability (group B) underwent primary survey and minimal diagnostics. If initial assessment with ultrasound showed no intraabdominal lesions, the unstable displaced (>10 mm) pelvic fracture was externally reduced and stabilized. In the case of intraabdominal and/or pelvic bleeding the external stabilization of the pelvic ring was followed by emergent laparotomy.

Angiography was only performed in patients with persistent signs of blood loss despite surgical bleeding control and/or external fixation of the pelvic ring.

Patients which were hemodynamically stable after adequate fluid replacement (group C) were treated with primary and definitive ORIF depending on the degree of pelvic dislocation and associated injuries. The presence of severe brain (GCS <8 points and intracranial lesions in CT-scan) or chest injury (multiple lung contusions) was an exclusion criteria for primary ORIF. Instead, the disrupted and displaced pelvis was closely reduced and stabilized by external fixator.

Statistical Analysis

Results are presented as mean ± SD. Comparisons between groups were carried out with the Kruskal-Wallis test. For evaluation of potentially predictive parameters of outcome multiple regression analysis was used.

Results

The study included 111 men and 63 women with a mean age of 40.3 ± 18.2 years (mean ± SD; range 13 to 90) in the 3 patients' groups (Table 1). Fifty-three percent of the injuries resulted from traffic accidents, the majority (25.9%) of those included motor vehicles, motorcycle and bicycle (17.3%), and pedestrians (9.8%). Thirty-eight percent of all accidents resulted from fall of which more than one third were suicide attempts. Motorcycle accidents showed a high incidence of Type B1 pelvic ring instabilities (46%), while fall accounted for the highest incidence of pelvic instabilities Type C (43%).

Forty-one (23.6%) of all patients arrived under resuscitation or severe clinical shock (group A). The average blood requirement was 33.9 ± 31.7 units (range 11 to 114) (Table 2). Thirty-nine patients (22.4%) revealed persistent hemodynamic instability despite massive fluid replacement (group B) (blood units: 29.3 ± 23.7; range 2 to 117) (Table 2). Only 94 patients (54.0%) enrolled in the study were hemodynamically stable (group C) with 19.2 ± 24.4 units (range 0 to 92) (Table 2). Patients of group A exhibited a significantly higher ISS, APACHE II, and lower GCS compared to groups B and C (Table 2). In addition, group B was significantly (p <

Number	n = 174
Age (years)	40.3 – 18.2
Male/female	111/63
ISS (points)	32.1 – 11.1
APACHE II (points)[1]	18.3 – 8.6
GCS (points)[2]	11.6 – 4.6
Mortality	52 (29.9%)

Table 1
Demographic data of enrolled patients. Mean ± SD. [1]At admission; [2]at scene.

	Group A (n = 41)	Group B (n = 39)	Group C (n = 94)
ISS	40.1 – 11.1	34.2 – 9.6*	27.6 – 9.4** #
APACHE II	29.3 – 6.4	21.7 – 7.2*	13.4 – 5.1** #
GCS	7.7 – 4.9	10.5 – 5.0*	13.4 – 3.2**#
Blood units	33.9 – 31.7	29.3 – 23.7	19.2 – 24.4**
Mortality	37 (90%)	10 (26%)	5 (5%)

Table 2
Severity of injury and mortality related to hemodynamics. Mean ± SD. *p < 0.05 group B versus group A. **p < 0.05 group C versus group A. # p < 0.05 group B versus group C.

0.05) different from group C with regard to ISS, APACHE II, and GCS (Table 2).

According to the classification of Tile and Pennal [35], there were 61 Type A, 38 Type B1, 24 Type B2, and 51 Type C pelvic injuries (Table 3). The symphysis was disrupted in 44 patients. Pubic ramus fractures were found in 139 patients. The sacroiliac joint was disrupted in 42 patients, while sacral fractures were noted in 73 patients. Thirteen patients had displaced iliac wing fractures.

The associated injuries are illustrated in Table 4. The involvement of other organ systems, especially of the head (110/174, 63.2% of all patients, average-AIS = 3.1 patients), chest (115/174, 66.5%, average-AIS = 3.3 patients), and abdomen (69/174, 39.7%, average-AIS = 3.9 patients), was substantial. While the incidence of head and chest injury was comparable in all 3 groups, patients of group A revealed a higher percentage (25/41; 61.0%) of associated intraabdominal injuries than the other 2 groups.

Overall mortality was 29.9% (52/174). The highest mortality was found in patients in extremis (90.0%). Thirty-three out of 52 non-survivors (63.5%) died during the first 24 hours after admission, most of them in the emergency room (Table 5). Exsanguination (n = 23; 70.0%) was the leading cause of death in these patients, while 8 patients (24.0%) died of fatal head injury, and 2 patients (6.0%) because of acute lung failure (Table 5). In 14 out of 23 patients (60.9%) lethal hemorrhage was due to a combination of pelvic ring instability and severe intraabdominal lesions. Most of these patients suffered from severe liver ruptures (Type III or IV, according to Moore et al. [40]) (Table 6). Eight of the 19 patients (42%) who died after 24 hours after admission succumbed to death due to severe head injury, while the others died from isolated or combined organ failure (Table 5). The mean survival time of these patients was 9.3 ± 9.6 days (range 2 to 36 days).

To evaluate the parameters predicting mortality multiple logistic regression analysis was used. Shock ($p < 0.001$, β-estimate = -3.64) and to a lesser extent the severity of injury ($p < 0.001$, β-estimate = 0.25) and the age ($p < 0.001$, β-estimate = 0.09) were independent variables. In contrast, the APACHE-II score ($p = 0.31$) assessed at admission and the type of pelvic fracture were not independent parameters for survival.

Classification1	Group A (n = 41)	Group B (n = 39)	Group C (n = 94)
A	10 (10)[2]	18 (4)	33 (2)
B1	9 (8)	9 (3)	20 (0)
B2	3 (1)	3 (2)	18 (1)
C	19 (18)	9 (1)	23 (1)

Table 3
Type of pelvic injuries related to hemodynamics and mortality. [1]According to the classification of Tile and Pennal [35]. [2] (in parentheses) number of non-survivors.

	Group A (n = 41)	Group B (n = 39)	Group C (n = 94)
Head	27 (65.9%)	24 (61.5%)	59 (62.8%)
Chest	30 (73.2%)	28 (71.8%)	57 (60.6%)
Abdomen	25 (61.0%)	15 (38.5%)	29 (30.9%)
Spleen	12	8	8
Liver	11	9	8
Kidney	2	2	7
Gut	8	2	6
Pancreas	1	—	—
Bladder	4	3	6
Ruptured Diaphragm	4	1	4
Musculoskeletal System	36 (87.8%)	32 (82.1%)	62 (66.0%)
Spine	5 (12.2%)	13 (33.3%)	31 (33.0%)

Table 4
Numbers of associated injuries related to hemodynamics.

	Group A (n = 41)	Group B (n = 39)	Group C (n = 94)
Mortality	**37 (90.2%)**	**10 (25.6%)**	**5 (5.3%)**
Died < 24 h	**28 (75.7%)**	**3 (30.0%)**	**2 (40.0%)**
Hemorrhage	23	—	—
Brain edema	4	2	2
ARDS	1	1	-
Died > 24 h	**9 (24.3%)**	**7 (70.0%)**	**3 (60.0%)**
Brain edema	5	3	—
ARDS	—	—	1
MODS	4	4	—
Pulmonary embolism	—	—	2

Table 5
Mortality in relation to hemodynamics.

Abdominal ultrasound and the standard anterior-posterior view were performed in all patients, even in those in extremis (Table 5). In contrast, CT-scan was

Table 6
Treatment of patients with fatal pelvic hemorrhage.

Mechanism	Fracture type	ISS	Associated abdominal injuries	Aortic occlusion	Resuscitation needed	Blood (units)
Fall	C	34	Liver	Yes	Yes	11
Car	C	41	Liver	Yes	Yes	25
Pedestrian	C	25	—	No	No	9
Crush	C	34	Rectum, bladder	Yes	Yes	18
Fall	C	41	Spleen, liver, kidney	No	Yes	58
Car	A	34	Spleen	No	No	21
Car	C	41	Spleen	No	No	68
Motorcycle	B1	41	—	Yes	No	28
Motorcycle	A	45	Spleen, liver, gut, diaphragm	Yes	No	22
Crush	C	45	Colon	Yes	No	17
Crush	B1	34	Liver	No	No	21
Fall	B1	45	—	Yes	No	12
Motorcycle	C	50	Spleen	Yes	Yes	15
Car	A	27	Diaphragm	No	No	20
Fall	C	50	Spleen, liver	No	Yes	24
Pedestrian	C	41	—	No	No	20
Pedestrian	B2	43	—	No	No	4
Fall	C	18	—	No	No	26
Car	C	50	Liver	No	No	21
Crush	A	27	—	No	No	4
Crush	C	18	Iliac artery	Yes	Yes	30
Crush	C	32	—	No	Yes	33
Pedestrian	C	61	—	No	Yes	4

only performed in 91/174 patients (52.0%), because the other patients were in critical hemodynamic conditions. Pelvic angiography was carried out in 1 patient in group A (2.4 %), in 2 patients in group B (5.1%), and in 2 patients in group C (2.1%). Active bleeding was due to injury to the gluteal artery (n = 2), internal iliac artery (n = 1), pudendal artery (n = 1), and obturator artery (n = 1). Bleeding was successfully terminated in all patients through selective embolization with either gelfoam particles or coils.

Twenty-three out of 41 patients (56.1%) in extremis (group A) underwent crash laparotomy to control excessive hemorrhage (Table 7). Sixteen of these patients demonstrated Type B1 (n = 4) or Type C pelvic (n = 12) disruptions. Aortic occlusion was carried out in 9 patients (22.0%), either with aortic clamping (n = 7) or balloon occlusion technique (n = 2). Hemorrhage could only be controlled in one of these patients.

Reduction and fixation of the pelvic ring was carried out in patients with Type B1 and C fractures with

Table 7
Acute surgical treatment in relation to hemodynamics. ( ) = type of pelvic injuries according to Tile and Pennal [35].

	Group A (n = 41)	Group B (n = 39)	Group C (n = 94)
Crash thoracotomy	9	—	—
Crash laparotomy	23	—	—
Emergency laparotomy	—	14	15
Aortic clamping	9	—	—
Pelvic packing	12	3	3
External fixator	5 (5 × C)	2 (1 × B1, 1 × C)	4 (2 × B1, 2 × C)
C-clamp	2 (2 × C)	1 (1 × C)	-
ORIF	2 (2 × B1)	5 (4 × B1, 1 × C)	25 (2 × A, 10 × B1, 2 × B2, 11 × C)

significant dislocation (symphysis disruption >20 mm, posterior ring dislocation >10 mm). Additionally, 2 patients with Type-B2 fractures met criteria for operative treatment, one for sacral nerve root decompression, the other showed a severely dislocated fracture of the ischial tuberosity.

Six patients in extremis (group A) with Type C pelvic ring injuries were treated with external fixation devices following crash laparotomy and pelvic packing. In 1 of those patients the sacro-iliacal joint was additionally stabilized with plate fixation. 2 patients in group A with Type B1 fractures were stabilized by ORIF of the symphysis after crash laparotomy and pelvic packing. In 3 patients with persistent hemodynamic instability (group B) the unstable pelvic fracture was primarily fixed by external devices. While 1 patient demonstrated stable hemodynamics, 2 patients needed laparotomy because of continuous bleeding. In 5 patients of group B primary ORIF of the pelvic fracture was carried out after bleeding control through laparotomy (Table 7).

Definitive open reduction and internal fixation was performed as "day-1 surgery" in 30 patients (17.2%), whereas 47 patients (27%) were operated for their pelvic fracture postprimarily (Table 8). Most of the patients with Type B1 injuries were stabilized with plate fixation of the symphysis through midline incision after emergency laparotomy or using a Pfannenstiel approach. In 2 patients, the symphysis was fixed with tension banding following median laparotomy, while 2 patients were definitively treated with an external fixator (Table 8).

	B1 (n = 38) <24 h	B1 (n = 38) >24 h	B2 (n = 24) <24 h	B2 (n = 24) >24 h	C (n = 51) <24 h	C (n = 51) >24 h
Anterior pelvic ring	**16**	**6**	**1**	**—**	**10**	**8**
Plate fixation symphysis	13	6	1	—	8	8
Tension banding	1	—	—	—	—	—
External fixation	2	—	-	—	2	—
Posterior pelvic ring	**—**	**—**	**1**	**—**	**13**	**18**
Plate fixation iliac wing	—	—	—	—	—	4
Plate fixation SI-joint	—	—	—	—	1	4
Internal fixateur sacrum	—	—	1*	—	10	8
Screw fixation sacrum	—	—	—	—	2	2

Table 8
Timing and technique of definitive pelvic ring fixation. *Decompression of sacral nerve roots.

Discussion

The combination of pelvic ring injury and multiple trauma represents a life-threatening injury with a high mortality. Because torrential hemorrhage has been identified as a major cause of death, there is widespread consensus that successful treatment of severe hemorrhage represents the hallmark for survival of these patients. Most trauma centers especially in North America developed treatment protocols for the control of hemorrhage in isolated pelvic ring injuries which include the pneumatic antishock garment (PASG), external pelvic fixation, and angiographic embolization as initial therapeutic procedures [41]. Though mortality of isolated pelvic injuries has been decreased by applying appropriate combinations of the mentioned techniques [42, 43], the management of pelvic injuries in combination with life-threatening organ injuries remains unsatisfactory. There is still a considerable controversy about the sequence and the timing of various emergency techniques in those patients. In this study, the management and outcome of 174 severely injured patients with pelvic ring instabilities were reviewed to better understand the characteristic of this complex injury pattern.

The high overall mortality rate of 29.9% in this series confirms the serious therapeutical problems of patients with multiple injuries combined with pelvic ring injuries. The observed overall mortality in our study is considerably higher than those reported by McMurtry et al. [8] (19%) and by Evers et al. [7] (14%). However, in none of these studies patients in extremis have been included. This may be due to either the exclusion of those patients from the study or the fact that patients in extremis may not reach the emergency room in areas with long distance transport. In fact, the mortality rate in this study excluding patients in extremis was 11%. Despite significant hemorrhagic shock in 29% of the remaining patients, none of those patients died due hemorrhage. Moreover, the complexity and the severity of associated injuries in our study population was higher in comparison to recent studies [7, 8]. Forty percent of all non-survivors (21/52) had a combination of at least 2 associated life-threatening (AIS ≥ 4 points) injuries of the head, the chest, and/or the abdomen. The mortality rate of patients with pelvic injuries Type B or C, head, and abdominal injury requiring surgery has been reported to be >90% [44]. In our series, the mortality rate of these trauma pattern was 75%.

Considering parameters predicting mortality, only 3 independent factors were found, of which the hypovolemic shock caused by severe hemorrhage represents the predominant "killing factor" in multiple traumatized patients with pelvic ring injuries. The ISS and age were other independent parameters, but to a lesser degree. In contrast, the APACHE-II score, assessed at admission, was not predictive for mortality. It is surprising that similar to the APACHE-II score the type of pelvic ring injury did not predict the outcome as an independent variable. This is further supported by the fact that there was no correlation found between mortality and the type of pelvic injury. Despite a comparable distribution of Type B1 and C pelvic injuries in the 3 patient groups, none of the patients in group B or C died due to pelvic injury. Moreover, 10 patients in extremis with stable Type A pelvic fracture died due to severe associated torso and head injuries. These results are in line with previous data by Poole et al. [41, 45]. Though severity of injury correlated with the severity of the pelvic fracture in their study, hospital outcome was determined by associated injuries and not by the pelvic fracture. Furthermore, no patient with isolated Type B1 or C pelvic injuries (n = 13) had a lethal outcome at our institution (data not shown). However, there is evidence from our statistical analysis that the type of pelvic fracture influences in part the hemodynamic status which represents an independent variable for survival.

Rapid recognition of hemorrhage and evaluation of its severity represent the hallmark in treating severly injured patients. In this light, measurement of lactate levels has been found to correlate with the true state of hemodynamic shock and consequently with the probability of survival [46, 47]. Additionally, the ability to clear lactate to normal levels can be used to evaluate the effectiveness of resuscitation. We have previously reported that lactate levels correlate with the outcome of severely injured patients with pelvic fractures [48] and advocate to use this parameter for assessment of the patients hemodynamic state and to monitor success of shock treatment.

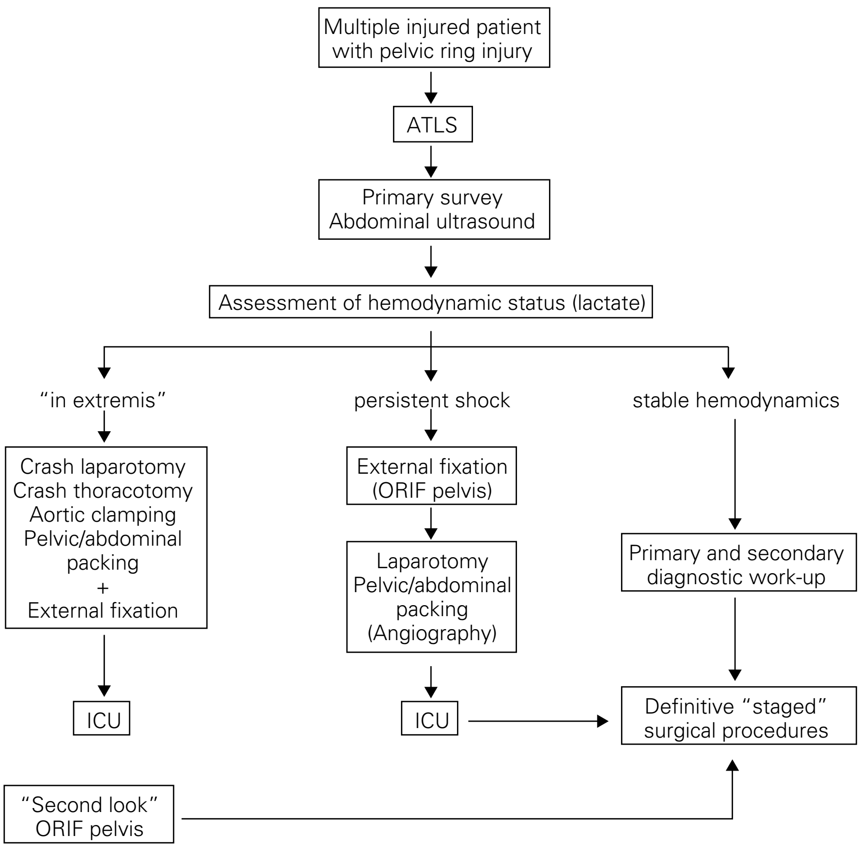

Figure 1
Management protocol for multiple injured patients with pelvic ring injuries. ORIF = open reduction and internal fixation.

The results of this study confirm previous investigations that rapid localization and control of the major source of hemorrhage is pivotal for survival of multiple injured patients with pelvic ring disruption. We advocate to immediately reduce and stabilize significant dislocation of the pelvic ring in a closed manner in the emergency room. This reduces bleeding from cancellous bone and venous sites. In patients in extremis (group A) crash laparotomy for damage control or even resuscitative thoracotomy including aortic clamping often precede external fixation of the pelvic ring (Figure 1). In patients with persistent hemodynamic instability despite adequate fluid replacement (group B) external fixation of the pelvic ring should acutely be carried out. Persistent bleeding and/or presence of intraabdominal lesions require emergency laparotomy and, if necessary, packing of the retroperitoneal space (Figure 1). Laparotomy does not only allow a rapid evaluation of intraabdominal and retroperitoneal lesions, but also their repair. In addition, through midline laparotomy, a rupture of the SI-joint can be adequately addressed through an transperitoneal approach and a symphysis disruption can be reduced and plate-fixated before closure of laparotomy [49].

Angiography and embolization have recently been described as alternative for controlling pelvic fracture hemorrhage. However, in the study of Agolini et al. [50] only 1.9% of patients with pelvic ring injury required embolization. Though they could successfully stop bleeding in all of their embolized patients, the mortality rate was 47%. Moreover, if angiography is not available in the emergency room, hemodynamically unstable patients may not be transported to the angiography unit. Due to the high degree of hemodynamic instability transportation to the angiography suite was not possible in any of the patients from group A and most of the patients from group B. Finally, angiography and embolization are time consuming procedures (50 to 190 minutes [50]) even in the hands of perfectly trained experts. Thus, angiography for control of pelvic bleeding is not advisable in hemodynamically unstable patients, particularly in the presence of severe associated injuries.

Multiple injured patients with pelvic ring injury remain a challenge for the trauma and/or orthopedic surgeon. Patients at risk are those with a severe hemodynamic instability and a concomitant head, thoracic, and/or abdominal injury. These patients should be managed by an aggressive treatment protocol including emergency or even crash laparotomy, pelvic and retroperitoneal tamponade, and early fracture stabilization. In these injury pattern, the diagnostic and therapeutical approach by 1 surgeon ("trauma leader") seems to our opinion more effective than a multidisciplinary approach.

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