Pelvic Fracture from Major Blunt Trauma

Outcome Is Determined by Associated Injuries

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Pelvic hemorrhage has been implicated as the cause of death in 50% of patients who die following pelvic fractures. To establish correlates of morbidity and mortality from pelvic fractures due to blunt trauma, we reviewed 236 patients treated during 4 years. The average age of the 144 men and 92 women was 31.5 years, the average Injury Severity Score was 21.3, the average blood requirement was 5 units, and the average hospital stay was 16.8 days. One hundred fifty-two patients (64.4%) were injured in motor vehicle accidents, 33 (14%) had motor vehicle-pedestrian accidents, 16 (6.8%) had crush injuries, 12 (5.1%) each had either motorcycle accidents or falls, and 11 (4.6%) had miscellaneous accidents. Eighteen patients (7.6%) died, with seven (38.9%) deaths due to hemorrhage. Only one death was caused by pelvic hemorrhage. Other deaths were due to hemorrhage from other sites (6), head injury (5), sepsis or multiple-organ failure (4), pulmonary injury (1), and pulmonary embolus (1). None of the septic deaths was related to a pelvic hematoma. Multivariate multiple regression analysis showed that the severity of injury was correlated with indices of severity of pelvic fractures such as fracture site ($p < 0.0001$), fracture displacement ($p < 0.005$), pelvic stability ($p < 0.0001$), and vector of injury ($p < 0.01$). However death could not be predicted on the basis of these indices of severity ($p > 0.28$). Of the nine patients who underwent pelvic arteriography, three required embolization of actively bleeding pelvic vessels, but seven had intra-abdominal hemorrhage that required laparotomy, and eight developed a coagulopathy. Massive bleeding from pelvic fractures was uncommon, and the major threat of hemorrhage was from nonpelvic sites. Furthermore, although injury severity was correlated with the severity of the pelvic fracture, hospital outcome was determined by associated injuries and not by the pelvic fracture.

THE PELVIS POSSESSES exceptional inherent strength and major external forces are required to fracture the normal pelvis. The large volume of highly vascular cancellous bone and the anatomic proximity of major blood vessels makes severe hemorrhage the most dreaded immediate complication of pelvic fractures. Recent reports incriminated hemorrhage as the cause of death in about one half of patients who died following pelvic fractures.[1,2]

The considerable forces necessary to fracture the pelvis are often delivered to other areas of the body. Associated injuries are therefore common, and these injuries may contribute significantly to the outcome of patients with pelvic fracture. Because in our experience exsanguination from the pelvis was an uncommon event, we tried to determine the correlates of morbidity and mortality in our patients with pelvic fracture. This was accomplished through a 4-year retrospective review of our experience with this clinical problem.

Materials and Methods

The medical records of all patients admitted to the University of Mississippi Medical Center (UMC) from January 1986 through December 1989 with a diagnosis of pelvic fracture were reviewed. Only those patients with pelvic fracture from blunt trauma who were initially admitted to our hospital were included in the study. Patients who were evaluated and stabilized in another hospital before transfer to our facility were included, but those who were admitted to another hospital, underwent more extensive treatment, and were later transferred to UMC were excluded. Also excluded were patients with penetrating wounds to the bony pelvis, those with pathologic fractures of the pelvis, and patients with avulsion fractures or fractures of only the acetabular rim.

In addition to demographic information and mechanism of injury, a number of criteria that reflected the se-

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verity of injury were recorded for each patient. These criteria included systolic blood pressure, respiratory rate, and Glasgow Coma Score in the emergency room; revised Trauma Score; volume of asanguinous resuscitation fluids received in the emergency room; blood transfusions received during the first 48 hours; duration of hospital stay; number of days in the intensive care unit; cause of death, if applicable; total hospital charges; associated injuries and Abbreviated Injury Scale (AIS) scores for each anatomic system;[3] and Injury Severity Score (ISS) calculated by the method of Baker et al.[4] The site to which the patient was discharged was recorded as home, other (rehabilitation facility, other hospital, or nursing home), or death.

Pelvic roentgenograms were reviewed on all patients. In addition to standard anterior–posterior views, inlet and outlet views of the pelvis were obtained in all but a few patients. In most instances computed tomography of the pelvis was performed as well. The vector of pelvic injury was determined from a consideration of the fracture pattern as well as from the mechanism of injury. The major vector of injury was classified into one of the following categories as defined by Pennal et al.,[5] and Young et al.[6]: anterior–posterior compression; lateral compression; and vertical shear. When there appeared to be at least two vectors of injury, the fracture was classified as caused by 'multiple forces.' Impaction injuries were defined as fractures in which the femoral head was impacted into the acetabulum without any involvement of the rest of the pelvis. When the vector of injury could not be determined it was listed as 'unknown.' Most of the latter were isolated pubic or ischial ramus fractures. Each pelvic fracture also was classified as open or closed. An open fracture was defined as one in which the skin overlying the fracture was violated, or in which there was an injury to the rectum or vagina. Fractures associated with injuries to the urinary bladder or urethra were considered to be closed. The anatomic segment of the pelvis that was involved by the fracture was recorded. These categories were acetabulum, ilium, ischium, pubis, sacrum, or multiple sites. The maximal displacement of the fracture fragments or the gap between separated elements of the pelvis was measured and categorized as none, mild (less than 1 cm), moderate (1 to 2 cm), or severe (more than 2 cm). Finally each fracture was classified as either stable or unstable. An unstable fracture was defined as one in which the pelvic ring would not be stable with weight bearing because of involvement of the anterior elements (pubis and or ischium) as well as loss of integrity of the posterior elements, either osseous or ligamentous.

During the period of review, the standard management of patients with pelvic fracture at UMC was resuscitation with lactated Ringer's solution and blood if needed. All patients had roentgenograms of the cervical spine, chest, and pelvis. Additional films of the spine, extremities, and urinary system were obtained if clinically indicated. Patients with obvious or suspected head injuries underwent computed tomography. In addition to clinical examination, the abdomen was evaluated by diagnostic peritoneal lavage by a supraumbilical approach, or by computed tomography if the patient was hemodynamically stable. Patients with a red blood cell count of more than 100,000/mL or a white blood cell count of more than 500/mL, or clinical or radiographic evidence of visceral injury requiring repair underwent exploratory celiotomy. If a pelvic hematoma was present it was not entered. Patients with unstable or displaced pelvic fractures had an external fixator applied in the operating room. If this did not control bleeding in the pelvis, or if the volume of bleeding was too great to respond to osseous fixation, arteriography was performed in angiography. Actively bleeding vessels were embolized with autologous clot, gelatin sponge, or coils.

All data were recorded on a custom database on an IBM personal computer (Armonk, NY). Statistical analysis was performed using SAS software (SAS Institute Inc., Cary, NC) running on an IBM mainframe computer. Continuous data were tested by t tests, analysis of variance, or regression analysis, as appropriate. Categoric data were evaluated by chi square tests. Multivariate multiple regression (canonical) analysis was used to calculate the individual and collective contribution of multiple independent factors on combined outcome criteria. A type I error probability of 0.05 was established as the minimal level of significance.

Results

During the 48-month period of review, 305 patients with pelvic fractures were admitted to UMC. Sixty-nine patients were excluded for the following reasons: 34 were transferred from another hospital from 1 to 60 days after injury; 19 patients had a fracture of the acetabular labrum or an avulsion fracture as the only pelvic fracture; 8 had penetrating wounds of the bony pelvis; 6 patients had pathologic fractures. Two records could not be found. Of the remaining 236 patients, there were 144 men (61%) and 92 women; their mean age was 31.5 years (range, 1 to 86 years). Almost two thirds were injured in motor vehicle accidents, and only one of these—an elderly man with a fracture of the dome of the acetabulum—was wearing a seatbelt. Thirty-three pedestrians were struck by a motor vehicle, 16 patients were crushed, 12 each were injured in motorcycle accidents or falls, and 11 were injured in miscellaneous accidents (bicycle *versus* motor vehicle, all-terrain vehicle, and boating accidents). The mean ISS was 21.3. Blood transfusions were not needed in 85 patients (36%). The 151 patients who required blood

TABLE 1. *Patient Characteristics by Mechanism of Injury*

Mechanism	Motor Vehicle	MV–Pedestrian	Crush	Motorcycle	Fall	Miscellaneous
Number (%)	152 (64.4)	33 (14)	16 (6.8)	12 (5.1)	12 (5.1)	11 (4.6)
Age (yrs)	30.4	32.0	44.2*	27.6	45.9*	17.6
Revised trauma score	11.0	10.3	11.8	10.8	11.9	11.4
ISS	21.6	26.2	17.4*	21.4	12.1*	17.4
Units of blood in first 48 hours	4.8	6.7	4.4	8.2	2.9*	1.8*
Hospital days	16.9	16.8	17.8	20.4	13.7	13.2
Hospital charges	$18,348	$18,437	$17,251	$25,692	$8182	$13,196
Deaths (% of group)	10 (6.6)	5 (15.2)	0 (0)	2 (16.7)	1 (8.3)	0 (0)

* $p < 0.05$.

ISS, Injury Severity Score; MV, motor vehicle.

received 1 to 48 units, with a mean transfusion volume of 7.8 units. Hospital stay averaged 16.8 days.

When examined by mechanism of injury (Table 1), patients injured in falls and crushing accidents tended to be older and had lower ISS values and smaller transfusion requirements than other patients. Those with injuries from miscellaneous causes were younger than the other patients because this group included several children injured in bicycle-motor vehicle collisions. Their ISS values and the number of units of blood administered to them were less than in patients in motor vehicle, motorcycle, or motor vehicle *versus* pedestrian accidents. The greatest probability of death was in the last two categories, but the differences in mortality rates were not significant. There were no significant differences among the groups with regard to revised Trauma Score, hospital charges, or duration of hospital stay.

Eighteen of the 236 patients died (mortality rate, 7.6%), and of these, seven deaths (38.9%) were caused by hemorrhage. One patient with a severely comminuted open pelvic fracture died of irreversible shock from pelvic exsanguination, despite successful embolization of an arteriographically demonstrated bleeding vessel. Five patients died from abdominal hemorrhage caused by massive visceral or vascular injuries, and one patient exsanguinated from a traumatic above-knee amputation with contralateral open fractures of the femur and tibia. Of the 11 deaths not caused by hemorrhage, 5 patients died from head injuries, 2 died of sepsis, 2 from multiple-organ failure, 1 from respiratory failure due to a severe pulmonary contusion, and 1 from a pulmonary embolus, despite appropriate prophylaxis. Only one of the patients whose death was caused by abdominal hemorrhage had a pelvic hematoma, but the volume of blood in the pelvis was small compared to the massive blood loss from rupture of the abdominal aorta. None of the deaths from sepsis or multiple-organ failure were related to the pelvic fracture. All four patients had major cavitary hemorrhage and a head injury; their pelvic hematomas were small or nonexistent.

Nine patients with severe hemorrhage underwent arteriography for evaluation of suspected bleeding from the pelvic fracture. Only three of them had active bleeding from a pelvic vessel, and these were embolized successfully. Two patients survived and one died of irreversible shock. All six patients without active pelvic bleeding survived; all of them had a pelvic hematoma, but three were only small or moderate in size. Of the nine patients who underwent pelvic arteriography, seven had significant intra-abdominal bleeding that required celiotomy for control. Injuries were to the spleen (3 patients), liver (3 patients), and small bowel mesentery (2 patients). Three patients had pelvic arteriograms before peritoneal lavage because their bleeding was thought to be from their severe pelvic fractures. Arteriograms were negative in all three, but celiac and mesenteric injections were not performed. Eight of the nine patients in whom pelvic arteriograms were obtained developed a coagulopathy because of major hemorrhage and volume replacement, and their coagulopathy probably contributed to small-vessel and medullary bleeding into the pelvis.

Indices of injury severity were analyzed with regard to the following aspects of the pelvic fractures: anatomic site, vector of injury, maximal fracture displacement, and stability. Patients with fractures in multiple geographic areas of the pelvis had more severe injuries than patients with fractures in only one area. The only exceptions were that patients with acetabular fractures had higher AIS scores for the face than did patients with multiple fractures, and there were no differences among groups in Glasgow Coma Score or AIS scores for the head/neck and external systems. Patients whose pelvic fractures were confined to the acetabulum, ilium, pubis, or ischium had very similar values for all criteria of injury severity.

Compared to those with anterior–posterior compression, impaction, and unknown vectors of injury, patients with multiple force injuries had the highest requirement for crystalloid resuscitation, the lowest systolic blood pressure, the greatest hospital charges, and the longest duration of hospitalization ($p \leq 0.03$). Along with patients with vertical shear injuries, they also had the highest AIS scores for the abdomen and the highest ISS values ($p \leq 0.0001$). Other differences among groups were not great, and because of large variances were not statistically significant. There were no significant differences in any of the injury severity criteria between patients with lateral compression, vertical shear, or multiple force injuries.

The amount of displacement of the pelvic fracture was roughly correlated with injury severity criteria, but the differences were inconsistent and were primarily between patients with no fracture displacement and those with either moderate or severe displacement. Instability of the pelvic fracture was the best predictor of injury severity. As shown in Table 2, there were substantial differences between patients with stable pelvic fractures and those with unstable fractures, with the latter having more severe associated injuries.

Multivariate multiple regression analysis demonstrated that stability of the pelvis had the highest correlation with injury severity criteria ($r = 0.56$, $p < 0.0001$). Site(s) of the fracture had the next highest correlation ($r = 0.51$, $p < 0.001$), but its predictive ability was reduced because it could distinguish only between patients with fractures in either one anatomic area of the pelvis or fractures in more than one area. Correlations of injury severity with displacement of the fracture ($r = 0.41$, $p < 0.005$) and with the vector of injury ($r = 0.42$, $p < 0.01$) were significant but contributed little to predictive capability. If site and stability of the pelvic fracture were known, their combined correlation with injury severity criteria was increased slightly to 0.59 ($p < 0.0001$). Adding displacement did not improve prediction ($r = 0.60$, $p < 0.0001$). Similarly, if displacement and stability were known ($r = 0.59$, $p < 0.0001$), adding vector of injury did not alter the ability to predict injury severity ($r = 0.58$, $p < 0.0001$). Because of a close relationship between fracture site and vector of injury, it was not possible technically to evaluate by canonical analysis any contribution of these two variables in combination to predicting injury severity.

TABLE 2. *Injury Severity Criteria and Pelvic Fracture Stability*

Criteria	Stable	Unstable
Systolic BP	114.1	101.8*
Glasgow Coma Score	13.8	13.6
Revised Trauma Score	11.1	10.6
Units of blood in first 48 hours	2.6	5.6*
Crystalloid volume (mL)	1477.0	2668.4*
ICU days	1.1	3.7*
Hospital days	14.8	22.5*
Hospital charges	$14,051.8	$28,720.2*
AIS, abdomen	0.67	1.93*
AIS, chest	0.91	1.33*
AIS, extremities	2.72	3.81*
AIS, face	0.41	0.26
AIS, head/neck	1.13	1.43
AIS, external	0.96	1.08
ISS	18.08	29.67*

* $p < 0.05$.

BP, blood pressure; ICU, intensive care unit; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score.

TABLE 3. *Injury Severity Criteria and Discharge Site*

Criteria	Discharge Site		
	Home	Other*	Death
Systolic BP	114.4	104.3	74.1†
Glasgow Coma Score	14.2	12.9	8.8†
Revised Trauma Score	11.4	10.0	6.9†
Units of blood in first 48 hours	2.1	5.7	17.4†
Crystalloid volume (mL)	1583.0	2728.9‡	3429.0†
ICU days	1.4	2.8	4.7‡
Hospital days	17.0	29.7‡	6.1†
Hospital charges	$16,582.7	$32,773.0‡	$24,543.8
AIS, abdomen	0.91	0.83	2.12‡
AIS, chest	0.89	2.08‡	1.82‡
AIS, extremities	2.94	3.50‡	3.41‡
AIS, face	0.30	0.58	1.12‡
AIS, head/neck	1.01	1.92	3.00‡
AIS, external	0.94	1.50	1.35
ISS	18.54	29.75‡	45.24†

* Other: rehabilitation facility, nursing home, or other hospital.

† Different from home, other.

‡ Different from home.

BP, blood pressure; ICU, intensive care unit; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score.

As would be expected, final disposition was closely related to indices of injury severity (Table 3). Patients who died had the most severe injuries, those who were discharged to home had less severe anatomic injuries and physiologic derangements, and those who were discharged to a rehabilitation facility or to a nursing home tended to have injuries of intermediate severity. When outcome was evaluated with regard to the severity of the pelvic fracture, there was no association between any aspect of the pelvic fracture and final disposition. Vector of injury ($p = 0.29$), amount of fracture displacement ($p = 0.57$), site of pelvic fracture ($p = 0.77$), and pelvic stability ($p = 0.94$), either individually or collectively, could not predict whether a patient would live, die, or have a significant disability.

Discussion

Pelvic fracture has been recognized for decades as a serious injury associated with high mortality rates. The considerable forces that are required to fracture the pelvis also involve other areas of the body, resulting in many associated injuries. Despite these injuries, massive hemorrhage within the pelvis has received a great deal of attention as one of the major consequences of pelvic fractures. This bleeding can originate from exposed cancellous bone and injured soft tissue at the fracture sites, or from veins or arteries that traverse the pelvis. Under normal circumstances the blood is contained within the pelvis between the parietal peritoneum superiorly and the strong fibromuscular and bony walls of the pelvis. If these barriers are violated by the wounding forces or at surgery, the bleeding no longer will be contained and exsanguination can occur. This accounts for the high mortality rate associated with open pelvic fractures[7,8] and also for the dismal results associated with attempts to achieve hemostasis by either direct surgical control of bleeding vessels or bilateral hypogastric artery ligation. Despite initial enthusiasm for these techniques,[9,10] individual ligation of bleeding vessels in pelvic hematomas is almost never technically feasible,[11] and attempts to do so will breach the peritoneum, which contains the hematoma. The rich collateral flow of blood within the pelvis prevents hypogastric artery ligation from being effective. More than 20 years ago Burchell[12] showed that ligation of both hypogastric arteries reduced mean arterial pressure in the distal arteries by only 24%, and on the basis of a review of the literature, Patterson and Morton[13] concluded that hypogastric artery ligation was of no value in the control of hemorrhage associated with pelvic fractures.

Pneumatic antishock garments[14] and fracture fixation with an external frame[15] have been promoted as techniques to reduce bleeding from pelvic fractures by providing tamponade, apposing the fracture fragments, and reducing the volume of the pelvis. The placement of packs would have similar effects but would require a celiotomy and secondary operations to remove the packs. Although these techniques are clearly helpful in some patients with significant hemorrhage from pelvic fractures, when bleeding originates from major arteries the only effective technique is a direct approach to the vessels. As stated above, a direct surgical approach is neither easy nor wise, but a transvascular approach allows the surgeon to avoid the problems inherent in entering the hematoma. Angiographic demonstration and control of bleeding from pelvic fractures was first proposed by Athanasoulis et al.[16] in 1971, and following its first reported use in 1972 by Margolies et al.,[17] this technique has become the standard approach for control of persistent arterial bleeding associated with pelvic fractures. Although successful embolization and control of pelvic hemorrhage can be achieved, the reported mortality rate following transcatheter embolization varies from 35% to 89%.[18-22] Most of the deaths are caused by associated injuries, not by the pelvic fracture. When embolization failure occurs, it is almost always in association with a severe secondary coagulopathy.

Cryer et al.[1] tried to predict the probability of major bleeding in pelvic fractures by classifying them into discrete categories of 'stable' or 'unstable.' They defined instability as a gap or displacement of the pelvic fracture of more than 0.5 cm, without regard to whether there was any mechanical instability of the pelvis. They found that they could predict with 90% certainty that 50% to 69% of patients with an unstable pelvic fracture would require at least a four-unit blood transfusion. Nearly one half of the patients with an unstable pelvic fracture had an associated intra-abdominal injury. When these patients were excluded from analysis, the authors reported that there was still 'a moderate to good correlation'[1] between pelvic fracture instability and blood transfusion requirements, but certainly some of the blood losses in their patients were from extrapelvic sites of injury. Furthermore their classification system did not define a group of patients with pelvic fractures who were not at risk for major bleeding because up to one fourth of patients with stable pelvic fractures would need four or more units of blood.

Trunkey et al.[23] showed that more severe pelvic fracture patterns are associated with a greater number and severity of associated injuries. Similar conclusions were reached by other investigators[24-26] using classification schemes of varying complexity. The common determinant of injury severity and morbidity in each of these studies was instability of the pelvic fracture, but most of the deaths in their patients were caused by associated injuries and were not due to the pelvic fracture.

In this study we corroborate that the pelvic fracture is a marker of injury severity and further demonstrated that the pelvic fracture, regardless of severity, does not determine the final outcome. Most pelvic fractures are relatively straightforward and require no specific treatment other than bedrest and analgesics. These fractures are usually caused by low-intensity forces and are associated with few and relatively minor injuries to other anatomic areas. Larger forces from high-speed motor vehicle accidents or crushing injuries result in increased pelvic fracture complexity, which is correlated with an increased risk of complications and a greater probability of more severe associated injuries.

The number of anatomic units of the pelvis that have been fractured and the amount of displacement of those fractures can be determined easily by a review of standard pelvic roentgenograms, with little interobserver variability for these parameters. Pelvic fractures that involve multiple areas of the pelvis and greater amounts of displacement of the fractures are associated with more severe injuries to other areas of the body. These more complex fractures are more likely to be mechanically unstable, and the highest correlate of injury severity is the presence of pelvic instability. Loss of stability by disruption of the strong posterior elements of the pelvic arch requires the transmission of major forces to the pelvis, and this is associated with the delivery of similar forces to other areas of the body, especially the head, chest, and abdomen. The severity of injuries to these areas determines the outcome from injury in most patients. Stability or instability of the pelvis can be implied from pelvic roentgenograms, but this is also a clinical determination that usually is readily apparent. It is somewhat more difficult to categorize the mechanistic vector of injury to the pelvis. The classification system first proposed by Pennal and Sutherland[27] has been modified to enhance its precision and has been very useful in explaining the patterns of fractures associated with various directions of energy transmission to the pelvis. Dalal et al.[25] developed an elaborate classification system for pelvic fractures based on vector and severity of injury to the pelvis. They reported that the mechanism (vector) of injury was related to the pattern of associated organ injuries, blood losses, and outcome. Unfortunately not all pelvic fractures can be classified accurately as to vector of injury; there is a moderate degree of variability of classification among observers. This probably accounts for the lower correlations that we observed between injury vector and injury severity criteria than with other aspects of the pelvic fracture. It is noteworthy that the most severe pelvic fractures in the series reported by Dalal et al.[25] were also the most unstable, emphasizing the fact that loss of pelvic stability is highly correlated with overall injury severity, as we demonstrated.

The fact that indices of severity of the pelvic fracture correlated with indices of injury severity, but not with final hospital outcome was an unexpected finding. This emphasizes that a diligent search must be made for other injuries in patients with pelvic fractures, and the more severe the pelvic fracture, the more likely the patient will have severe injuries to other anatomic areas. These injuries usually can be identified by physical examination and standard diagnostic studies in the trauma patient, such as chest roentgenograms, peritoneal lavage, or computed tomography. Unless the patient is clearly bleeding from the pelvis, and not from some other site, these injuries must take priority over the pelvic fracture. This approach is supported by Moreno et al.[2] and by Evers et al.,[18] who advocated celiotomy in all patients with pelvic fractures who have grossly positive peritoneal lavage. When the lavage is negative, or is positive by red cell count, they recommended that patients who were hemodynamically unstable should have the pelvis stabilized by placement of an external frame. Patients who continued to have pelvic bleeding after this maneuver should undergo arteriography.

Massive hemorrhage from the pelvis almost invariably originates from named arteries. Although tamponade with a pneumatic antishock garment or fracture stabilization with an external fixator may provide some benefit, all of these patients will require arteriography, with embolization of actively bleeding vessels. Such injuries are uncommon and usually seen with open pelvic fractures. Patients with relatively large pelvic hematomas often have normal pelvic arteriograms with no evidence of ongoing hemorrhage. This may be due to tamponade of the bleeding by a contained hematoma, but in our experience this scenario often is caused by a coagulopathy due to major cavitary hemorrhage, shock, and hypothermia. The pelvic hemorrhage is from cancellous bone and the surrounding soft tissues. It cannot be identified by arteriography and persists because of the coagulopathy. The appropriate treatment is to search for and control bleeding from the chest, abdomen, or other sites while simultaneously resuscitating the patient from shock and replacing platelets and coagulation proteins. Warming intravenous fluids in the trauma room is important to prevent or reverse hypothermia, which contributes to coagulopathy, but the best way to warm the patient is to restore visceral perfusion and thereby support metabolism. Early pelvic fracture stabilization should be performed to prevent the complications of prolonged bedrest. Although the application of an external frame might reduce the amount of bleeding from cancellous bone, it cannot be expected to provide significant benefit if the bleeding originates from major pelvic vessels or continues because of a coagulopathy.

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Discussions

Dr. Louis Britt (Memphis, Tennessee): Dr. Rhodes has done an outstanding job, not only in analyzing these patients but also in presenting this unbelievable mass of data. I think you are to be congratulated on your mortality rate of 7%, which is about one half that reported by Drs. Fabian and Fox from our institution.

I am uncertain about the cause of this. We think this discrepancy is either because you are better doctors or there is a problem in our classification. Would you define what you consider an open pelvic fracture? Because 43% of our pelvic fractures were open; therefore the bleeding, and so forth, was into other areas.

Second I certainly agree, and it has been our experience that most deaths have been due to associated injuries. You stated in your conclusions that the major hemorrhage comes from named arteries. You only had three named arteries embolized in 9 of 239 patients arteriogramed. I think this leads us to the issue that we have all talked a great deal about: arterial embolization and pelvic angiography.

I wonder if you could tell me what the place of this is, not only in the diagnosis but also in the treatment of these patients. Sometimes we get involved with the technology and our good sense gets away from us.

Finally we have found something that we think is very significant in the last couple of years, and that is external fixation. We believe this has reduced the pelvic hemorrhage.

One of the most important things Dr. Rhodes has done, in addition to a lot of hard work, is that he has stressed that the pelvic fracture does not kill patients; rather it is the associated injuries that cause deaths. And when patients are in shock we should look outside the pelvis for another source of hemorrhage.

Dr. Anthony Meyer (Chapel Hill, North Carolina): I would like to congratulate the authors on an excellent paper and the use of multivariate analysis to try to identify the factors that contribute to survival from pelvic fractures.

I have three questions. First what criteria did you use for arteriography: absolute blood loss, rate of transfusions, or any evidence of hemodynamic instability?

Second did you have any protocols for either the evaluation, such as using abdominal or pelvic computed tomography or treatment, such as when you would use external fixation?

Third what was the frequency of severe coagulopathy or profound hypothermia in your series overall? Because these are, obviously, contributing factors in these patients, as you mentioned, on whom did you perform arteriography?

One of the things that struck me the most was the fact that only one of those patients was wearing a seat belt, which might prompt some question as to the value of seat belts for vehicular passengers.

Dr. Lewis Flint (New Orleans, Louisiana): Let me preface my questions by stating that on two previous occasions we presented data concerning pelvic fractures to this group. The last time was this past year. And in both of those presentations, we stressed the use of a multimodality evaluation approach that identified in priority those sites of bleeding outside the pelvis, followed by the injuries that are common to the genitourinary system, then the pelvic bleeding.

In your manuscript, it implies, at least, that you took a different approach, in that you tried to identify the pelvic bleeding site before you identified the extrapelvic bleeding sites.

We think that may be the wrong order in which to do things, and I wonder if the coagulopathy that you implied was a contributor to the pelvic hemorrhage in some of your patients may have been encountered because of delay in dealing with the extrapelvic bleeding sites.

I'm not quite sure—maybe you can clarify for me—what is the bottom-line message of your paper. If it is that we need to have a highly disciplined approach to these injuries and that extrapelvic bleeding sites are important determinants of the outcome, then I agree with you completely.

But if your thesis is that the site of the bleeding in the pelvis is not important a factor in the outcome of these injuries, then we have some grounds for disagreement. Perhaps you could clarify that in your closing.

Dr. Galen V. Poole (Closing discussion): Dr. Britt, I do not think that the difference in mortality rate has anything to do with the quality of the physicians. To some extent it may be because we were very vigorous in identifying all patients with pelvic fractures, even those with fairly minor injuries to the pubic rami and things of that nature, which may not have been coded in your own series or those of others or may not have been included although they were identified. We may have had a larger proportion of relatively minor injuries that would not be associated with significant injuries to nonpelvic sites.

An open fracture, by our definition, was one that involved the overlying skin, the rectum, or the vagina. We did not include those that involved the bladder or other areas of the genitourinary system because, in most circumstances, those areas would be sterile. There would be very little contamination that would involve them, and patients were not likely to have a greater incidence of death from pelvic hemorrhage if they had an injury to the bladder compared to those with other closed fractures.

You asked what the role of hemorrhage was and how we identified the patients who would have arteriography.

If a patient seemed to be bleeding to death, had no blood in the chest, no external sites of hemorrhage from extremities, a negative lavage or lavage that was positive only by counts, then that was a patient who probably was bleeding into the pelvis.

This is not new information, and we are not trying to present anything revolutionary. We are re-emphasizing the importance of what will cause death in these patients.