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Do patients with multiple system injury benefit from early fixation of unstable axial fractures? The effects of timing of surgery on initial hospital course.

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ABSTRACT

Objectives: We hypothesized that early definitive management (within 24 hours of injury) of mechanically unstable fractures of the pelvis, acetabulum, femur and spine would reduce complications and shorten length of stay.

Design: Retrospective review

Setting: Level 1 trauma center

Patients/Participants: 1005 skeletally-mature patients with ISS≥18 with pelvis (n= 259), acetabulum (n= 266), proximal or diaphyseal femur (n= 569), and/or thoracolumbar spine (n= 98) fractures. Chest (n=447), abdomen (n=328) and head (n=155) injuries were present.

Intervention: Definitive surgery was within 24 hours in 572 patients and after 24 hours in 433.

Main Outcome Measurements: Complications related to the initial trauma episode included infections, sepsis, pneumonia, deep venous thrombosis, pulmonary embolism, acute respiratory distress syndrome (ARDS), organ failure, and death.

Results: Days in ICU and total hospital stay were lower with early fixation (5.1±8.8 vs 8.4±11.1 ICU days (p=0.006); 10.5±9.8 vs 14.3±11.4 total days (p=0.001), after adjusting for ISS and age. Fewer complications (24.0% vs 35.8%, p=0.040), ARDS (1.7% vs 5.3%, p=0.048), pneumonia (8.6% vs 15.2%, p=0.070), and sepsis (1.7% vs 5.3%, p=0.054) occurred with early vs delayed fixation. Logistic regression was used to account for differences in age and ISS between the early and delayed groups. Adjustment for severity of chest injury was included when analyzing pulmonary complications including pneumonia and ARDS.

Conclusions: Definitive fracture management within 24 hours resulted in shorter ICU and hospital stays and fewer complications and ARDS, after adjusting for age and associated injury types and severity. Surgical timing must be determined with consideration of the physiology of the patient and complexity of surgery. Parameters should be established within which it is safe to proceed with fixation. These data will serve as a baseline for comparison with prospective evaluation of such parameters in the future.

Key words: Damage control, early fixation, pelvis fracture, femur fracture, spine fracture

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

INTRODUCTION

Early fixation of mechanically unstable fractures of the femur, pelvis, acetabulum, and spine reduces some complication rates and may be considered the standard of care for stable patients without injury to other body systems.[1-11] However, in patients with multiple injuries the optimal treatment of skeletal trauma is affected by severe injury to the head, chest, and/or abdomen. The influence of associated injury on the timing of definitive management of mechanically unstable fractures is debated.[12-24] The practice of “early total care,” including early definitive fracture management, has been criticized, because additional hemorrhage from surgery may incite a deleterious systemic inflammatory response.[17,19,25,26] The alternative extreme of “damage control orthopedics” (DCO) has been recently proposed as a means of providing provisional stability of major skeletal injury, generally through external fixation.[17,18,20,25-27] It is speculated that DCO will diminish the potential for systemic compromise. However, the need for further (definitive) surgery on a delayed basis several days later, and the possible additional complications and costs associated with this strategy are also controversial.

Mechanically unstable fractures of the pelvis, acetabulum, femur and thoracolumbar spine require bedrest and recumbency until they are stabilized.[28-30] In many cases skeletal traction is temporarily utilized. While definitive fixation of these axial and proximal lower extremity injuries will promote mobilization, the timing of that fixation is influenced not only by the availability of surgeon specialists, but also by associated injuries to other systems. Chest injury is a risk factor for pulmonary complications regardless of timing of fracture care,[1,8,11,12,31-33] and hemorrhage associated with other system injuries contributes to the total amount of blood loss and the risk of systemic inflammation and immune dysfunction.[19,20,22-24,26,27] Damage control orthopedics using external fixation as a temporizing measure has been advocated to reduce complications in some of these groups of patients. However, spine and acetabulum fractures and many pelvic and proximal femoral fractures are not amenable to external fixation. Our general practice has been early definitive management of major skeletal injury in a team-based fashion with emphasis on definitive fixation of femur fractures within 24 hours of injury. We hypothesized that early definitive management of mechanically unstable fractures of the pelvis, acetabulum, femur, and thoracic and lumbar spine would reduce complications and shorten length of hospital stay in patients with injury to multiple systems.

PATIENTS AND METHODS

Over an eight years period, 1005 consecutive skeletally-mature patients with 1192 fractures with multiple system trauma and Injury Severity Score (ISS)[35] greater than or equal to 18 were included. They were treated surgically for mechanically unstable fractures of the pelvis (n= 259), acetabulum (n= 266), proximal or diaphyseal femur (n= 569), and/or thoracolumbar spine (n= 98) at a level I trauma center. Some patients had bilateral fractures or more than one fracture of interest treated surgically. Fractures from a low energy mechanism of injury such as a fall from standing height were excluded. Fractures secondary to neoplasm were also excluded. Demographic information located in Table 1. The study group consisted of 712 men and 293 women with a mean age of 38.2 years (range 16 to 88) and mean ISS of 30.6 (range 18 to 66). Timing of definitive surgical treatment for these fractures was within 24 hours in 572 patients (defined as early fixation) and after 24 hours of injury in 433 patients. The total number of each type of fracture is listed in Table 2. When patients were treated for more than one fracture of interest, the time of completion of the final definitive fixation was used. Other extremity fractures which could be splinted were not included in the analysis of fracture timing, whether treated in the same surgical setting or on a more delayed basis.

Associated injuries of the chest (n=447), abdomen (n=328) and head (n=155) were present (Table 3). Validated scoring systems: the Injury Severity Score (ISS),[35] the

Abbreviated Injury Scores (AIS),[36] and the Glasgow Coma Scale (GCS) were used to grade the severity of injuries. When AIS was less than or equal to 2 the chest and abdominal injuries were defined as minor, whereas when the AIS was greater than 2 they were defined as severe. Differences in types of associated injuries and injury severity were acknowledged during the statistical analyses. Fracture characteristics, associated injuries, medical co-morbidities, and the timing and techniques of provisional treatment and surgical procedures were documented. Transfusion requirements, length of ventilator assistance, length of ICU stay, and length of hospitalization were determined. Complications related to injury and treatment were reviewed, including wound infection, pulmonary complications (adult respiratory distress syndrome (ARDS), pneumonia, pulmonary embolism (PE)), renal failure, multiple organ failure (MOF), and deep venous thrombosis (DVT).

Adult respiratory distress syndrome was defined as PaO_2/FiO_2 ratio of less than 200 for more than four consecutive days with diffuse infiltrates on chest radiographs, in the absence of pneumonia.[37] Pneumonia was defined by plain chest radiograph with a new pulmonary infiltrate in the presence of purulent sputum, temperature greater than 38º Celsius and a white blood count greater than 10,000/mL. [38] Pulmonary embolus was diagnosed by positive ventilation/perfusion scan or spiral computerized tomography of the chest. Multiple organ failure was defined as two or more organs in failure for a minimum of three consecutive days with a score of four or more points.[39] Deep venous thrombosis was documented with venous duplex scanning proximal to the knee.

Statistical analysis was performed with SPSS software, version 20 (SPSS Inc., Chicago, IL). Statistical differences in the clinical outcome measures regarding the timing of surgical repair (early vs late) were assessed by the following statistical tests: Chi Square or Fisher's exact test (categorical data); Mann Whitney U Test (ordinal or nonparametric interval data) or the appropriate/pooled variance t-test based on the F ratio of the variances (parametric interval data). Parametric interval data are defined as having both a kurtosis and skewness between -3 and +3. The SPSS software reports "excess Kurtosis" instead of kurtosis by subtracting 3rd from the 4th moment. Hence the definition per the SPSS package for skewness and kurtosis is both set as "0" for the normal distribution. Thus, our definition for parametric interval data is that it must have both a kurtosis and skewness between -3 and +3. Unadjusted interval level data are reported as means and standard deviations whereas adjusted data are reported as means and standard error (analysis of covariance). Analysis of covariance was used to adjust for advanced age, ISS scores, and presence and severity of chest, abdomen and head injury when analyzing the length of stay, ventilator days and transfusion data. Final models included only the adjustments for age and ISS, as the ISS was considered a summation of the individual injuries and severities. Logistic regression analysis was performed to account for potential confounding variables. The dependent variables were the various complications. The independent variable was the timing of surgery (early v late) with potential confounding variables being presence and severity of head, chest, and abdominal injuries as well as advanced age and ISS. Final models included age and ISS, as well the final models for any pulmonary complications also included severity of chest injury. In all cases, statistical significance was defined a priori as a p<0.05 (two tail). The model fit was assessed by the Hosmer and Lemeshow Test. In all of the logistics models, the Hosmer and Lemeshow Test exceeded 0.05. Multicollinearity was assessed by running the collinearity diagnostic subroutine in the multiple linear regression program. For all four of the models the tolerance was > 0.8 for all independent variables with a VIF < 1.250.

RESULTS

The mean Injury Severity Score was 29.1 ± 9.3 for patients treated within 24 hours of injury, versus 32.5 ± 11.3 when treated after 24 hours ($p=0.001$), and the mean age was 36.2 ± 15.4 years for the early group versus 40.1 ± 16.2 years for the delayed group ($p<0.001$). Patients who were treated more than 24 hours after injury were more likely to be transferred from an outside hospital. 272 of the 572 (47.6%) patients treated early were transferred, versus 251 of the 433 (58.0%) patients treated later who were transferred ($p=0.001$). Mean initial pH and base excess were 7.32 ± 0.09 versus 7.34 ± 0.12, ($p=0.004$); and -5.5 ± 4.3 vs -4.4 ± 5.6, ($p=0.005$); respectively, for early and delayed patients, indicating a greater level of initial acidosis in the early group. The early and delayed fixation groups were not statistically different in terms of gender, ethnicity, mechanism of injury, femur fracture pattern, pelvic OTA fracture classification (types 61-A, B, or C), acetabulum OTA fracture classification (types 62-A, B, or C), although there was a trend for patients with 62-A fractures to be more likely to be treated within 24 hours ($p=0.06$).

The mean hospital stay, ICU stay, and days on the ventilator are presented in Table 4 along with total transfusion requirements. Both the days in ICU and the overall length of hospital stay were lower in the early group (5.1 ± 8.8 versus 8.4 ± 11.1 ICU days and 10.5 ± 9.8 versus 14.3 ± 11.4 total days; $p<0.001$). These differences remained statistically significant after adjusting for ISS and age with analysis of covariance. The adjusted values for ICU days were 5.9 ± 0.4 and 7.4 ± 0.4 for early versus delayed fixation, respectively, with $p=0.006$. The adjusted hospital length of stay was 11.2 ± 0.4 in the early group versus 13.3 ± 0.5, with $p=0.001$. LOS is clearly influenced by the timing of surgery, all other factors being equal. Other factors that could prolong LOS could include the development of complications, which could delay discharge from the hospital, and uninsured or underinsured status, which could delay discharge to a skilled nursing facility. We did not include the insurance status in our data collection. The number of transfusions ($p=0.084$) and days of mechanical ventilation ($p=0.11$) were not significantly different for early versus delayed treatment after adjusting for age and ISS. Estimated blood loss and durations of surgery were not recorded, but it is possible that more acetabulum and spinal fractures stabilized on a delayed basis (Table 2), versus within 24 hours, were responsible for the trend in a larger number of transfusions.

Complications occurred in 292 patients overall (29.1%), and are presented in detail in Table 5. A lower rate of overall complications was noted in the patients whose fractures were definitively treated within 24 hours (24.0% versus 35.8%, $p<0.001$). Logistic regression was used to account for differences in age, injury severity, and presence and severity of chest and/or abdominal injury between the early and delayed groups. The adjusted odds ratio for experiencing any complication was 0.731 with a 95% confidence interval (CI) of 0.546 to 0.986, p=0.04, indicating significantly fewer complications with early fracture management. Similarly, the adjusted odds ratios for ARDS, pneumonia, and sepsis, were 0.456, 0.682, and 0.463 with p=0.048, p=0.070, and p=0.054; respectively, favoring definitive care within 24 hours. Rates of DVT, PE, wound infection, renal failure, MOF, and death were not significantly different between the two groups.

Patients treated with definitive fixation within 24 hours were analyzed in more detail (Table 6). When grouping those treated within 12 hours of injury (n=383) versus between 12 and 24 hours of injury (n=189), no difference was seen in patient age, ISS, or associated injuries. Complications occurred in 20.1% of patients treated within 12 hours, versus 21.2% of those treated between 12 and 24 hours (p=0.82). There were no differences between these groups in any of the complications assessed.

DISCUSSION

Injury is a major public health problem. It is the leading cause of death and disability among people less than 45 years old. Annual medical expenses due to trauma in the United States exceed $200 billion.[41-42] Beyond the direct costs of treatment, the indirect costs of lost productivity are substantial. According to US Highway Traffic Safety Administration data, approximately 120 people die each day on federal highways, and thousands are injured.[43] Among these are people who sustain complex fractures of the pelvis, femur, and spine. The hypothesis of this study was that early definitive management of mechanically unstable fractures of the pelvis, acetabulum, femur and spine would reduce complications and shorten length of stay. Ultimately, reduced costs of care should be realized when complications and hospital stay are minimized.

Although this group of multiply-injured patients presents a heterogeneous spectrum of musculoskeletal problems, several common features exist. Injury produces pain which leads to splinting and impaired ventilation, predisposing to atelectasis. Atelectasis can result in hypoxemia and pneumonia. Recumbency and immobility, inherent in management of major axial injuries until they are reduced and stabilized, will also decrease ventilation, promote atelectasis and pulmonary complications, and increase the risk of DVT. Treatment of mechanically unstable fractures of the spine, pelvis, acetabulum, and femur promotes upright posture and mobility from bed, which should positively impact pulmonary function.[1,5,8,31,45] Pain is also decreased after fractures are stabilized. Pain is a contributor to sympathetic drive, which can enhance the inflammation associated with injury. In theory, reduction in pain should mitigate sympathetic discharge and should diminish usage of narcotic pain medications, which depress pulmonary effort.[44] In summary, major axial skeletal injuries predispose to pulmonary complications, systemic inflammation, and immune dysfunction; while fracture fixation provides pain relief and promotes mobility.

However, surgical treatment is not without risk. Most fracture surgery alleviates ongoing hemorrhage, but some bleeding is incurred with surgery, depending on the type of fracture and the method of treatment. Damage control orthopaedics (DCO) has been promoted as a means of minimizing surgical time and blood loss, while imparting some skeletal stability, generally through external fixation.[17,18,20,25-27] In patients who have massive hemorrhage from fractures and/or other sources, it is prudent to ensure an adequate level of resuscitation before proceeding with definitive fracture fixation. Excessive hemorrhage from initial trauma produces tissue hypoperfusion, activation of the inflammatory cascade, and immune dysfunction. In an under-resuscitated patient lengthy surgery with large blood loss creates a “second hit” potentially associated with a deleterious inflammatory response.[19,26,46] Unfortunately, many mechanically unstable pelvis and acetabulum fractures and thoracic or lumbar spine fractures can not be provisionally stabilized with external fixation. Additionally, patients initially treated with a DCO strategy require definitive surgery on a delayed basis. Efforts to clarify the indications for DCO, based on injury characteristics and the resuscitation profile, are needed. And for those fractures which can not be provisionally treated with DCO, objective guidelines for timing of definitive management of fractures are also needed.

Some prior studies have suggested that early fixation of skeletally unstable fractures of the femur, pelvis, acetabulum, and spine reduces complication rates.[1-13,31,33] Femur fractures are the most common and have been studied most often in prior literature on the timing of fixation. Rixen, et al. performed a comprehensive literature review of this subject.[47] No definite advantage or disadvantage was identified for “early definitive” fracture stabilization (within 24 hours). However, the level of evidence in the majority of studies was poor. These authors reviewed the German Trauma Society registry, which included 1465 femoral shaft fractures treated over 8 years. The use of provisional or definitive external fixation in these patients increased over this time period, and was more likely associated with patients with an increased Injury Severity Score (ISS), a lower Glasgow Coma Scale, thoracic trauma, a base deficit greater than 6.0, or an elevated prothrombin time. No advantage to external fixation versus primary femoral stabilization with a nail or plate was seen, in any of these patient groups. They concluded that further study is justified.[47]

Other previous authors have also studied morbidity and mortality with respect to timing of definitive fixation of femoral shaft fractures. Morshed, et al. reviewed the National Trauma Data Bank, including 3069 patients between 2000 and 2004. Definitive treatment between 12 and 24 hours after injury had the lowest mortality rates versus patients treated within 12 hours or later than 24 hours.[48] Patients with severe abdominal injury seemed to benefit the most from a 12 hour delay, likely because the additional time could permit resuscitation. Lefaivre, et al. reported comparable findings in a similar patient group with femoral shaft fractures.[49] Their patients treated within an 8 to 24 hour window after injury had the lowest mortality, versus those definitively treated within 8 hours, or more than 24 hours after injury. We did not identify differences in complications or mortality in our patients treated within 12 hours versus 12 to 24 hours. This may be due to a small sample size and heterogeneity of the sample. Additionally, it may be that the majority of our early patients had been adequately resuscitated prior to surgery. Our study did not have laboratory information to assess this. Recently O'Toole, et al. reported very low rates of pulmonary complications in patients with multiple system trauma, including severe chest injury, when treated with primary intramedullary nailing. They suggested that this tactic is safe when applied to patients who have achieved successful early resuscitation as measured by serum lactate.[9]

Our Institution has permitted early definitive fixation as long as the patient is adequately resuscitated and warm, and is not affected by severe increased intracranial pressure or underlying medical reason precluding surgery. Some patients may have already been in the operating room for other surgical procedures, such as laparotomy or craniotomy, at the time of fracture fixation, and we did not specifically study this. There was no formal protocol or objective parameters that were consistently used during the period of study to determine readiness for orthopaedic surgery. This is one limitation of our study. Other limitations include the heterogeneity of injuries and types of treatment and our sample size. Despite this, we identified fewer overall complications and less ARDS in patients who were treated with early definitive fixation. Although our patients in the early group had significantly higher initial pH and base excess, the majority of them were likely in a safe physiological range to proceed with definitive surgery. The levels of pH and base excess in the early and delayed groups were also so similar that the differences did not appear to be clinically relevant different between them. Further study is needed in this area to develop objective laboratory and injury parameters for the timing of fixation of orthopaedic injuries which relegate a patient to bedrest and possibly traction.

Other prior literature has supported early definitive management of pelvic ring injuries and acetabulum fractures.[2,4,6,10,11,45] Shorter hospital stay and fewer complications have been noted in retrospective studies in patients treated on an early basis. Caution should be exercised when surgery in excess of three hours in anticipated.[22] Such procedures often entail large surgical blood loss and may predispose to a heightened inflammatory response when undertaken in patients that are inadequately resuscitated. It has been recommended that early surgery remain short (less than one hour) and that if procedures in excess of three hours are anticipated, definitive fixation be performed on a delayed basis. [22] Our practice has been to develop a plan of care for these complex patients with our general trauma surgeons, so that longer procedures are only undertaken in patients who are not severely acidotic and who are responding to resuscitation. In such cases lengthy procedures may be safe and could be preferable on an early basis to minimize complications. We believe that definitive fixation of fractures may also contribute to the resuscitation of the patient by reducing ongoing blood loss.[50] More study is needed, and protocols should be prospectively tested.

With respect to unstable lower spinal injuries, the National Trauma Data Bank records have shown that most patients undergo stabilization within three days of injury, and that they have fewer complications and utilize fewer resources versus patients who have later surgery.[51] Other studies have corroborated these findings.[8,52,53] Another recent report has applied the concept of damage control to spinal fractures, consisting of immediate posterior reduction and instrumentation followed by completion of the construct on a delayed basis when the physiology is more stable, over three days later.[53] These authors recognized the benefits and risks with either an early total care tactic or with a completely delayed tactic. Further assessment of their methodology in a larger group of patients would be informative.

Reasons for surgical delay included need for further medical work up or resuscitation in a minority of our patients. More common reasons for delayed definitive fracture care were surgeon preference, with particular respect to spine fractures, acetabulum fractures, and pelvic ring injuries where the majority of patients were treated on a delayed basis (Table 2). Dissemination of these research findings within our Institution has subsequently influenced the practice of surgeons and encouraged earlier definitive management by some. Potential other reasons for delayed management include lack of operating room availability and surgeon unavailability. In an ideal system, trauma room resources should be available on a daily basis to ensure efficient patient throughput. Our data support that most of these fractures may be safely treated on an earlier basis. Reduced costs of care for the trauma center through minimizing both complications and length of stay should underscore the need for operating room space, personnel, and equipment resources to be so allocated. Lastly, the finding that a significantly larger number of patients treated on a delayed basis were transferred from outside hospitals highlights the need of enhanced inter-hospital communication and transport systems. Further evaluation of the transferred patients would be instructive. We have identified two groups of patients that are transferred to our facility: those with lower patient complexity and an uninsured or underinsured status and those with a higher level of injury severity. This is consistent with prior reports.[54-57]

In summary, 1005 patients with multiple system injury and 1192 mechanically unstable fractures of the pelvis, acetabulum, femur, and thoracolumbar spine were reviewed.

Patients who had definitive management of all of these fractures within 24 hours of injury had shorter ICU and hospital stays and lower overall rates of complications and ARDS, compared with those treated later, even when adjusted for age and associated injury types and severity. While fracture fixation serves a role in reducing ongoing bleeding and in promoting mobility from bed, surgical timing must be determined with consideration of the overall physiological status of the patient and the complexity of the surgery needed. Parameters should be established within which it is safe and efficacious to proceed with fixation. These data will serve as a baseline for comparison for prospective evaluation of such parameters in the future.

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Table 1. Demographic information on 1005 patients, treated surgically for at least one of the fractures of interest. Some patients had bilateral fractures or more than one fracture of interest treated surgically. Bilateral fractures explain the differences in the sample size between column headings and the total numbers by gender. Data for age and ISS are presented as mean plus or minus standard deviation and range.

	Pelvis ring fracture	Acetabulum fracture	Thoracolumbar spine fracture	Femur fracture	Totals
All patients	259	266	98	569	1005 patients with 1192 fractures
Men	198	194	79	370	712
Women	61	68	19	158	293
Age (years)	39.0±15.8 (18-84)	41.6±16.2 (16-86)	37.3±16.6 (18-71)	36.3±15.7 (16-88)	38.2±15.2 (16-88)
ISS	33.4±11.4 (18-66)	28.6±11.0 (18-59)	31.1±11.9 (18-50)	30.3±10.2 (18-66)	30.6±9.5 (18-66)
Mechanism of Injury					
MVC	103	188	50	356	607
MCC	54	26	15	68	154
Ped vs MVC	37	9	7	32	79
Fall	51	39	3	40	123
Other	14	0	23	32	42

ISS: Injury Severity Score; MVC: motor vehicle collision; MCC: motorcycle collision

Table 2. Timing of definitive fracture fixation. The number of patients is shown for each type of fracture for fixation within 24 hours and after 24 hours.

	Fixation within 24 hours (n=572 patients)	Fixation after 24 hours (n=433 patients)	
Pelvic ring fracture	111 (42.9% of pelvis fractures)	148 (57.1%)	($p<0.001$)
Acetabulum fracture	74 (28.2% of acetabulum fractures)	188 (71.8%)	($p<0.001$)
Thoracolumbar spine fracture	21 (21.4% of spine fractrues)	77 (78.6%)	($p<0.001$)
Femur fracture	411 (77.8% of femur fractures)	117 (22.2%)	($p<0.001$)

Table 3. Associated injuries. The numbers of patients with associated abdominal, chest, and/or head injuries are listed. The percentage of patients in each column with abdominal, chest, or head injury are also listed. P values compare early versus delayed fixation for each of the types of injuries, for example the presence of minor abdominal injury in patients with early versus delayed fixation, p=0.008.

	Fixation within 24 hours (n=572 patients)	Fixation after 24 hours (n=433 patients)	Totals	
Any minor injury				
Abdomen (AIS≤2)	87 (15.2%)	94 (21.7%)	181 (18.1%)	p=0.008
Chest (AIS≤2)	99 (17.3%)	80 (18.5%)	179 (17.9%)	p=0.62
Any severe injury				
Abdomen (AIS>2)	71 (12.4%)	76 (17.6%)	147 (14.7%)	p=0.022
Chest (AIS>2)	127 (22.2%)	141 (32.6%)	268 (26.7%)	p=0.0002
Head injury (GCS<8)	75 (13.1%)	80 (18.5%)	155 (15.4%)	p=0.02

AIS: Abbreviated Injury Score; GCS: Glasgow Coma Scale

Table 4. Length of stay in the hospital, intensive care unit, and total transfusions. Data are presented as mean and standard deviation.

	Fixation within 24 hours (n=572)	Fixation after 24 hours (n=433)	Totals	
Transfusions	5.0 ± 8.4	7.2 ± 9.1	6.0 ± 8.3	($p<0.001$)
ICU days	5.1 ± 8.8	8.4 ± 11.1	6.9 ± 10.5	($p<0.001$)
Ventilation days	3.0 ± 7.4	5.1 ± 8.8	4.0 ± 8.3	($p<0.001$)
Hospital days	10.5 ± 9.8	14.3 ± 11.4	12.7 ± 11.2	($p<0.001$)

Table 5. Unadjusted complications based on timing of definitive fracture fixation.

	Fixation within 24 hours (n=572 patients)	Fixation after 24 hours (n=433 patients)	Totals	
Pneumonia	49 (8.6% of 572)	66 (15.2% of 433)	115 (11.4% of 1005)	(p=0.001)
ARDS	10 (1.7%)	23 (5.3%)	33 (3.3%)	(p=0.002)
Renal failure	13 (2.3%)	10 (2.3%)	23 (2.3%)	(p=0.10)
MOF	2 (0.35%)	1 (0.23%)	3 (0.30%)	(p=0.73)
DVT	40 (7.0%)	36 (8.3%)	76 (7.6%)	(p=0.43)
PE	10 (1.7%)	6 (1.4%)	16 (1.6%)	(p=0.65)
Wound infection	6 (1.0%)	4 (0.92%)	10 (1.0%)	(p=0.84)
Sepsis	10 (1.7%)	23 (5.3%)	23 (2.3%)	(p=0.002)
Death	8 (1.4%)	7 (1.6%)	15 (1.5%)	(p=0.78)
Any complication	137 (24.0%)	155 (35.8%)	292 (29.1%)	(p<0.001)

ARDS: Adult respiratory distress syndrome; MOF: multiple organ failure;
DVT: Deep venous thrombosis; PE: pulmonary embolism

Table 6. Patients with fixation within 24 hours were further analyzed into groups ≤ 12 hours after injury and 12 to 24 hours after injury.

	Fixation within 12 hours (n=383 patients)	Fixation 12 to 24 hours (n=189 patients)	Fixation within 24 hours (totals) (n=572 patients)	P values
Pneumonia	32 (8.4% of 383)	17 (9.0% of 189)	49 (8.6% of 572)	(p=0.92)
ARDS	4 (1.0%)	6 (3.2%)	10 (1.7%)	(p=0.14)
Renal failure	9 (2.3%)	4 (2.1%)	13 (2.3%)	(p=0.86)
MOF	2 (0.52%)	0 (0%)	2 (0.35%)	(p=0.81)
DVT	26 (6.8%)	14 (7.4%)	40 (7.0%)	(p=0.92)
PE	7 (1.8%)	3 (1.6%)	10 (1.7%)	(p=0.84)
Sepsis	4 (1.0%)	6 (3.2%)	10 (1.7%)	(p=0.14)
Death	6 (1.6%)	2 (1.6%)	8 (1.4%)	(p=0.91)
Any complication	77 patients (20.1%) with 90 complications	40 patients (21.2%) with 52 complications	117 patients (20.5%) with142 complications	(p=0.82)