

Traumatic Hemipelvectomy

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Abstract

Purpose: Open or closed traumatic hemipelvectomy is defined as a uni- or bilateral avulsion of the bony hemipelvis in combination with rupture of the large pelvic nerves and vessels and is usually accompanied by injuries of the genitourinary tract and bowel. According to a literature review between 1960 and 2005, 96 cases of traumatic hemipelvectomy were documented.

Patients and Methods: Between 1998 and 2004, nine male patients fulfilled the criteria for a traumatic hemipelvectomy, out of 1.8% pelvic injuries ($n = 507$) and of 2.4% pelvic ring injuries ($n = 373$). Seven patients were admitted directly to the authors' trauma center, one patient was admitted 3 h after the accident, and one patient was stabilized in another hospital and transferred 5 days later.

Results: All seven patients admitted primarily after trauma and the patient transferred 3 h later were in shock class IV. The traumatic hemipelvectomy was unilateral in eight patients with one complete avulsion and bilateral in one patient. Injuries of the pelvic vessels occurred in all patients. Most of the patients had injuries of both the genitourinary tract and the intestine. Associated injuries were mostly those of extremities, thorax and head. Neurologic deficits could be documented clinically on admission in four patients. Laparotomy for damage control with packing of the abdominal cavity and the retroperitoneum was performed in all cases. Four patients died during stabilization attempts in hemorrhagic shock during the first 4 h of treatment and three patients died after 3, 5, and 7 days in the intensive care unit because of septic complications. Two patients survived with a follow-up of 21 and 34 months.

Conclusion: Traumatic hemipelvectomy is a most severe pelvic ring injury. If the diagnosis of traumatic hemipelvectomy is clear, surgical hemipelvectomy should be performed. Limb-saving procedures endan-

ger patient's life. Early and frequent second-look operations and aggressive management of associated pelvic injuries minimize wound problems and septic complications.

Key Words

Pelvic fractures · Polytrauma · Infection of bone and joints · General trauma · Fractures · Abdominal trauma

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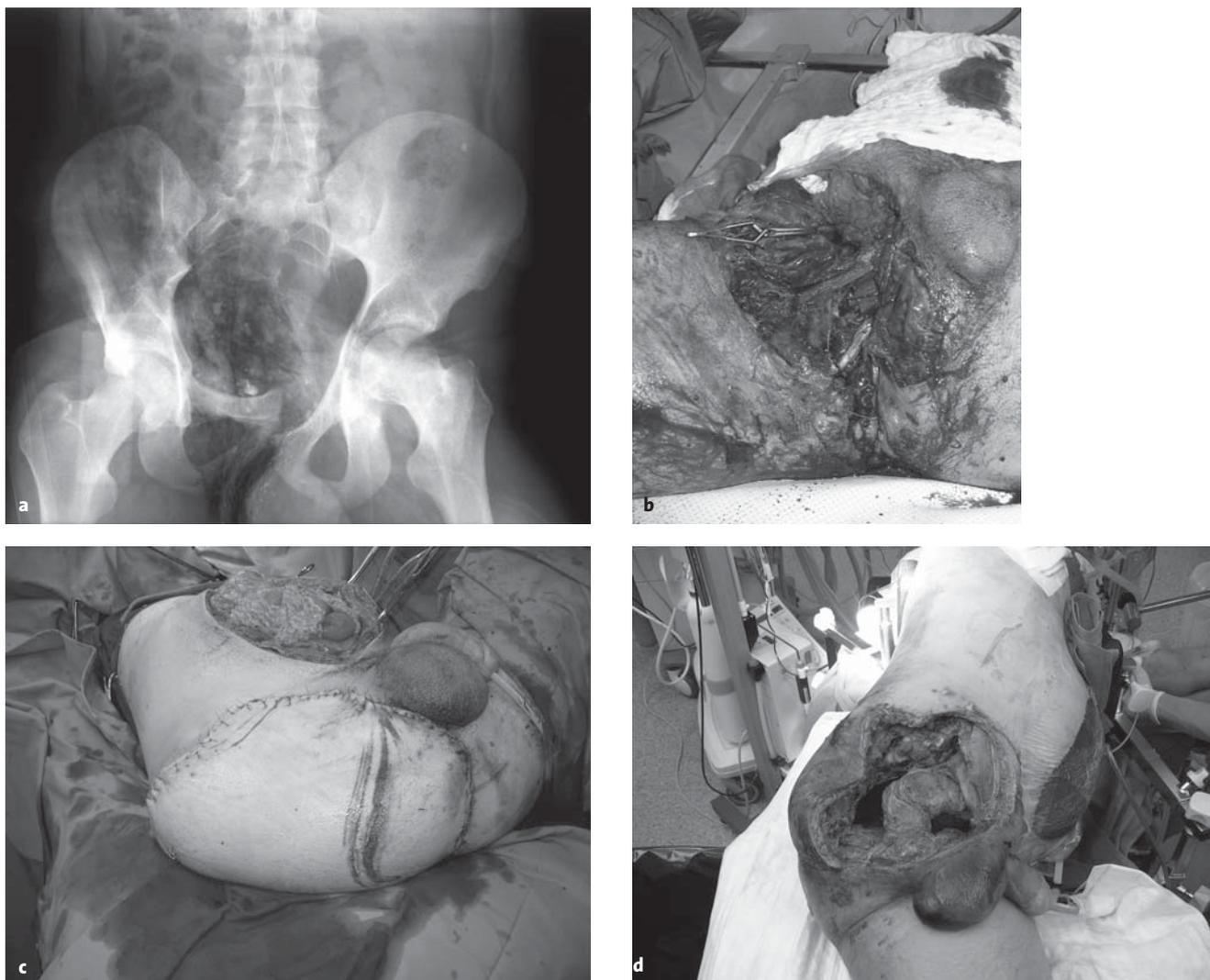
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Introduction

Traumatic hemipelvectomy is the most severe form of closed or open pelvic fractures caused by a high-energy impact on the hemipelvis and results in a uni- or bilateral wide bony separation of the pelvic ring at the symphysis and the sacrum combined with a traumatic rupture of iliac vessels. In addition, a severe stretch injury or a disruption of the femoral and sciatic nerves takes place [1–3]. The traumatic hemipelvectomy results either in a complete avulsion or an incomplete disruption with closed or severely damaged soft tissue and is often associated with injuries of the genitourinary tract and intestine as well as severe soft-tissue disruption of the pelvic diaphragm. The injury occurs mostly after motorcycle or bicycle traffic accidents and a rollover or high-velocity abduction movements are the cause of a disruption of the pelvic ring. Some cases of this severe trauma were due to accidents at work and one reported case of traumatic hemipelvectomy was a result of a blast injury [4]. The mortality rate is very high and the rare cases of surviving patients appeared sporadically in the literature, mostly as case reports, in the course of the recent 45 years. The aim of this retrospective study was to discuss the management and to analyze the course of

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Figures 1a to 1d. Patient #8.

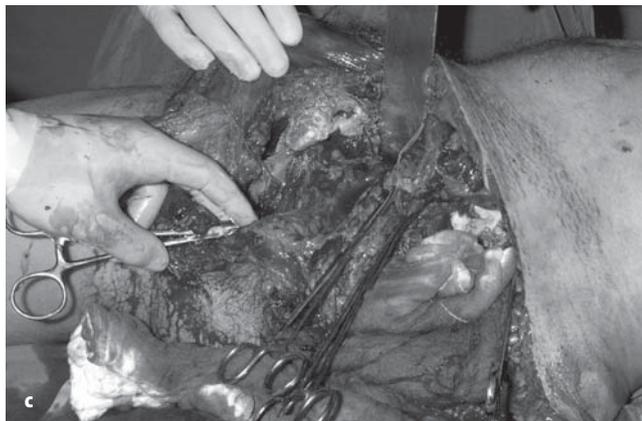
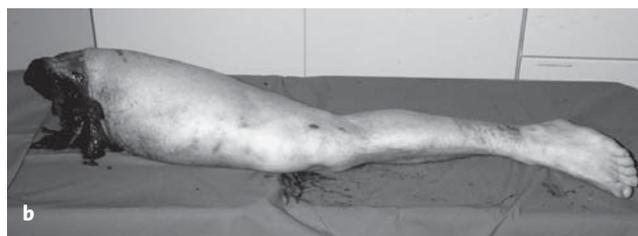
- a) X-ray of open traumatic hemipelvectomy. The plane of the hemipelvectomy runs through the symphysis pubis and the sacroiliac joint on the right side. Notice the bony lesion of the acetabulum of the contralateral hemipelvis.
- b) Patient on arrival in the operating room with incomplete traumatic hemipelvectomy. Complete transection of the vascular and neurogenic structures (clamp positioned on external iliac artery). Complete disruption of the anorectum as an associated injury.
- c) Temporary closure of the soft-tissue defect after surgical hemipelvectomy. Open abdomen situation after damage control procedure.
- d) Complete necrosis of gluteus muscle and the associated soft tissue 6 days after traumatic hemipelvectomy. Open abdomen closed by Abdominal V.A.C.[™] Dressing. The patient died 1 day later due to septic complication in multiple organ failure.

traumatic hemipelvectomy in patients treated at our institution in the last 6 years.

Patients and Methods

Out of a total of 507 pelvic injuries treated at the Department of Trauma Surgery, University Hospital Zurich, Switzerland, between 1998 and 2004, 373 were pelvic ring injuries and nine of them fulfilled the criteria of traumatic hemipelvectomy (Figures 1a and 1b) with an incidence of 2.4%. All patients were males of an aver-

age age of 30 ± 6 years (range 13–75 years). The causes of the injury were six traffic accidents and three accidents at work. Seven patients were transferred primarily to our department by a helicopter (#1, 3, 4, 5, 6, 8, 9). The remaining two patients were transferred from other hospitals as soon as they were stable for further transport, one patient 3 h after the accident (#7) and the other after 5 days (#2). Except one complete avulsion in patient #4 (Figures 2a to 2d), the traumatic hemipelvectomy was incomplete in the remaining patients, com-



Figures 2a to 2d. Patient #4.
 a) X-ray on arrival. Complete avulsion of the left hemipelvis.
 b) Avulsed extremity with hemipelvis on arrival.
 c) Soft-tissue injury of the complete traumatic hemipelvectomy. Clamps are positioned on iliac vessels in the operating room.
 d) X-ray of complete traumatic hemipelvectomy on the left side with associated multifragmented femur fracture.

bined with a wide selection of soft-tissue injuries from closed skin situation up to deep perineal defects. Except one patient with a bilateral hemipelvectomy (#2), six patients named at last had a unilateral hemipelvectomy on the left side and one on the right side (#8). Injury Severity Score (ISS) [5], associated injuries to the pelvic ring injury, and associated extrapelvic lesions are summarized in Tables 1 and 2. The following parameters were evaluated: Revised Trauma Score (RTS), the probability of survival (TRISS), shock classification, time management, emergency operation procedures, transfusion analysis, intensive care unit (ICU) stay and the outcome.

Results

Seven patients (#1, 3, 4, 5, 6, 8, 9) admitted primarily after trauma and the patient transferred after 3 h (#7) were in shock class IV. The mean pre-hospital rescue time by a helicopter amounted to 70 ± 4 min (range

55–85 min). The mean ISS of the patients was 49 ± 3 points (range 41–66 points) and the mean RTS at admittance 3.269 ± 0.257 (range 2.628–4.094). On arrival, the TRISS for blunt trauma was $16.2 \pm 5\%$ (range 3–42.2%). After arrival, the patients were managed according to Advanced Trauma Life Support Guidelines [6]. Initial diagnostic steps on arrival included solely thoracic and pelvic X-ray and FAST (focused assessed sonography in trauma). Injuries of the genitourinary tract and colorectal injuries were found in most of the cases (Table 1). Neurologic deficits could be documented clinically on admittance in four patients only. Injuries of the pelvic vessels were present in all patients. Severe soft-tissue injuries such as Morel-Lavallée lesion [7] were documented in four patients (#1, 7, 8, 9). Most of the associated extrapelvic lesions included thorax, abdomen and head (Table 2). The mean time from admittance to emergency surgery was 33 ± 6 min (range 5–60 min) and the mean operating time 156 ± 27 min (range 55–240

min). In all cases a laparotomy with packing of the abdominal cavity and the retroperitoneum was carried out. A pelvic clamp was used for bleeding control in five patients. Aortic clamping was performed during six damage control procedures. Damage control [8] of the colon and colostomies were performed in six and of small bowel injury in two patients. Suture repair of the urinary bladder was carried out in five cases. On average, 45 ± 10 blood units, 29 ± 7 fresh frozen plasmas and $6,400 \pm 2,500$ ml Ringer's infusion were necessary for transfusions during the emergency procedures.

Four of the patients admitted primarily died during attempts at stabilization as a result of hemorrhagic shock in the course of the first 4 h of treatment (#1, 3, 5, 6). At admittance we operated one surviving patient with complete traumatic hemipelvectomy (#4). In the group of the surviving patients with incomplete traumatic hemipelvectomy, a surgical hemipelvectomy was performed initially (#9) and one 8 h after stabilization on the first day of admittance (#8). In two patients, bilateral surgical hemipelvectomies were performed on the 5th and 6th day after trauma, in one case (#2) because of completely missing perfusion of both lower limbs and in the other (#7) because of a septic complication and a severe soft-tissue defect (Morel-Lavallée). Frequent and repeated aggressive debridements of the hemipelvectomy wounds were performed. Three patients (#2, 8, 9) had large septic wounds and died after 3, 5, and 7 days in the ICU because of septic-toxic shock and/or multiple organ failure. All three patients, in addition to the direct mechanical injury of the structures, also had an ischemic injury caused by a ligation of the internal or common artery and vein. A large necrosis of the gluteus maximus muscle, bladder and pelvic musculature was observed in these cases during second-look procedures (Figures 1c and 1d). Two patients (#4, 7) could be stabilized and underwent ten and 30 second-look operations, respectively, in order to achieve a complete debridement of the injured and necrotic tissue. In one case (#4), the soft-tissue defects were covered with a free flap. Both patients survived their catastrophic pelvic ring injury and were available for a follow-up after 21 and 34 months. The now 15-year-old boy (#7) is visiting school again and the 25-year-old man (#4) has a job and is working full time.

Table 1. Associated abdominal injuries after traumatic hemipelvectomy. ISS: Injury Severity Score [5].

Patient #	Age (years)	ISS	Bladder	Urethra	Perineum	Anus	Rectum	Colon
1	29	57			+			+
2	22	50				+		+
3	75	41	+	+	+			
4	22	41	+		+	+		
5	33	50	+	+	+	+	+	+
6	24	41	+	+				
7	13	45	+	+		+	+	
8	18	66			+	+	+	+
9	33	50	+		+	+		+

Table 2. Injury severity of associated extrapelvic lesions. AIS: Abbreviated Injury Scale [39].

Patient #	AIS head	AIS thorax	AIS abdomen ^a
1	2	4	4
2			5
3		3	
4			
5		3	4
6	4		
7			
8	5		
9			

^a all injuries in the abdominal cavity except associated injuries of traumatic hemipelvectomy

Both survivors refused prosthetic rehabilitation. The boy is mobilized in a wheelchair and the young man is ambulatory on crutches. Early psychological support of the patients and their families was necessary for social reintegration.

Discussion

Traumatic hemipelvectomy is caused by an extremely high kinetic energy force applied to a partially abducted and externally rotated lower extremity [1, 9]. The injury results predominantly in motor vehicle accidents and mostly the left side is entangled typically involving motorcycle or bicycle riders colliding with an oncoming car or an object in right-hand traffic [10]. When the impact occurs, the pubic symphysis of the involved extremity is disrupted and as the deformation continues, disruption of the remaining pelvic supporting structures continues posterior to and through the sacroiliac joint. In 71%, the plane of the hemipelvectomy runs through the symphy-

Table 3. Traumatic hemipelvectomies in the literature.

First author	Patients Total	Survivors			Year
		Children	Women	Men	
McPherson [40]	1			1	1960
McLean [41]	2			2	1962
Wade [1]	2	1		1	1965
Palvolgyi [55]	1			1	1969
Johansson [43]	1	1			1971
Konzen [42]	4	1	1	2	1972
Ganapathy [44]	1			1	1973
Berman [45]	1			0	1974
Zierott [46]	2			2	1974
Orcutt [36]	1		1		1974
Meester [47]	1			1	1975
Tortorolo [48]	1			1	1976
Mauil [20]	12			5	1977
Siemens [31]	1			1	1977
Oppenheim [9]	1			1	1978
Turnbull [2]	1			1	1978
Rodriguez-Morales [3]	2			2	1983
Evans [14]	1	1			1984
Sattel [50]	2			2	1984
Danisi [13]	1			1	1985
Lipkowitz [16]	1	1			1985
Chappel [37]	1			1	1986
Cooper [33]	1			1	1987
Ikpeme [17]	1			1	1987
Moore [18]	1		1		1987
Nichter [34]	1	1			1988
Sham [32]	1			1	1988
Beal [10]	8			3	1989
Klasen [15]	3	1		2	1989
Jahn [30]	1			1	1990
Wand [26]	1			1	1990
Klingman [24]	2		2		1991
Smith [51]	1			1	1991
Spiers [52]	1			1	1991
Dendrinis [19]	1		1		1992
Glorion [25]	2	2			1993
Raftos [27]	1			1	1994
Weiss [53]	1			1	1994
Smektala [35]	3			3	1995
Cesarec [4]	1			1	1996
Pohlemann [12]	11	2		2	1996
Ossewaarde [54]	1	1			1997
Rieger [49]	1			1	1998
Cho [23]	1	1			1999
Schoderbek [22]	1		1		2005
Labler et al.	9	1		1	2005
Total	96	14	7	48	69

sis pubis and the sacroiliac joint [11]. This tremendous shearing force and displacement of the affected hemipelvis result in an extensive soft-tissue destruction including avulsion of iliac vessels, genitourinary and colorectal injuries [10, 12–14]. Direct avulsion of the limb after entanglement in heavy machinery is the next most common mechanism of injury [3, 15]. Complete avulsion of the hindquarter amounts to about 50% of cases [10, 16]. Other author describes an incidence of 32%, whereas 68% of the limbs remained connected by means of a soft-tissue bridge [11].

The incidence for traumatic hemipelvectomy is about 0.6% of all pelvic fractures and about 4.9% of complex pelvic fractures [12]. In our own patient group we found an incidence of 1.8% and 2.4%, respectively. No more than 96 documented traumatic hemipelvectomies were reported in the literature in the last 45 years (Table 3). The actual incidence, however, remains unknown because most of the victims, as a consequence of an uncontrollable hemorrhage, die before reaching the hospital [17–19]. Nevertheless, the number of patients arriving at the hospital alive has increased during the recent 20 years (Table 3), presumably as a result of improved pre-hospital aggressive resuscitation, a shorter transport time by helicopter to the trauma centers and an improved shock treatment. This correlates well with our own patient group where the time for the rescue and diagnostic procedures after arrival in the hospital was relatively short. Consequently, the surgeon is, and will be in the future, more often confronted with this kind of injury than in the past. However, Table 3 shows that the rate of successful management of these surviving patients still remains unknown. Except few studies of groups of patients published [10, 12, 20], including our own study (Table 3), their number being too small to be statistically relevant, the majority of publications are case reports describing only successful management of selected cases of traumatic hemipelvectomies leaving the rate of survivors who died later in the course of treatment unnoticed.

Most of the cases described, as well as our own patient group, showed a severe shock at arrival [10, 12, 15, 16, 21]. The survivors, almost < 30 years, were healthy individuals able to tolerate massive hemorrhage and soft-tissue destruction [16, 22, 23]. Patients with complete hemipelvectomy seem to have a better chance of survival than patients with partial hemipelvectomy. This supposedly is due to a retraction of the vessels, which takes place after complete transection and allows a clo-

sure by a muscular contraction. Partial vessel injuries usually do not allow this kind of mechanism [24].

Associated injuries of the pelvic region are common and 88% of them are genitourinary or anorectal injuries [11]. Associated extrapelvic regions, not regarding injuries of the ipsilateral lower extremity, were observed in 48% of the survivors [11]. The associated injuries might substantially reduce the survival rate and careful attention should be paid to them. A survival of only 8% was reported for traumatic hemipelvectomies with more than two associated injuries [10, 13].

The aim of initial treatment is to save patient's life by a shock therapy and a hemorrhage control. Immediate application of direct pressure starting at the scene of the accident was described by many authors [14, 25–27]. Direct judicious clamping of large bleeding vessels as a control of hemorrhage at the scene was reported [27]. The role of the pneumatic anti-shock garment (PASG), however, remains controversial [13, 15, 28]. Contralateral leg loss after PASG-associated compartment syndrome has been reported [10, 29]. On arrival at the hospital, a vigorous resuscitation and expeditious evaluation of the injuries should take place simultaneously [12, 16] but an exploration of the wound before the operation should be avoided [12, 15, 16, 24, 27, 30]. An early laparotomy as a damage control procedure is usually necessary for clamping the abdominal aorta to achieve a hemostasis before the particular injured vessels can be managed individually [18, 31]. Bleeding from the sacral and prosthetic venous plexus often cannot be adequately controlled by suture ligation and requires mechanical compression by local packing [32]. In patients with incomplete separation where the limb remained partially attached, bleeding may continue and is difficult to control. In such a case, as a life-saving intervention, the hemipelvectomy should be completed [10, 12, 15, 18, 24, 33] because attempted salvage of the lower extremity, out of the uncontrollable bleeding, often leads to septic complications or organ failure [11]. Salvage of hemipelvectomy bone fragments by means of internal fixation as an initial procedure converts hemipelvectomy to a hip disarticulation level [34]. This procedure, however, remains controversial in view of a massive contamination [24]. Also attempted primary salvage of a part of the iliac bone failed because of extensive infection [12].

Problems regarding wound healing were reported in 75% of the survivors [11]. If the wound is closed primarily, it should be reexplored and debrided early in the

postoperative period [3, 16]. Other authors prefer an open amputation, which allows good drainage and makes reexploration easier [15, 17]. Reexploration of an amputation wound with about three repeated debridements on average (range one to ten redebridements) was carried out in 86% of the survivors [11]. Delayed debridement contributes directly to sepsis and organ failure [3, 10, 12, 15, 27, 34, 35]. The definitive closure of an amputation wound is fastidious and requires reconstructive surgery techniques. The use of a full-thickness gluteus myocutaneous flap was reported [18, 24]. The used musculocutaneous flaps included thoracoabdominal, rectus abdominis, latissimus dorsi, contralateral gluteus flaps, or a composite island flap [10, 27, 33, 34, 36]. Split-thickness skin grafting able to withstand the stress generated by prosthesis was also reported [10, 13]. Skin can be harvested from the amputated extremity [9, 14, 15]. The use of a tissue expander was also described. The latter was placed under the skin of the buttock and fully inflated over 6 weeks to finally completely close the amputation wound [27].

Prevention of a sepsis caused by associated injuries in the pelvic region is another goal of the management. Broad-spectrum antibiotic and tetanus prophylactic must not be forgotten. A local infection may lead to lethal systemic sepsis [10, 34, 35]. Any injury of the perineum should be treated by a diverting colostomy or ileostomy and by a thorough irrigation of the distal colon segment (rectal washout) to prevent continued fecal contamination of the pelvic wound [3, 12, 13, 18, 24]. A literature review showed that 80% of the survivors had a colostomy [11]. The position of the colostomy should take the eventual prosthesis into account and should be placed in a safe area of the abdominal wall [3, 15]. The main therapeutic aim in the management of injuries to the lower urinary system is prevention of a sepsis by means of a suprapubic urinary drainage to ensure separation of the urinary flow. A damaged urethra should be splinted with a catheter [15, 16]. The question of an immediate reconstruction of the urethra is still controversial. Some authors recommend a secondary repair because of a breakdown of the initial repair resulting in an urinary fistula. Intraperitoneal bladder injuries have to be treated surgically. The treatment of extraperitoneal bladder ruptures is still under discussion. Some authors prefer catheter drainage, whereas others recommend surgical repair. Injuries of ipsilateral ureter require stenting and primary repair [10, 15, 16, 24, 32]. Genitourinary complications such as infections, calculi of the

urinary tract, fistulae, urinary incontinence, neurogenic bladder, urethral stricture, sexual dysfunction or infection of penile prosthesis are reported in 46% of the survivors [11]. Another risk is the development of meningitis, probably secondary to an ascending infection along the course of the avulsed lumbar and sacral nerve roots [3]. As reported in about 28% of the survivors, the patients may suffer from intractable phantom limb pain [10, 24, 37].

Attention must be paid to associated extrapelvic lesions such as skeletal and neurologic injuries. As these injuries will significantly influence the patient's potential for rehabilitation [16, 18, 19, 36], they should be managed, provided the patient's condition permits.

According to the literature a total of 71% of the survivors received a prosthesis [11]. However, not all patients were able or willing to wear it, some preferred mobilization on crutches, others a wheelchair. Only 55% of the patients accepted a prosthesis and were able to ambulate with it, often in combination with crutches [11]. Some patients refused rehabilitation or were unmotivated due to organic brain syndrome, psychic confusion, alcoholism, or drug dependency.

The last determinant of a successful outcome is the patient's ability to psychologically adapt to the injury [19]. Early integration of the patient's family in the psychological therapy has shown good results [12]. Only a multidisciplinary support by psychologically instructed staff and a psychiatrist may suppress the depressive mood and prolong the euphoric phases [13, 17]. Information concerning a long-term social reintegration is available in the literature [38]. Successful courses exist for survivors of a traumatic hemipelvectomy [9, 12, 13, 16, 18, 23, 24]. On the other hand, there are patients with severe psychological and social problems, drug or alcohol dependency, and isolation [10, 15, 38].

Conclusion

Traumatic hemipelvectomy is a most severe and mutilating but seldom survivable injury. Management of traumatic hemipelvectomy includes pre-hospital hemostasis by local pressure, shock therapy, and prompt transfer to a trauma center. In-hospital management consists of immediate surgical hemostasis. If the diagnosis of traumatic hemipelvectomy is clear, surgical hemipelvectomy should be performed. Limb-saving procedures endanger patient's life. Early and frequent second-look operations and aggressive management of associated pelvic injuries minimize wound healing prob-

lems and septic complications. Successful rehabilitation is possible in this patient group.

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