



Epidemiology and outcome of complex pelvic injury

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Soft tissue injuries associated with pelvic fractures are often responsible for compromised haemodynamics. The objective of this study was to clarify what parameters determine patient outcome. In a cohort study, all patients with a pelvic fracture treated between 1991 and 2001 at a Level I trauma center were analysed for associated intrapelvic injuries, classification, severity of trauma, type of intervention and outcome. Of 552 patients with a pelvic fracture who entered the study, 15.5% presented with associated intrapelvic injuries secondary to the fracture (group I). A subgroup of patients with lacerations of branches of the iliac artery was identified as being at high risk for lethal outcome; they represented 4.3% of all patients with pelvic fracture (group II). The overall mortality reached 4.4%; it increased in group I to 15.5%, and in group II to 33.3%. In the subgroup with pelvic arterial haemorrhage (group II), the severity of injury, the proportion of multiple injured patients, the prevalence of unstable fractures and the incidence of sepsis were significantly increased. The only predictive factor for outcome was the amount of blood transfused, suggesting that fast elimination of the bleeding source decides about patient survival.

INTRODUCTION

The strong construction of the pelvic ring normally facilitates transmission of forces from the spine to the lower extremities and, in case of trauma, provides protection of internal organs as well as neural and vascular structures in the pelvis. Only very high-energy trauma can destroy the integrity

of the pelvic ring, resulting in a low rate of such fractures (3 to 8%); they are nevertheless associated with a high death rate, between 5 and 20% (6, 21, 26, 33, 36). A high impact force also causes a relatively high percentage of extra- and intrapelvic injuries associated with the fracture. Typical mechanisms causing pelvic disruption are traffic injuries (60%), falls from a height (30%) and crush injury under heavy weights (10%) (32). Fractured pelvic bones may lacerate surrounding neural and vascular structures as well as soft tissue. These associated pelvic injuries involving the urogenital system, rectum, sigmoid, nerves of the lumbosacral plexus, venous and arterial structures of the retroperitoneum characterise the complex pelvic injury. The latter remains a challenge for the treating trauma team and requires a multidisciplinary approach to treatment (7, 10, 17, 21, 27). The fundamental objectives of management include control of

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haemorrhage, restoration of haemodynamics, early stabilisation of the pelvic ring utilising the least compromising surgical technique possible, and early diagnosis and treatment of the associated injuries. The main bleeding sources are cancellous fracture zones, lacerations of veins in retroperitoneal networks, and lacerations of branches of the internal iliac artery. Since complex pelvic injury often occurs in multiply injured patients, the possibility of other possible bleeding sources in the thorax, abdomen and extremities also has to be taken into consideration. In patients with a haemodynamic instability after pelvic fractures, the proportion with intrapelvic arterial haemorrhage is around 25% (14, 25). In order to provide adequate treatment to these patients, they must be identified as early as possible in order to begin a sufficient resuscitation. The guiding principles for resuscitation are early blood substitution including red blood cells, fresh frozen plasmas (FFPs) and platelets, mechanical stabilisation with a pelvic clamp, an external fixator or wraps. In case of persistent haemorrhagic instability, angiography in combination with selective embolisation or an immediate laparotomy with packing followed by temporary closure of the abdomen appear to be possible measures for an effective management. With this study we emphasise the significant risk of associated intra-pelvic soft tissue injury in patients with pelvic fractures and evaluate the value of predictive factors for outcome such as blood pressure and haemoglobin level on admission, and the amount of transfusions.

MATERIAL AND METHODS

All patients with pelvic fractures treated between 1991 and 2001 were prospectively included in this study and records of the radiology department were cross-referenced to identify all patients who underwent digital subtraction angiography in combination with superselective embolisation. The emergency protocol registering all drugs administered, infusions, transfusions, and haemodynamic data were retrospectively analysed as well as the records of the Intensive Care Unit. Complex pelvic injuries were defined as pelvic fractures associated with injury to urethra, bladder, vagina, penis or scrotum, pelvic soft tissue, rectum, sigmoid, nerves from the lumbosacral plexus, venous and arterial structures of the

retroperitoneum (group I). The group that was identified as having pelvic injury with lesion of arterial branches (group II) includes all patients with arterial haemorrhage in the pelvic region demonstrated by angiography or by operating reports when patients had undergone primary operation. Group II is part of group I, and both are subgroups of all patients with pelvic fractures.

Statistics

The database was prepared using the Filemaker Pro 6 software (Filemaker, USA); statistical analysis was made with SPSS 10.0 for Windows (SPSS, USA). The mean values for the parameters studied were checked for equal variances and then compared by a two-sided t-test for unpaired comparison. Statistical significance was accepted when the p value did not exceed 0.05. Since data were entered anonymously into the final database, fields were left empty in some cases, without the possibility to reconstruct the whole case. These fields were statistically treated as missing values; for no variable, did they exceed 5% of the total number of cases.

Clinical regimen

Patients were resuscitated according to the guidelines of the American College of Surgeons Committee on Trauma Advanced Life Support (1). The first clinical examination includes a body check, a torso ultrasound and anteroposterior radiographs of pelvis and thorax. If the patient could be stabilised by usual resuscitation measures, a CT-body scan and afterwards radiographs of the extremities completed the diagnostic workup (29). Otherwise a superselective digital subtraction angiography (SS-DSA) is performed to further identify the source of bleeding, or the patient was treated in the operating room (OR) when the source can be identified. Emergency operations such as preliminary stabilisation of the pelvic ring or a laparotomy could of course be performed right in the emergency room (ER).

RESULTS

A total of 552 patients had been treated in our department for a pelvic fracture and were included in the study. Of these, 85 (15.5%) presented with a complex pelvic injury (group I), including 24 (4.3%) patients who presented with associated arterial lesions (group II). The average age was 44 years and was similar in all subgroups. Males

were affected significantly more frequently than females, and they tended to have more severe injuries. As expected, injury severity, represented by the polytrauma score (PTS) and the injury severity score (ISS) almost doubled in the subgroups with severe additional pelvic injuries secondary to a pelvic fracture, and the differences reached statistical significance. Demographic data are summarised in table I. There were almost equal numbers of isolated pelvic fractures, possibly combined with other minor injuries, and of pelvic fractures in polytrauma patients. In case of complex pelvic injuries (group I) and arterial lesion (group II) the proportion of multiple injured patients significantly increased as shown in fig 1. Pelvic fractures were classified according to Tile's system (16, 31). Overall, type A fractures were the most frequent, but type B and particularly type C fractures were more likely to be associated with intra-pelvic soft tissue injuries. Interestingly, 3.4% (5 cases) were isolated acetabular fractures associated with mainly neural lesions, and 14% (12 cases) of type A fractures featured fracture-associated pelvic lesions, indicating that one should never underestimate the severity of any type of pelvic fracture. The data are summarised in fig 2. Lacerations of the urinary tract, extensive retroperitoneal haematoma and neural lesions appeared to be the most common

pelvic injuries associated with pelvic fractures. Injuries of bladder and urethra accounted for 29%, a retroperitoneal haematoma for 27%, and lesions of the lumbosacral plexus for 27% of all fracture-associated pelvic injuries (fig 3). Emergency therapy such as application of a pelvic clamp, laparotomy, operative stabilisation within 24 hours following admission, external fixation, embolisation or a combination of these treatment methods was applied in 144 cases (26%). Open and external fixation account for 44 and 52 cases, respectively, representing the main undertaken measures. Forty-eight percent of all fractures underwent an operative treatment. Fifty-two percent of all operations were performed to stabilise the pelvic component, 39% to reconstruct the acetabulum, and 9% to treat both components. Twenty-four patients with pelvic fractures died (4.3%), 4 directly because of exsanguination as a consequence of the pelvic trauma, one because of an associated head injury, two from other causes. We found 22 cases (4%) of sepsis in combination with multiple organ failure (MOF), a subpopulation with a very bad prognosis containing 17 cases with lethal outcome, which represented the main cause for death. All 6 cases with an associated adult respiratory distress syndrome (ARDS) survived. Nine of 24 patients with associ-

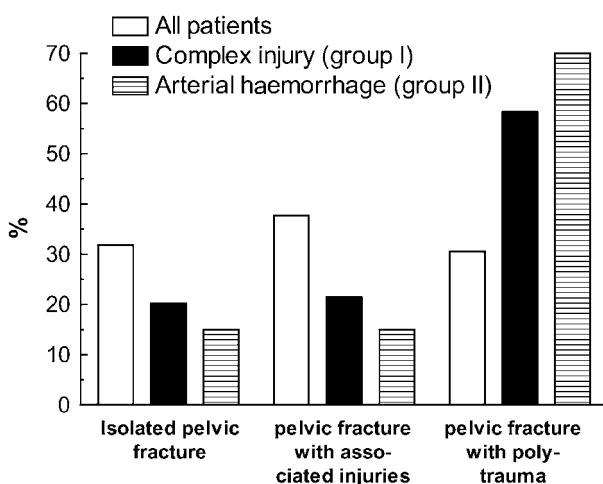


Fig. 1. — Frequency of pelvic fractures in combination with other injuries.

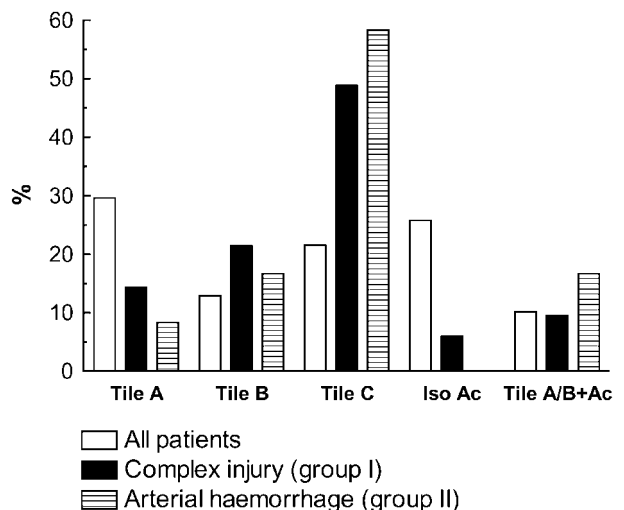


Fig. 2. — Distribution of pelvic fractures according to the classification of Tile. Iso Ac : isolated fracture of the acetabulum, Ac : fracture of the acetabulum.

Table I. — Epidemiology of the investigated subgroups. Statistical comparison was performed between the group of all patients and the indicated subgroup, percentage was calculated taking the number of all patients as 100%

	All patients	Complex injury (group I)	Arterial haemorrhage (group II)
Total number	552	85 (15.5%)	24 (4.3%)
Age (years)	44.2 ± 21.5	42.4 ± 23.8#	41.2 ± 21.9#
Gender (F/M)	190/360 (0.53)	23/62 (0.37)	7/17 (0.41)
Hannover Polytrauma Score (PTS)	18.3 ± 12.2	30.6 ± 19.1*	34.0 ± 14.3*
Injury Severity Score (ISS)	19.3 ± 17.3	40.8 ± 19.8*	43.1 ± 18.7*

n.s.

* p < 0.00001.

Table II. — Overview about frequency of application of interventional radiological methods in the subgroup with arterial haemorrhage (24 patients of group II representing 4.3% of all patients with pelvic fracture)

Criterion	Number (Percentage of 24)
Angiography	18 (75%)
Embolisation	13 (54%)
Non-survivors among patients undergoing embolisation	5 (38.5%)

ated arterial haemorrhage and 16 of 85 patients with complex pelvic injury suffered from sepsis, which was associated with mortality rates of 89% and 82%, respectively in these subgroups.

In order to evaluate possible factors to predict outcome in an endangered subpopulation, the study further focused on patients with associated arterial

injuries. Mortality was significantly increased to 33% in this subpopulation. Typically, superselective digital subtraction angiography was applied to diagnose the injury (75% of group II); in the remaining 25%, immediate operation decided because of haemodynamic instability clarified the situation. The technique most often used to control haemorrhage was selective embolisation by gel foams or coils, which was used in 13 cases (54% of group II), mainly clotting branches of the internal iliac artery (table II). Direct ligation or tamponade by laparotomy was performed in 42% of patients in group I; patch reconstruction (8%) or vessel interposition (4%) were necessary in cases with disruption of the external iliac artery. The subgroup of patients with arterial haemorrhage was further divided into survivors and non-survivors and various parameters were compared. Both severity of injury represented by ISS and PTS and length of

Table III. — Comparison of parameters characterising the subgroups of survivors and non-survivors with arterial haemorrhage secondary to pelvic fracture

	Pelvic Injury with arterial haemorrhage (group II)	Non-survivors	Survivors
PTS	32.82 ± 14.71	46.4 ± 8.4	27.9 ± 12.7*
ISS	40.82 ± 19.82	55.2 ± 20.1	37.0 ± 15.1*
Length of hospitalisation	37.00 ± 32.51	18.5 ± 18.8	44.7 ± 29.3*
Initial haemoglobin (g/dl)	8.91 ± 3.23	10.5 ± 3.3	8.5 ± 2.9#
Initial systolic blood pressure (mmHg)	101.92 ± 29.97	95.0 ± 26.0	112.6 ± 24.6#

n.s.

* p < 0.05.

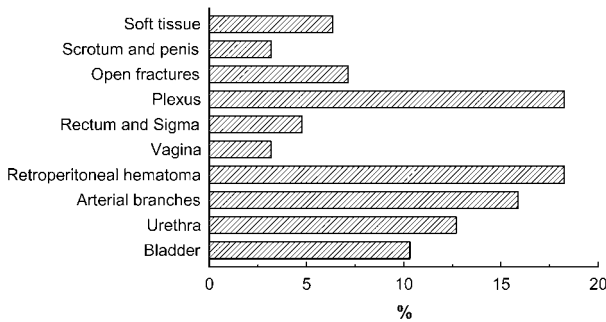


Fig. 3. — Frequency of affected organs in a complex pelvic injury. Percentage indicates portion of all fracture-associated pelvic injuries.

hospitalisation differed significantly. As expected, non-survivors were more severely injured, but initial haemoglobin level and initial systolic blood pressure did not show any statistical difference (table III). The amounts of transfusions were monitored and showed a decline with time in both groups, but non-survivors started resuscitation with a requirement for packed red blood cells (RBC) units that was twice as high compared to survivors. The difference in transfusion requirement reached statistical significance after 12 hours, when surviving patients were haemodynamically stabilised and required virtually no more transfusion (fig 4).

DISCUSSION

Despite progress made in the last years in the treatment of severely injured patients, which includes a number of patients with pelvic fracture, the death rate in case of initial haemodynamic instability remains high (24). Efforts have been made to identify the endangered patient group and strategies have been developed to effectively treat these patients (2, 3, 19). Our study contributes to clarify that issue, providing statistical evidence that prolonged need for blood substitution after 12 hours and later on is associated with a high mortality. The interplay of several different components of a complex pelvic injury leads to this outcome. High-energy trauma causes disruption of the pelvic ring and is associated with a high number of additional intra-pelvic injuries and multiple trauma. It has been shown that the interaction of initial

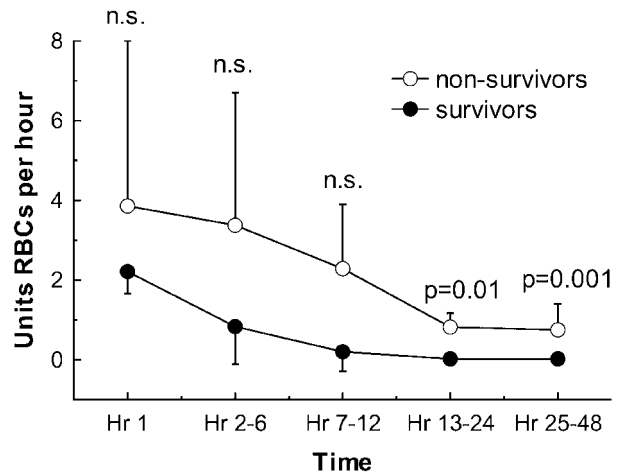


Fig. 4. — Transfusion requirements of survivors and non-survivors with arterial haemorrhage.

acidosis, hypothermia and severe blood loss causes a coagulopathy with impaired thromboplastin time (PT), activated partial thromboplastin time (PTT) and diminished platelet counts already on admission of patients (11). In fact, trauma-related coagulopathy represents the most common reason for coagulopathy at all. The more the coagulation parameters differ from normal, the higher the probability for transfusion, and the more units of blood have to be substituted, the higher the probability for death (12). Carson has stated in 1988 that admission with a haemoglobin level lower than 4 g/dl leads to mortality greater than 60% (5). No patient in our study population was admitted with such low haemoglobin level, but all patients with a value below 6 g/dl surprisingly survived. Although the haemoglobin level certainly represents an important indication for a life-threatening situation, it does not seem to be a good predictor for outcome by itself (18). However, the threat of ex-sanguination has to be considered in the process of treatment. Therefore we favour early crystalloid resuscitation starting in the preclinical stage and immediate transfusion of packed red blood cells upon arrival in the emergency department. Since a coagulopathy has to be expected in case of haemodynamic instability, transfusion should be combined with administration of clotting factors using fresh frozen plasma and platelets. At first, the reason for haemo-

dynamic instability has to be identified, which should be accomplished by a clinical body check, an abdominal ultrasound and anteroposterior radiographs of thorax and pelvis. If the source of haemorrhage is recognised to be related with intrapelvic bleeding, it is usually attributed to cancellous fracture zones, lacerations of veins in the retroperitoneal plexus, and lacerations of branches of the internal iliac artery. Bleeding from cancellous bone is preferably treated by mechanical stabilisation with the least compromising technique as possible. This includes the pelvic clamp, an external fixator or wraps (22, 32). Internal iliac artery ligation has already been described in 1964 as a possible treatment in case of haemodynamic instability (28). However, results in controlling haemorrhage by ligation have been unsatisfactory, because of abundant cross-circulation via collaterals between the two internal iliac arteries and because haemorrhage occurs at different sites in case of extensive bony damage to the pelvic skeleton. Some authors have suggested immediate percutaneous fixation, even in a haemodynamically compromised patients; but this should probably be limited to experienced hands with a navigation device at reach and can as yet not be considered as a standard procedure in every hospital (38). Laceration of veins is preferably treated by a laparotomy and packing the pelvis with pads, since the mechanism of self-tamponade is ineffective in case of laceration of fasciae (20, 22). This procedure may be performed right in the emergency room, the pads left in place and the skin temporarily closed, following which the patients may be further treated in the operating room or at the intensive care unit (ICU) and later scheduled for a second look. In case of arterial bleeding, or persistent blood loss after packing, an additional arteriography has to be performed possibly in combination with a superselective embolisation (23). Although this technique is regularly used in the regimen in trauma centers of the United States, it serves in our setup as a second-line measure and is appreciated as a valuable adjunct to pelvic stabilisation and transfusion (8, 15, 35).

But in the last years the method became increasingly popular. Prerequisite for performing emboli-

sation is a fairly stable situation in order to perform a procedure that may, even in skilled hands, take longer than one hour (13). It requires the permanent availability of an experienced interventional radiologist and of the necessary equipment. Under these conditions, the method provides a safe possibility to achieve haemorrhage control by minimally invasive means (4, 9, 35). In our study, the mortality of patients undergoing selective embolisation was even slightly higher than average, probably caused by a bias of patient selection. Unfortunately, until now the literature lacks a randomised, controlled study comparing protocols using laparotomy and packing versus angiography and embolisation. Complications have been reported following embolisation, such as iatrogenic injury of vessels, misplaced gel foams and coils, persistent and re-occurring haemorrhage, necrosis of gluteal muscles, parts of the bladder wall or gluteal skin, and intima flaps in arteries where catheters were placed (30, 34, 37). In our study we have seen only one case of unsatisfactory haemorrhage control.

Some authors have found that an initial blood pressure below 90 mmHg results in a higher mortality. The reason why we could not confirm this effect in our study, although a low blood pressure undoubtedly stands for a sign of shock and life threat, may be attributed to the organisation of our pre-clinical emergency system. Instead of a 'scoop and run' policy we favour a 'stay and play' strategy on the field with an outside emergency doctor working primarily on haemodynamic stabilisation and ventilation.

In summary, early mechanical stabilisation of the pelvic ring, a multidisciplinary approach starting from the patient's arrival in the emergency room and an immediate effective control of the haemodynamic situation remain the bases of an effective treatment. This supports initial survival and prevents or at least reduces long-term damages.

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