0022-5282/90/3007-0848$02.00/0
THE JOURNAL OF TRAUMA
Vol. 30, No. 7

Pelvic Ring Disruptions: Effective Classification System and Treatment Protocols

ANDREW R. BURGESS, M.D.*, BRIAN J. EASTRIDGE, M.D.,† JEREMY W. R. YOUNG, M.D.†, T. SCOTT ELLISON, M.D.*, P. STRIBLING ELLISON, JR., M.D.*, ATTILA POKA, M.D.*, G. HOWARD BATHON, M.D.*, AND ROBERT J. BRUMBACK, M.D.*

From January 1, 1985, to September 10, 1988, 210 consecutive patients with high-energy pelvic ring disruptions (exclusive of acetabular fractures) were admitted to a statewide referral center for adult multiple trauma. They were treated by one of four attending orthopaedic traumatologists per protocol as determined by their injury classification and hemodynamic status; the injury classification system was based on the vector of force involved and the quantification of disruption from that force, i.e., lateral compression, anteroposterior compression, vertical shear, and combined mechanical injury. Of the 210 patients, 162 had complete charts: 126 (78.0%) were admitted directly from the scene, 110 (67.9%) were injured in motor vehicle or motorcycle accidents, 25 (15.0%) were admitted in shock (blood pressure <90 mm Hg), the average Glasgow Coma Score was 13.2, and the average Injury Severity Score was 25.8. Treatment of the pelvic fracture included the following methods (alone or in combination): acute external fixation (45.0; 28.0%), open reduction/internal fixation (22; 13.5%), acute arterial embolization (11; 7.0%), and bedrest (68; 42.0%). Overall blood replacement averaged 5.9 units (lateral compression, 3.6 units; anteroposterior compression, 14.8 units; vertical shear, 9.2 units; combined mechanical, 8.5 units). Overall mortality was 8.6% (lateral compression, 7.0%; anteroposterior, 20.0%, vertical shear, 0%; combined mechanical, 18.0%). The cause of death was associated with the pelvic fracture in less than 50%; no patient with an isolated or vertical shear pelvic injury died. We conclude that the predictive value of our classification system (incorporating appreciation of the causative forces and resulting injury patterns) and our classification-based treatment protocols reduce the morbidity and mortality related to pelvic ring disruption.

Pelvic ring disruptions have traditionally been equated with relatively high rates of morbidity and mortality (6, 8, 14, 16, 19, 21). In an effort to identify and thereby to treat disruptions efficiently and effectively, clinicians have over the years devised a multitude of classification systems based on a variety of parameters. In 1938, Watson-Jones (23) classified pelvic fractures according to a combination of type and location factors (crush, avulsion, or sacral/coccyx injuries). Three decades later, Conolly and Hedberg (3) used interruption of the major line of weight transmission as a classification basis. Huittinen and Slatis (10, 11), who emphasized the close relationship between the direction of impact and the pelvic pathology, discussed both high- and low-energy pelvic injuries, including acetabular fractures. Trunkey et al. (22) classified pelvic fractures according to stability (comminuted, unstable, or stable). Looser and Crombie (13) grouped severe pelvic fractures into anterior or posterior fractures. Most of these early classifications were also based on the assumption that all of the pelvic ring pathology had been identified on the initial anteroposterior (AP) films; since this assumption is highly suspect (many subtle injuries of the posterior pelvic ring, especially of the sacrum, are easily missed on plain AP film), the resulting classification systems were also likely to be inaccurate.

Pennal et al. (17, 18) introduced a more systematic approach, incorporating the role of the force of injury and its direction. They described pelvic disruptions as lateral compression (LC), anteroposterior compression (APC), and vertical shear (VS) injuries. Tile (20) later modified this system by adding a "stability" component (stable, stable vertically but unstable rotationally, and unstable both rotationally and vertically).

From the *Shock Trauma Center, Maryland Institute for Emergency Medical Services Systems and the †University of Maryland Medical Systems, Baltimore.
Presented at the Third Annual Scientific Session of the Eastern Association for the Surgery of Trauma, Naples, Florida, January 1990.
Address for reprints: Andrew R. Burgess, M.D., Chief, Orthopaedics, Shock Trauma Center/MIEMSS, 22 S. Greene St, Baltimore, MD 21201-1595.

Young et al. (25, 26) also devised a modification (hereinafter termed the Young classification system) of the Pennal system; they incorporated subsets of the LC and APC groups to quantify the amount of force applied to the pelvic ring and they devised a fourth category, combined mechanical (CM) injury, to incorporate pathology that resulted from a combination of forces and/or directions, and therefore could not be strictly classified as either AP, LC, or VS injuries. As does the Tile system, the Young system addresses acetabular fractures separately. The Young classification system enables clinicians to develop a system of pattern recognition that serves three functions: 1) it increases clinicians' ability to note frequently missed lesions, particularly of the posterior ring; 2) it provides a predictive index for both local and distal associated injuries and for the resulting resuscitative requirements [a conclusion validated by Dalal et al. (7)]; and 3) it enables clinicians to reduce the morbidity and mortality through selection of the most appropriate treatment based on accurate pathology identification and the patient's overall profile and hemodynamic status.

MATERIALS AND METHODS

Injury Identification.

According to the Young classification system, pelvic disruptions are divided into LC, APC, VS, and CM categories. In addition, both the LC and APC categories have subsets (I, II, and III) based on the increasing severity of the injury produced by increasing force magnitude. The importance of accurately identifying these fractures, in terms not only of categories but also of subsets, is that doing so also indicates the type and severity of associated visceral and vascular injuries, both locally and distally. Table I provides the "key" or "signature" elements for differentiating these patterns.

Diagnosing these injury patterns according to the Young classification system depends on a radiographic protocol that includes a standard series of three films (lateral cervical spine, chest, and AP pelvis) supplemented by additional pelvic views when the AP view reveals pelvic ring pathology: inlet and outlet views as described by Pennal (17, 18) and Tile (20) [Judet views (12) define acetabular pathology]. According to this protocol, the anterior pathology (best elucidated by the inlet view) is assessed first, followed by the posterior pathology. Each category exhibits a characteristic type of anterior pathology; the posterior pathology generally provides the subset distinction within each category. (Computed tomography of the pelvic ring is valuable to occasionally elucidate subtle posterior ring injuries but is infrequently necessary to guide classification and acute treatment.)

LC injuries

The LC injury is one of "implosion": lateral impact to the innominate bone occurs either directly or via the proximal femur and iliac crest; simultaneously, the pelvis on the side of impact rotates toward the midline. The "anterior" pelvic ligaments [anterior sacroiliac (SI), sacrotuberous, and sacrospinous ligaments] and the local vasculature (internal iliac vessels and their tributaries) are shortened rather than subjected to tensile or shear forces; if major, named vessels are disrupted, the direct cause is usually a fracture fragment. If hemorrhage occurs, the unviolated ligaments of the pelvic ring provide a "tamponade" effect by not permitting expansion of the pelvis beyond its preimpact diameter.

TABLE I
Injury classification keys

Category	Common Characteristic	Differentiating Characteristic
LC-I	Anterior transverse Fx (pubic rami)	Sacral compression on side of impact
LC-II	Anterior transverse Fx (pubic rami)	Crescent (iliac wing) Fx
LC-III	Anterior transverse Fx (pubic rami)	Contralateral open-book (APC) injury
APC-I	Symphyseal diastasis	*Slight* widening of pubic symphysis and/or SI joint; stretched but intact anterior and posterior ligaments
APC-II	Symphyseal diastasis or anterior vertical Fx	Widened SI joint; disrupted anterior ligaments; intact posterior ligaments
APC-III	Symphyseal diastasis or anterior vertical Fx	Complete hemipelvis separation, but no vertical displacement; complete SI joint disruption; complete anterior and posterior ligament disruption
VS	Symphyseal diastasis or anterior vertical Fx	Vertical displacement anteriorly and posteriorly, usually through SI joint, occasionally through iliac wing and/or sacrum
CM	Anterior and/or posterior, vertical and/or transverse components	Combination of other injury patterns: LC/VS or LC/APC

The anterior pathology in LC injuries may be unilateral, contralateral, or bilateral, involving one or more sets of pubic rami, but one set of rami will always have a transverse fracture pattern. The posterior pathology differentiates the subsets.

a) **LC-I.** LC-I injury combines the typical anterior component with a compression injury to the sacrum on the side of impact (Fig. 1). For example, a well defined transverse fracture pattern of the left pubic rami would lead the clinician to a systemic search for a certain subset of posterior pathology, most frequently a compression fracture of the sacrum. Often, these fractures are missed on the initial AP views and best evaluated on the inlet view by careful examination of the radiographic boundaries of the sacral foramina. Interruption of the smooth, unbroken contour of the foraminal borders indicates LC-I injury.

b) **LC-II.** LC-II injury has the typical anterior fracture pattern common to all LC injuries and a crescent fracture (see below), created by a lateral force fracturing the iliac wing at or near the anterior border of the SI joint (Fig. 2), the remainder of the ilium having rotated medially from this point at the time of impact, leaving a small crescent-shaped segment of posterior ilium firmly attached to the sacrum via the strong posterior SI ligaments. This type of LC injury (transverse anterior fracture and medial rotation injury of the iliac wing) is classified as a LC-II injury.

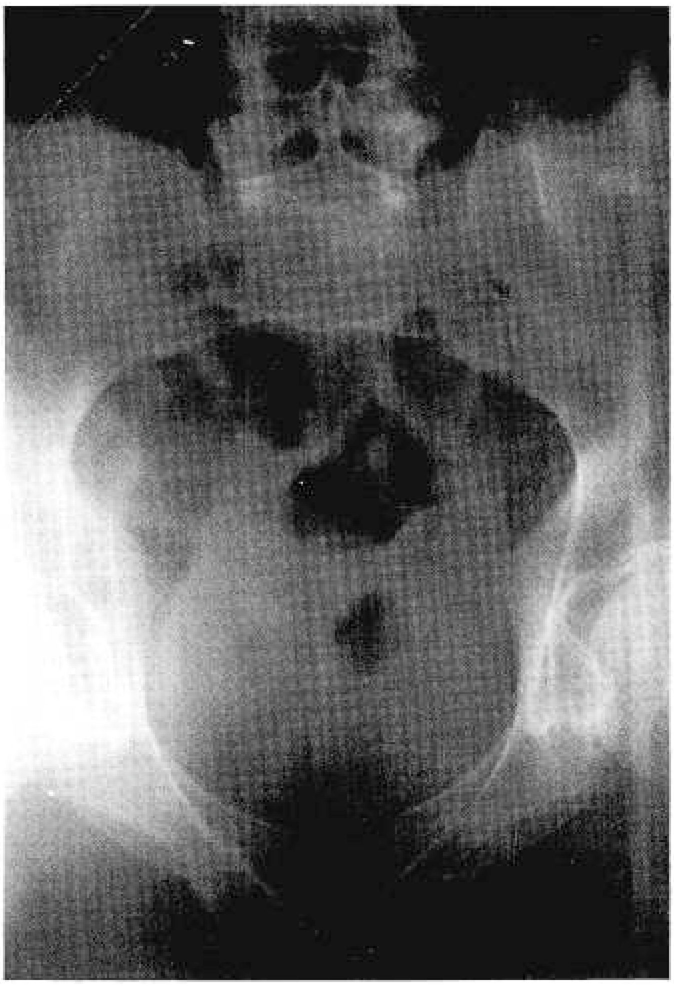

FIG. 1. LC-I injury.

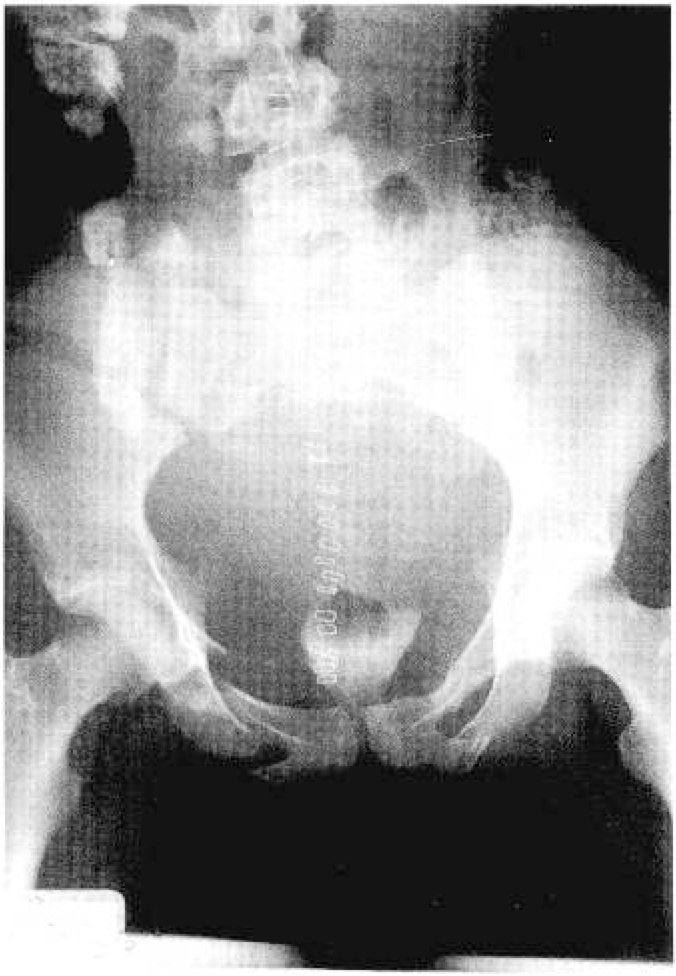

FIG. 2. LC-II injury.

The crescent fracture, produced by LC (internal rotation) forces to the pelvic ring, manifests as a distinctive posterior iliac wing segment that remains attached to the sacrum (Fig. 3). Its crescent shape is composed of two edges, the relatively straight edge being the anterior fracture line and the curved edge being the most posterior portion of the iliac crest up to and including both posterior iliac spines; frequently, the curved edge also includes the most posterior portion of the roof of the greater sciatic notch. The fracture pattern thus created spares the posterior SI ligaments, forming a strong connection between the sacrum and the fragment. We have found this distinctive fracture pattern only in the LC-II and LC-III categories. VS injuries occasionally produce a lesion similar to the crescent fracture, but in that case the large anterior portion of the innominate bone is obviously vertically displaced on the initial AP radiographs.

c) **LC-III.** LC-III injury has a direct LC-I or LC-II injury on the side of impact, but the greater force involved creates an additional contralateral "open-book" (APC) injury (Fig. 4). This injury profile, that may or may not include a crescent fracture, may be produced by an extremely high-velocity, "pure impact" force or by a "roll-over" mechanism, such as when a pedestrian is struck and then rolled over by a motor vehicle. In other words, the LC-III injury is one of both initial impact and secondary crush (or extremely high-velocity pure impact). This type of injury is also known as a "windswept" pelvis: the hemipelvis on the side of lateral impact rotates internally and the contralateral hemipelvis rotates externally.

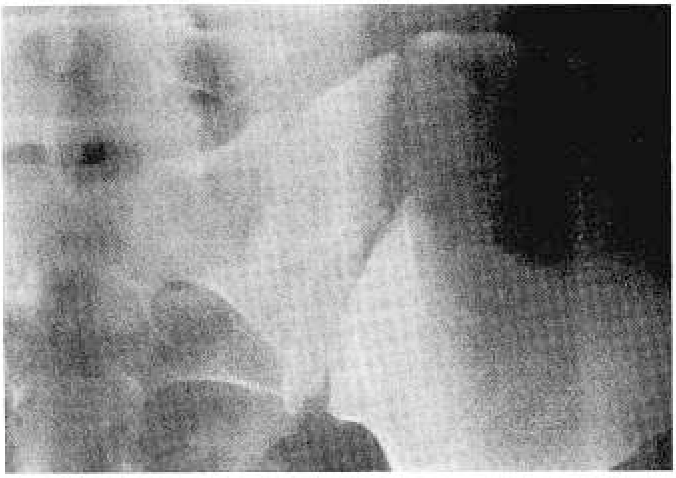

FIG. 3. Crescent fracture.

APC injuries

APC injury demonstrates a pubic symphysis diastasis or an anterior vertical fracture pattern of the rami; there is no cephalad shift of the hemipelvis. The posterior pathology, usually the extent of SI joint disruption, defines the subsets.

If the initial reading of the radiographic examination demonstrates either a widening of the pubic symphysis or a longitudinal (vertical) fracture through the pubic rami, the posterior

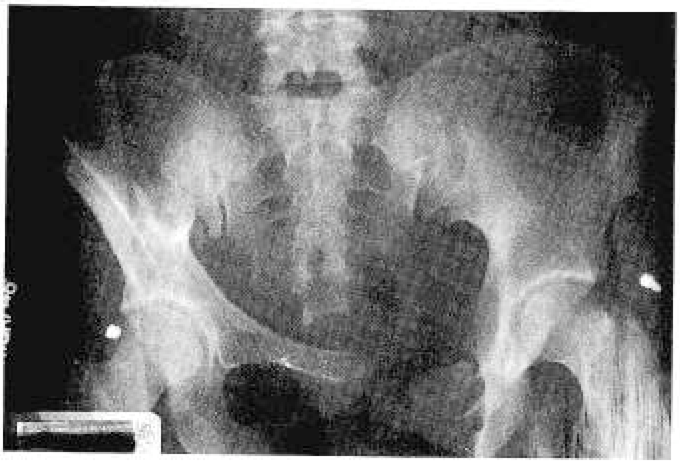

FIG. 4. LC-III injury.

elements are examined systematically, searching for one of the typical patterns of APC injury. Careful evaluation of the posterior pelvic ring will then reveal one of two types of posterior pelvic pathology, both disruptions of the SI joint. The radiographs of the pelvis, especially the AP and inlet views, are evaluated to determine the extent of any disruption to the SI joint, whether the injury is confined to an anterior widening (the posterior SI ligaments intact) or the entire joint is disrupted (all ligaments). In the lesser injury, only the anterior SI joint is open; in the more severe injury, the entire SI joint is disrupted (without vertical displacement, however). The Young subdivisions of these APC patterns are based on the amount of disruption of the SI joint as a function of these radiographic findings.

a) **APC-I.** These injuries are rare in our experience, and there are none in this series of high-energy pelvic ring disruptions. They correspond in many ways to the Type 1 injuries described by Bucholz (1). The impact to the pelvis is from the front or back, creating a slight widening of the pubic symphysis (1 to 2 cm) and perhaps of one SI joint. This slight external rotation of the innominate bone will not increase with time, and it is verified by physical examination; the pelvis will not demonstrate any instability to external rotation when an examiner attempts to "open" it. The ligaments of both the anterior SI joint and the floor of the pelvis (sacrotuberous and sacrospinous) are not violated but perhaps are stretched, as suggested by Bucholz's Type 1 classification (1).

b) **APC-II.** This injury results from a force to the victim's front or back that widens the SI joint anteriorly; the affected anterior SI ligaments are violated, as are the ipsilateral sacrotuberous and sacrospinous ligaments. The strong posterior SI ligamentous complex is not disrupted, giving this injury its "open-book" character (Fig. 5). Because tearing the sacrotuberous, sacrospinous, and anterior SI ligaments requires considerable force, an obviously widened anterior SI joint is a good radiographic marker for serious injury to the soft tissue and visceral structures in close anterior juxtaposition to the anterior SI joint, in particular the branches of the internal iliac vessels and the lumbosacral nervous plexus.

c) **APC-III.** The most severe AP injury, APC-III, represents complete separation of the hemipelvis from the remainder of the pelvic ring, including the opposite innominate and sacrum. Radiographically, the posterior pelvic ring pathology includes complete disruption of the SI joint, both anteriorly and posteriorly (Fig. 6). It is differentiated from severe VS injuries by the fact that the hemipelvis is not vertically displaced on the initial film and that the history is consistent with AP crush, etc. In this type of injury, severe local visceral and vascular pathology accompanies the complete disruption of the posterior

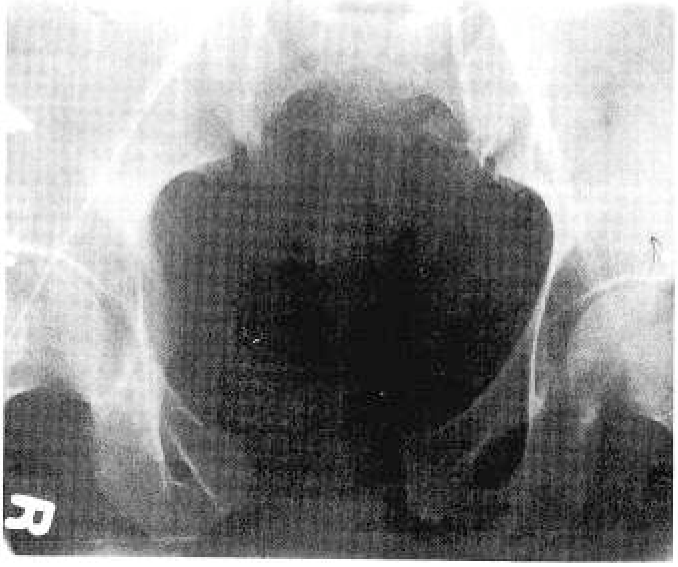

FIG. 5. APC-II injury.

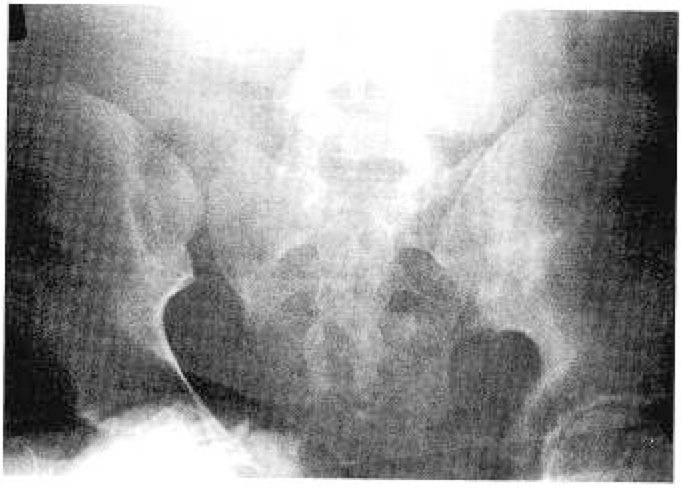

FIG. 6. APC-III injury.

ligamentous elements. In addition, when local hemorrhage occurs, tamponade is often limited because the disrupted checkreins permit continuing expansion of the unbound, unrestricted retroperitoneal space.

VS injuries

VS injury has a symphyseal diastasis or a vertical fracture pattern of the rami anteriorly but is usually distinguished anteriorly and posteriorly by vertical displacement of the hemipelvis (Fig. 7). The anterior injury is frequently through the symphysis, and the posterior injury is often through the SI joint, although occasionally a vertically displaced iliac wing or sacral fracture, or combination of the two, occurs.

VS injuries may be unilateral or bilateral. They also have a history consistent with violent axial loading of the hemipelvis, such as a fall from a height or axial loading of an extended limb during rapid deceleration, ejection off a motorcycle, or "submarining" underneath a vehicle restraint system. Although the vertical displacement of the hemipelvis can be seen on the initial AP views, pure cephalad displacement is often best shown on the outlet view, while the inlet view best shows "posterior" displacement.

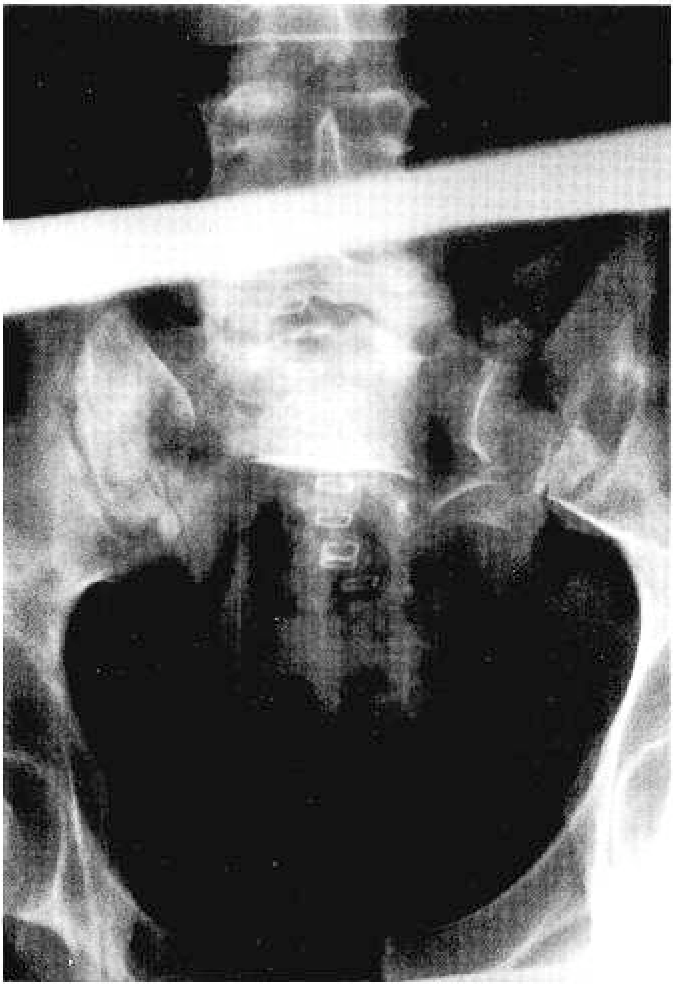

FIG. 7. VS injury.

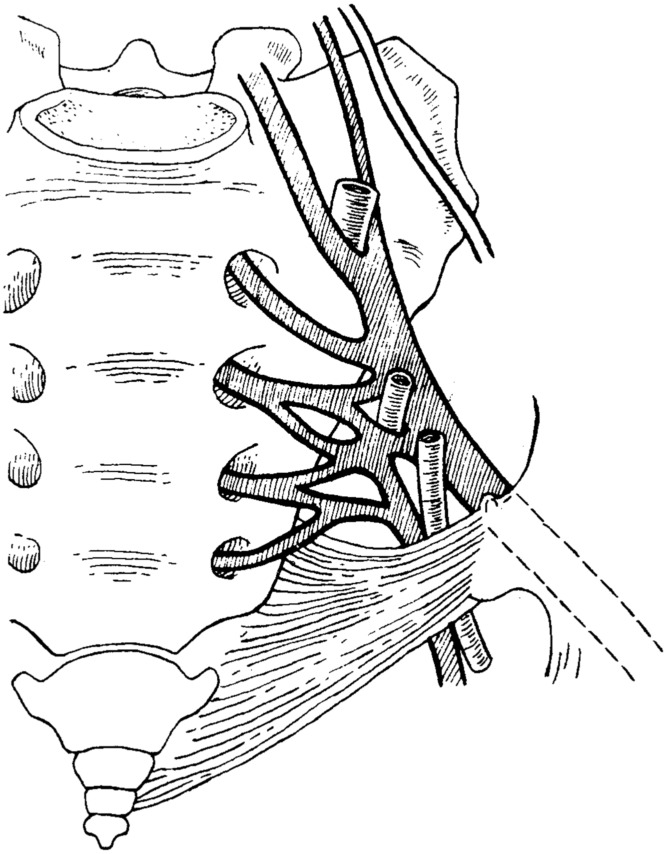

FIG. 8. Artist's drawing showing the proximity of the internal iliac vessels and the elements of the lumbosacral plexus to the anterior SI joint. [Adapted from Grant (9).]

TABLE II
Mechanisms of injury by fracture type*

Etiology	LC			APC		VS	CM	IWF	Totals (%)
	I	II	III	II	III				
MVA	53	7	11	5	0	4	4	8	92 (56.8)
MCA	5	0	1	6	3	1	2	0	18 (11.1)
Ped.	11	2	2	4	2	0	3	0	24 (14.8)
Fall	7	2	0	1	1	3	2	2	18 (11.1)
Crush	2	1		2	1	1	0	0	8 (4.9)
Other	1	0	0	0	0	0	0	1	2 (1.2)
Totals	79	12	15	18	7	9	11	11	162
(%)	(48.8)	(7.4)	(9.3)	(11.1)	(4.3)	(5.6)	(6.8)	(6.8)	

* The abbreviations used are: MVA, motor vehicle accident; MCA, motorcycle accident; Ped., vehicular/pedestrian accident; IWF, iliac wing fracture.

CM injuries

In any classification system there will be some elements that do not strictly fit the given categories. In the Young system, the CM category accommodates injuries occurring from blunt trauma in other than pure AP, lateral, or vertical modes, e.g., an injury to the hemipelvis that laterally compresses or "implodes" the pelvic ring while slightly displacing it vertically. Thus, because the CM injury results from a combination of forces (APC and LC or, more frequently, LC and VS), the anterior ring pathology pattern also varies.

Significance of the Fracture Pattern to Surrounding Structures.

The radiographic pattern also serves as a marker for the type and direction of injurious forces delivered to the surrounding visceral structures and the vasculature of the pelvis, specifically, the internal iliac vessels and their tributaries. The tearing, shearing forces responsible for disruption of the anterior SI ligaments and the sacrotuberous ligaments injure the local viscera and vessels in the same manner. Figure 8 demonstrates the proximity of the internal iliac vessels and the elements of the lumbosacral plexus to the anterior SI joint. The most severe type of APC injury, as described by Young et al., is a complete disruption of the SI joint from AP-directed forces (APC-III). In this type of injury, frequently the result of crush injuries, the complete disruption of the posterior ligamentous elements is accompanied by severe local visceral and vascular injuries. In addition, with the ligamentous injuries suffered in APC-I and APC-II injuries, when local hemorrhage occurs from tensile forces on the retroperitoneal vasculature, tamponade is often difficult, because the ligamentous checkreins preventing expansion of the pelvis beyond its original boundaries are disrupted, permitting continued hemorrhage into an unrestrained retroperitoneal space.

Patient Population. From January 1, 1985, to September 10, 1988, 210 consecutive patients with high-energy pelvic ring disruptions (exclusive of acetabular fractures) were admitted to our statewide referral center for adult multiply injured patients. "High-energy" was defined as a force of high magnitude or velocity, such as generated by motor vehicle accidents, vehicular/pedestrian accidents, motorcycle accidents, falls from a height, and crushing injuries (Table II). Maryland State trauma triage protocols (15), as well as this study's design, excluded low-energy injury etiologies such as a pelvic fracture suffered by an elderly individual tripping on the sidewalk. For purposes of this study, high-energy pelvic ring disruption was defined as any fracture which interrupted the pelvic ring through both anterior and posterior portions of the ring. For the sake of completeness, we also included all isolated iliac wing fractures that resulted from high-energy blunt trauma; these relatively infrequent fractures did not interrupt the weight-bearing struts of the pelvic ring but usually resulted from severe blunt injury primarily to the abdomen and/or thorax.

Of the 210 patients, 162 had complete records for our review, forming our study group. Of the 162, 110 (67.9%) were injured in vehicular accidents (Table II), 126 (77.8%) patients were admitted directly from the accident scene, and 25 (15.0%) were admitted in clinical shock (systolic pressure <90 mm Hg) (Table III). The average Injury Severity Score (ISS) was 26 (Table III) and the average Glasgow Coma Score (GCS) was 13.7. Each patient had an average of 0.9 additional orthopaedic injuries and 1.6 associated nonorthopaedic injuries (Tables IV & V).

The 162 pelvic fractures were classified acutely according to the Young system (24): LC-I, 79 (48.7%); LC-II, 12 (7.4%); LC-III, 15 (9.3%); AP-I, 0; AP-II, 18 (11.1%); AP-III, 7 (4.3%); VS, 9 (5.6%); CM, 11 (6.8%); and isolated iliac wing fracture, 11 (6.8%).

Treatment.

Protocols. All patients included in this study had blunt trauma and those treated at the scene were managed according to state protocols as described in the Maryland EMS Manual (15). In-hospital treatment followed the Advanced Trauma Life Support guidelines of the American College of Surgeons (2) and protocols specific to the MIEMSS Shock Trauma Center (4, 5). Pneumatic antishock garments were used for transport only and removed in-hospital upon establishment of adequate intravenous access. (If necessary, they were used as a temporary "pneumatic external fixator" until definitive acute external fixation was applied.) Evaluation and treatment of emergent life-threatening conditions coincided with initial patient survey by physical examination (including manual examination of the pelvic ring for rotational stability) and radiographic studies (lateral cervical spine, chest, and AP pelvic radiographs). Pelvic ring disruptions were further evaluated using inlet and outlet views. (Acetabular injuries present on the initial radiograph were further evaluated using iliac and obturator oblique radiographs and computed tomography; these fractures, however, were excluded from this study.) The attending orthopaedic traumatologist then classified the pelvic ring disruption according to the Young system and selected the appropriate treatment based on that classification by fracture type.

Modalities. Treatment of the pelvic fracture often involved more than one modality; the choice of modality depended on a protocol incorporating factors such as the time since injury (admitted from the scene versus a transferred patient), the patient's associated injuries, and the patient's hemodynamic status, as well as the pelvic fracture pattern (Table VI). Interventions (used alone or in combination) included acute external fixation, traction, open reduction/internal fixation (ORIF), and acute arterial embolization.

a) **External fixation.** Patients with no interruption of the anterior or posterior ligamentous complexes, i.e., LC-I and LC-II, were treated with either bedrest (LC-I) or bedrest/delayed ORIF (LC-II).

Patients with injuries that interrupted the anterior SI ligaments and sacrotuberous, sacrospinous complex (APC-II) were treated with acute external fixation (placed within the first 4 hours after injury, usually less than 2 hours).

Patients with injuries that completely interrupted the posterior pelvic ring, i.e., VS and APC-III, were treated with acute application of external fixation.

Patients with complex disruptions of the ring, i.e., LC-III and CM injuries, were treated based on the primary injury to the pelvic ring and the patients' hemodynamic status.

b) **Exceptions to Acute External Fixation.** There are three general categories of exceptions. 1) Patients with intact ligamentous elements (LC-I and LC-II) were treated with acute external fixation if they demonstrated prolonged hemodynamic

TABLE III
Patient demographics*

Parameter	LC I (79)	LC II (12)	LC III (15)	APC II (18)	APC III (7)	VS (9)	CM (11)	IWF (11)
Age (yrs)	31.1 (14–87)	27.9 (16–42)	34.0 (16–84)	35.5 (16–70)	29.3 (20–37)	33.4 (18–48)	34.6 (15–76)	27.6 (14–58)
Race (W)	68 (86.1%)	10 (83.4%)	13 (86.7%)	14 (77.7%)	6 (85.7%)	9 (100%)	8 (72.7%)	10 (90.9%)
Sex (M)	37 (46.8%)	6 (50.0%)	12 (80.0%)	17 (94.4%)	7 (100%)	9 (100%)	9 (81.8%)	8 (72.7%)
GCS	13.5 (3–15)	13.1 (7–15)	11.9 (3–15)	14.5 (13–15)	9.1 (3–15)	13.4 (7–15)	11.0 (3–15)	14.5 (11–15)
ISS	21.3 (4–66)	34.4 (16–57)	37.7 (16–75)	25.5 (4–45)	46.2 (17–66)	30.6 (13–57)	36.1 (22–66)	18.9 (8–43)
Scene†	63 (79.7%)	11 (91.7%)	12 (80.0%)	9 (50.0%)	6 (85.7%)	6 (66.7%)	9 (81.8%)	10 (90.9%)
BP > 90‡	73 (92.4%)	11 (91.7%)	14 (93.3%)	12 (66.7%)	3 (42.8%)	8 (88.9%)	7 (63.6%)	9 (81.8%)
HR > 100§	42 (53.2%)	8 (67.7%)	10 (67.7%)	10 (55.5%)	4 (57.2%)	5 (55.5%)	9 (81.8%)	5 (45.5%)

* The abbreviations used are: IWF, iliac wing fracture; BP, blood pressure; HR, heart rate.
† Admitted directly from the scene; total = 126 (78.0%).
‡ Admission blood pressure > 90; total = 137 (85.0%).
§ Admission heart rate > 100; total = 93 (57.0%).

TABLE IV
Associated nonorthopaedic injuries*

Injury	LC I (79)	LC II (12)	LC III (15)	APC II (18)	APC III (7)	VS (9)	CM (11)	IWF (11)	Totals (162) (% of pts)
CHI	48	11	10	13	5	5	8	7	107 (66.1)
H/pneumo.	9	4	5	0	1	3	0	4	26 (16.1)
Bladder	11	3	4	2	3	0	2	1	26 (16.1)
Pulmonary	9	1	2	1	0	0	1	1	15 (9.3)
Spleen	4	1	3	2	1	1	0	3	15 (9.3)
Retro. hema.	3	1	4	0	2	2	1	1	14 (8.6)
Bowel	2	1	4	1	0	2	0	0	11 (6.8)
Liver	5	0	0	0	1	0	1	2	9 (5.6)
Renal	3	1	1	0	1	0	1	2	9 (5.6)
Diaphragm	4	0	1	1	0	0	0	1	7 (4.3)
Urethra	2	1	1	1	0	0	1	0	6 (3.7)
Other†	0	2	1	3	3	0	2	0	11 (6.8)
Totals	100	26	36	24	16	15	16	23	256
Average/Pt	1.3	2.2	2.4	1.3	2.3	1.7	1.5	2.1	1.6

* The abbreviations used are: IWF, iliac wing fracture; CHI, closed head injury; H/pneumo., hemo/pneumothorax; Retro. hema., retroperitoneal hematoma.

† Includes 3 perineal tears (AP-II), 2 ovarian ruptures (LC-II and CM), and 1 each of the following: aortic rupture, stomach rupture, pancreatic transection, SMV, femoral artery and vein tear, and internal iliac tear.

TABLE V
Associated orthopaedic injuries

Injury	LC I (79)	LC II (12)	LC III (15)	APC II (18)	APC III (7)	VS (9)	CM (11)	IWF* (11)	Totals (162) (% of pts)
Femur	8	2	4	2	2	1	5	0	24 (14.8)
Radius	6	3	2	3	0	1	2	1	19 (11.7)
Spine	8	1	0	5	0	2	0	2	18 (11.1)
Tib/fib	9	0	1	2	1	1	2	0	16 (9.9)
Clavicle	9	2	0	0	0	0	2	1	14 (8.6)
Ulna	7	0	2	2	0	0	1	1	13 (8.0)
Humerus	4	2	0	2	1	1	0	1	11 (6.8)
Ankle	4	1	2	1	0	2	1	0	11 (6.8)
Foot	2	2	1	0	0	3	2	1	11 (6.8)
Tibia	2	1	0	2	0	0	1	0	6 (3.7)
Shoulder	3	0	1	1	0	0	0	0	5 (3.7)
Fibula	3	0	0	1	0	0	1	0	5 (3.1)
Totals	65	14	13	21	4	11	17	7	152
Average/Pt	0.8	1.2	0.9	1.2	0.6	1.2	1.5	0.6	0.9

* The abbreviation used is: IWF, iliac wing fracture.

instability or a complex of associated injuries that would benefit from early and aggressive mobilization. 2) Patients who by protocol would have received external fixation (APC-II, APC-III, and VS) were treated with anterior ORIF if concurrent laparotomy permitted. 3) Patients who by protocol would have received acute external fixation (APC-II, APC-III, and VS) were treated conservatively (bedrest/delayed ORIF) if they had been interhospital transfers, had remained hemodynamically stable for more than 12 hours since injury, and had required little or no blood replacement.

c) **Angiography and Embolization.** In patients who were thought to have serious retroperitoneal hemorrhage secondary to their pelvic injury, acute external fixation was the primary treatment. If there was no response (stabilization of vital signs, decreased fluid requirements), pelvic angiography was performed. Any important sites of arterial hemorrhage were embolized.

d) **Traction.** Traction was used primarily to treat concurrent orthopaedic injuries or as a temporizing measure for the treatment of posterior pelvic ring instability when satisfactory reduction of posterior displacement could not be achieved.

RESULTS

This patient population had an average ISS of 25.8 and an average GCS score of 13.2. The overall mortality rate was 8.6%: 7/106 (6.6%) patients with LC injuries died, 5/25 (20.0%) patients with APC injuries died, and 2/11 (18.2%) patients with CM injuries died; no patient with a VS or iliac wing injury died. In this study, the mortality rate was highest in APC injuries. Of the 14 patients who died, the pelvic and locally related injuries were thought to be primarily responsible for death in two, contributory to death in ten, and unrelated to death in two.

In nonsurvivors with LC injuries, the average ISS was 54, the average GCS was 4.7, and the average blood replacement in the first 24 hours was 5.8 units; the principal cause of death was closed head injury, although pelvic injury had some contribution in four of the seven deaths; the pelvic injury was the principal cause of death in one of the seven. In nonsurvivors with APC injuries, the average ISS was 39, the average GCS score was 10.2, and the average blood replacement was 28.4 units; the primary cause of death was a combination of visceral and pelvic injury. In nonsurvivors with CM injuries, the average ISS was 49, the average GCS score was 9, and the average blood replacement was 11.5 units; the primary cause of one death was the pelvic injury and that of the second death was a combination of closed head, visceral, and pelvic injuries.

By the protocols outlined above, 45 patients required acute external fixation; 39 (86.7%) patients survived. For the survivors, the average ISS was 30.7, the average GCS score was 13.6, and the average blood replacement in the first 24 hours was 7.0 units. The six patients treated with external fixation who died had an average ISS of 45.3, an average GCS score of 7.7, and an average blood replacement in the first 24 hours of 25.8 units.

Overall blood replacement averaged 5.9 units: LC, 3.6 units; APC, 14.8 units; VS, 9.2 units; CM, 8.5 units.

DISCUSSION

LC Injuries. LC-I injuries are usually relatively stable since the sacral compression fracture is compacted. Occasionally, however, the sacrum "disimpacts" and one notes slight motion when compressing the pelvis from the anterior superior iliac spines. In general, these fractures were treated nonoperatively with a short period of bedrest and early mobilization with weight-bearing permitted on the side with the uninjured posterior elements,

TABLE VI
Blood replacement, interventions, and mortality*

Parameter	LC I (79)	LC II (12)	LC III (15)	APC II (18)	APC III (7)	VS (9)	CM (11)	IWF (11)	Totals (162) (% of pts)
Blood replacement									
0–24 hr	2.4	2.8	5.7	6.4	20.4	7.8	7.1	4.5	
24–48 hr	0.3	0.3	1.7	1.2	15.0	1.6	1.5	0.5	
Totals	2.7	3.1	7.4	7.6	35.4	9.4	8.6	5.0	5.9 (ave.)
Interventions (alone or in combination)									
Bedrest	52	2	2	3	1	0	1	7	68 (42.0)
PASG	18	5	6	5	6	2	2	3	47 (29.0)
Ex. fix.	6	3	5	13	6	6	6	0	45 (28.0)
Traction	6	1	6	2	1	5	2	1	24 (14.8)
ORIF	1	5	2	5	0	4	5	0	22 (13.5)
Embolization	1	0	1	2	3	2	2	0	11 (7.0)
Prot. colost.	0	0	0	3	0	0	1	0	4 (2.5)
H-pelvectomy	0	0	0	0	1	0	0	0	1 (0.6)
Mortality†	4	1	2	2	3	0	2	0	14 (8.6)

* The abbreviations used are: IWF, iliac wing fracture; Ex. fix., external fixation; H-pelvectomy, hemipelvectomy; Prot. colost., protective colostomy; PASG; pneumatic antishock garment.

† The mortality by fracture type was: LC: 7/106 (6.6%), 7/14 (50.0%), 7/162 (4.3%); APC: 5/25 (20.0%), 5/14 (35.7%), 5/162 (3.1%), CM: 2/11 (18.2%); 2/14 (1.4%), 2/162 (1%).

provided the patient's other injuries permitted early ambulation. If the patient had severe multiple injuries and/or was hemodynamically unstable, an external fixator was placed to permit early mobility for nursing care. In this study, six (7.5%) of 79 patients with LC-I fractures were treated with external fixation because of this multiple injury profile (average ISS for the six LC-I patients treated with external fixation = 32.3; average ISS for all patients with LC-I injuries = 21.3%).

LC-II injuries are defined by a typical fracture of the posterior portion of the iliac wing and as such are less stable to internal rotation than LC-I injuries. As isolated skeletal injuries, they are best fixed by techniques of ORIF, but in a patient with multiple injuries and/or hemodynamic instability, external fixation was used to provide temporary fixation of the pelvic ring.

ORIF of these injuries was performed on an elective basis if displacement of the fracture fragments or overall management of the patient necessitated it. ORIF of LC-II was contraindicated for two primary reasons: 1) local wound/skin conditions, secondary to either the injury or pin tract problems from an earlier fixator; 2) prohibition of elective surgical repair secondary to other injuries.

LC-III injuries were treated with external fixation for acute hemodynamic instability, multiple injuries requiring early and aggressive mobilization, and/or concurrent serious local associated injuries such as ruptured bladder.

ORIF was used if closed reduction and/or external fixation could not achieve good reduction of the pelvic ring.

APC Injuries. By the Young classification system, APC injuries have injury to the SI joint, either anteriorly (APC-II) or both anteriorly and posteriorly (APC-III). These SI injuries plus the disruption of the sacrotuberous and sacrospinous ligaments render APC injuries unstable to external rotation. With the potential for associated vascular damage as discussed above and the inability of the pelvis unstable to external rotation to aid in tamponade, control of the pelvic ring by reduction and fixation is necessary. External fixation is the method of choice for acute treatment of both APC-II and APC-III injuries (19/25). ORIF of anterior pelvic disruptions (symphysis diastasis) is performed acutely only if there is a concurrent laparotomy for intraperitoneal injury. ORIF is not used in this situation if a superpubic cystostomy is to be used.

Only the APC-II injuries are definitively treated by external fixation or symphysis plating. Ideally, APC-III injuries would have posterior fixation (anterior SI plating, iliosacral screw placement, sacral bars) to fix the completely disrupted SI joint. Such posterior fixation is done electively when patient condition and local wound/skin conditions permit. Previous experience has demonstrated that posterior stabilization would often not be possible under the criteria listed above. Therefore acute stabilization by external fixation often became the definitive treatment. External fixation placed in the very acute stage, before hematoma blocks the reduction, permits a good "interference fit" of the disrupted posterior elements and external fixation can maintain posterior reduction in spite of its biomechanical limit.

VS Injuries. Patients with VS injuries and hemodynamic instability/multiple injuries were treated acutely with external fixation (6/9; 66.7%); 2/6 underwent delayed ORIF. Hemodynamically stable patients with VS injuries (3/9, 33.3%) were treated acutely with traction; 2/3 underwent delayed ORIF.

CM Injuries. Most CM injuries had a primary component, i.e., LC, etc., treated according to protocols above.

CONCLUSIONS

The literature reports mortality rates for pelvic injuries ranging from 10.1 to 19.1% for similar patient populations (6, 8, 14, 16, 19, 21). The overall mortality for patients in this study was 8.6%. This study emphasizes that treatment protocols based on accurate identification and classification of pelvic fractures lead to reduced mortality.

REFERENCES

1. Bucholz, R. W.: The pathological anatomy of Malgaigne fracture-dislocations of the pelvis. *J. Bone Joint Surg.*, **63-A:** 400–404, 1981.
2. Committee on Trauma, American College of Surgeons: *Advanced Trauma Life Support Manual.* Chicago, American College of Surgeons, 1981.
3. Conolly, W. B., Hedberg, E. A.: Observations on fractures of the pelvis. *J. Trauma,* **9:** 104–111, 1969.
4. Cowley, R A., Conn, A., Dunham, C. M. (eds): *Trauma Care.* Philadelphia, Lippincott, 1987.
5. Cowley, R A., Dunham, C. M. (eds): *Shock Trauma/Critical Care Manual: Initial Assessment and Management.* Baltimore, University Park Press, 1982.
6. Cryer, H. M., Miller, F. B., Evers, B. M., et al.: Pelvic fracture classification: Correlation with hemorrhage. *J. Trauma,* **28:** 973–980, 1988.
7. Dalal, S. A., Burgess, A. R., Siegel, J. H., et al.: Pelvic fractures in multiple trauma: Classification by mechanism is key to pattern of organ injury, resuscitative requirements and outcome. *J. Trauma,* **29:** 981–1002, 1989.
8. Evers, B. M., Cryer, H. M., Miller, F. B.: Pelvic fracture hemorrhage: Priorities in management. *Arch. Surg.*, **124:** 422–424, 1989.
9. Grant, J. C. B.: *A Method of Anatomy, Descriptive and Deductive,* ed 6. Baltimore, Williams & Wilkins, 1958.
10. Huittinen, V.-M., Slatis, P.: Fractures of the pelvis: Trauma mechanism, types of injury and principles of treatment. *Acta Chir. Scand.*, **138:** 563–569, 1972.
11. Huittinen, V.-M., Slatis, P.: Nerve injury in double vertical pelvic fractures. *Acta Chir. Scand.*, **138:** 571–575, 1972.
12. Letournel, E., Judet, R.: *Fractures of the Acetabulum (edited and translated by Elson, R.A.).* New York, Springer-Verlag, 1981.
13. Looser, K. G., Crombie, H. D., Jr.: Pelvic fractures: An anatomic guide to severity of injury. Review of 100 cases. *Am. J. Surg.*, **132:** 638–642, 1976.
14. McMurtry, R., Walton, D., Dickinson, D., et al.: Pelvic disruption in the polytraumatized patient: A management protocol. *Clin. Orthop.*, **151:** 22–30, 1980.
15. MIEMSS: *The Maryland Way: EMT-A Skills Manual.* Baltimore, MIEMSS, 1984.
16. Peltier, L. F.: Fractures of the pelvis: A report of eighty cases treated at university hospitals. *Minn. Med.*, **38:** 563–564, 1951.
17. Pennal, G. F., Davidson, J., Garside, H., et al.: Results of treatment of acetabular fractures. *Clin. Orthop.*, **151:** 115–123, 1980.
18. Pennal, G. F., Tile, M., Waddell, J. P., et al.: Pelvic disruption: Assessment and classification. *Clin. Orthop.*, **151:** 12–21, 1980.
19. Rothenberger, D. A., Fischer, R. P., Strate, R. G., et al.: The mortality associated with pelvic fractures. *Surgery,* **84:** 356–361, 1978.
20. Tile, M. *Fractures of the Pelvis and Acetabulum.* Baltimore, Williams & Wilkins, 1984.
21. Tile, M.: Pelvic ring fractures: Should they be fixed? *J. Bone Joint Surg.*, **70-B:** 1–12, 1988.
22. Trunkey, D. D., Chapman, M. W., Lim, R. C., Jr., et al.: Management of pelvic fractures in blunt trauma injury. *J. Trauma,* **14:** 912–923, 1974.
23. Watson-Jones, R.: Dislocations and fracture-dislocations of the pelvis. *Br. J. Surg.*, **25:** 773–781, 1938.
24. Young, J. W. R., Burgess, A. R.: *Radiologic Management of Pelvic Ring Fractures: Systematic Radiographic Diagnosis.* Baltimore, Urban & Schwarzenberg, 1987.
25. Young, J. W. R., Burgess, A. R., Brumback, R. J., et al.: Pelvic fractures: Value of plain radiography in early assessment and management. *Radiology,* **160:** 445–451, 1986.
26. Young, J. W. R., Burgess, A. R., Brumback, R. J., et al.: Lateral compression fractures of the pelvis: The importance of plain radiographs in the diagnosis and surgical management. *Skeletal Radiol.*, **15:** 103–109, 1986.