The Impact of Trauma-Center Care on Mortality and Function Following Pelvic Ring and Acetabular Injuries

Morshed S, Knops SP, Jurkovich GJ, Wang J, MacKenzie E, Rivara FP

J Bone Joint Surg Am. 2015 Feb 18;97(4):265-272

ABSTRACT

Background: Lower mortality and improved physical function following major polytrauma have been associated with treatment at level-1 trauma centers (TC) compared with that at non-trauma centers (NTC). This study investigates the impact of TC care on outcomes after pelvic and acetabular injuries.

Methods: Mortality and quality of life-related measures were compared among patients treated in 18 hospitals with level-1 trauma centers and 51 hospitals without trauma centers in 14 U.S. states. Complete data were obtained on 829 adult trauma patients (18-84 years old) with at least one pelvic ring or acetabular injury (OTA 61 or 62). We used inverse probability of treatment weighting to adjust for observable confounding.

Results: After adjustment for case mix, in-hospital mortality was significantly lower at TC versus NTC (RR 0.10, 95% CI 0.02-0.47), as was death by 90 days (RR 0.10, 95% CI 0.02-0.47), and one year (RR 0.21, 95% CI 0.06-0.76) for patients with more severe acetabular injuries (OTA 62-B or 62-C). Patients with combined pelvic ring and acetabular injuries treated at TC had lower mortality by 90 days (RR 0.34, 95% CI 0.14-0.82) and one year (RR 0.30 95% CI 0.14-0.68). Care at TC was also associated with mortality risk reduction for those with unstable pelvic ring injuries (OTA 61-B or 61-C) at one year (RR 0.21, 95%CI 0.06-0.76). Seventy-eight percent of included subjects discharged alive was available for interview at twelve months. Average absolute differences in SF-36 physical functioning and Musculoskeletal Functional Assessment at one year were 11.4 (95%CI 5.3 – 17.4) and 13.2 (1.7 – 24.7) respectively, indicating statistically and clinically significant improved outcomes with TC treatment for more severe acetabular injuries.

Conclusions: Mortality is reduced for patients with unstable pelvic and severe acetabular injuries when care is provided in a TC compared to NTC. Moreover, those with severe acetabular fractures experience improved physical function at one year. Patients with these injuries represent a well-defined subset of trauma patients that should be preferentially triaged or transferred to a Level-1 trauma center.

INTRODUCTION

Critically injured trauma patients benefit from an organized trauma service and integrated multidisciplinary care.[1] Efforts at regionalization of trauma care have been based on the premise that concentration of resources for delivery of this complex specialty care will result in improved outcomes.[2,3] However, the majority of studies supporting this notion have been retrospective studies of panel and registry data.[4] The National Study on Costs and Outcomes of Trauma (NSCOT) is a prospective study initiated to examine variations in care provided across level-1 trauma centers (TC) and non-trauma centers (NTC), identify predictors of outcomes, and estimate cost-effectiveness of trauma care[5]. This study showed that the risk of death is significantly lower when care to critically injured patients is provided in a level-1 TC than in a NTC hospital[6]. While data from this study also demonstrated modest functional benefits associated with treatment at a level-I trauma center among patients with a major lower-limb injury, similar mortality benefits were not found in patients across the broad spectrum of orthopaedic injuries.[7]

Patients with pelvic and acetabular injuries comprise a subset of trauma patients with particularly high morbidity and mortality.[8-10] These injuries typically result from high-energy trauma and are often accompanied with severe hemorrhage and other potential life threatening injuries. Given the complexity and multimodal needs of trauma patients with pelvic and acetabular injuries as compared to other extremity trauma, we hypothesize that such patients will show significant mortality and functional benefits from trauma center care. We conducted a secondary analysis of the NSCOT data to assess both the effect on mortality and functional outcomes of trauma center care, specifically for those patients with pelvic and acetabular injuries.

MATERIALS AND METHODS

The NSCOT was conducted in 15 regions defined according to contiguous Metropolitan Statistical Areas in 14 states according to sampling procedures that have been previously described.[5] The Metropolitan Statistical Areas were selected from among the 25 largest such areas in 19 states, and excluded those in which large NTC collectively treated fewer than 75 patients with major trauma (Injury Severity Score of more than 15, on the basis of diagnostic codes)[4]. Within each Metropolitan Statistical Area, all level-1 TC and large NTC were identified, as were large NTC that treated at least 25 patients with major trauma annually. Of the TC included, 13 were state designated and 10 were verified by the American College of Surgeons Committee on Trauma (ACSCOT)—5 were recognized by both state and the ACSCOT. Level-2 and Level-3 centers were not included. Ultimately, 18 of the TC and 51 of the NTC agreed to participate and received institutional review board approval.

Patients

Patients were included if they were 18 to 84 years of age, arrived alive at a participating hospital, and were treated for a moderate-to-severe injury (defined by at least one injury with a score of at least 3 on the Abbreviated Injury Scale)[11] between July 2001 and November 2002. Patients who presented with no vital signs and were pronounced dead within 30 minutes of arrival were excluded, as were patients who delayed seeking treatment for more than 24 hours, patients 65 years of age or older with a first listed diagnosis of hip fracture, patients with major burns, those who spoke neither English nor Spanish, non-U.S. residents, and patients who were incarcerated or homeless at the time of injury.

Patients were selected and eligibility was determined in two stages, followed by a third stage query to identify and include only those subjects with pelvic and/or acetabular injuries (Figure 1). In the first phase, administrative discharge records and emergency department logs were prospectively reviewed to identify patients with a principal International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9_CM) diagnosis code of 800 to 959 (excluding those due to late effects, foreign bodies, complications, burns, and [among patients 65 years of age or older] hip fractures). A computer program was then used to map ICD-9-CM diagnoses to Abbreviated Injury Scale scores to select patients with at least one diagnosis involving a score of at least 3 on the Abbreviated Injury Scale.[12] A total of 18,198 patients satisfied these initial eligibility criteria.

In the second stage, all 1438 patients who died in the hospital and a sample of 8021 patients who were discharged alive were selected. A quota sampling strategy was used with the goal of enrolling approximately 3000 patients who were 18 to 64 years of age and 1200 patients who were 65 to 84 years of age, evenly distributed across TC and NTC and across categories of injury severity and principal region injured. Completed medical records were obtained for 1391 of the patients who died in the hospital. After exclusion of 287 who did not meet eligibility criteria, 1104 eligible subjects were identified and for whom medical records were abstracted. Patients discharged alive and selected for the study were contacted at 3 months by mail and then telephone, and informed consent was obtained to access their medical records and interview them at 3 and 12 months after injury. Of the 8021 such patients who were selected for the study, 4866 were enrolled and 4087 were ultimately found eligible and for whom complete medical-record data were abstracted.

For the purposes of this study, a third stage involved inclusion of only patients with a traumatic pelvic injury (pelvic and/or acetabulum fracture and/or sacrum and coccyx fracture) from the Emergency Department (ED) and Hospital deaths and live discharges found eligible in stage 2. Patients with at least one diagnosis ICD-9 code in the range 808.0 – 808.9 (fracture of pelvis, open/closed) and/or 805.6 – 806.79 (fracture of sacrum and coccyx, open/closed)) and an Orthopaedic Trauma Association (OTA) fracture classification[13] of 61- or 62- were selected for inclusion in the final cohort for this study. This resulted in 278 patients included from NTC and 551 patients from level-1 TC.

There are two reasons why it is necessary to weight data on the 829 eligible included participants with pelvic injuries and complete medical record data to the population of eligible patients. First, the sampling protocol selected all patients who died in the hospital but only a proportion of patients discharged alive. Second, not all patients selected for inclusion in the study were enrolled. The resulting “sampling” weights consisted of the reciprocal product of two probabilities: the conditional probability of being selected and the probability of being enrolled and having data abstracted from the medical record, given that the patient was selected. The target population to which inferences are made for this secondary analysis of the NSCOT consists of 2644 patients with pelvic and acetabular injuries projected to meet the inclusion criteria.

Outcomes

Outcomes of primary interest included death in the hospital and death within 90 days after injury. Deaths that occurred after discharge were identified either by interviewing a proxy or through a match with the National Death Index. Secondary outcomes were twelve-month follow-up functional assessments including the Short Form-36 (SF-36)[14] and the Short Musculoskeletal Functional Assessment (SMFA).[15]

Statistical Analysis

All analyses were performed with the use of data weighted to the population of eligible patients (n=2644). To adjust for potential confounding bias by observable factors explaining differences in patients treated at TC and those treated at NTC, the inverse probability of treatment weighting approach described by Robins[16] was used. In this approach, data on each patient are further weighted by the reciprocal of the conditional probability of receiving care at a trauma center, given all demographic and injury characteristics listed in Table 1, plus ED first shock, First ED assessment of pulpils, midline shift, flail chest, open skull fracture, obesity and paralysis, together with relevant two-way interaction terms. The result is a reweighted population in which measured variables that may confound the estimated association between trauma center and outcome are balanced between treatment groups. Then, generalized linear models were used to model outcomes (mortality and functional outcomes) in order to generate estimates of causal effects. Robust standard errors were computed to account for clustering within hospitals. Mortality risk was compared both in-hospital and within 90 days; effects attributable to level of care were hypothesized to exist within this period of time from injury. Quality of life outcomes (SF-36 physical and mental component summary scores, SMFA) were compared at one year after injury. We used SAS 9.2 (Cary, NC, USA) and R2.1.1 (Vienna, Austria) for all of the analyses.

Source of Funding

Funding for NSCOT came from a grant (R49/CCR316840) from the National Center for Injury Prevention and Control of the Centers for Disease Control and Prevention, and a grant (R01/AG20361) from the National Institute on Aging of the National Institutes for Health. The present investigation was not funded.

RESULTS

On the basis of data weighted back to the target population of 2644 eligible patients (1727 pelvis, 297 acetabulum, and 620 combined injuries), 92% survived at least 12 months after injury. Compared with trauma-center patients, non-trauma center patients were older, carried more comorbidities, more likely to be female and insured (Table 1). Patients treated at TC had higher Injury Severity Scores and lower admission motor score of the GCS (Table 1). Higher scores in trauma center-treated patients were present in nearly every AIS region, suggesting that these patients were more severely injured. After inverse probability of treatment-weighted adjustment of the population for reduction of confounding bias due to imbalances in covariates, the two groups were similar (Table 1). Only gender and AIS maximum scores in the abdominal, extremity and spine regions remained different in the reweighted population and these variables were subsequently adjusted for in the statistical analysis.

In-hospital crude (unadjusted) mortality rates were higher at TC (6.1% versus 2.5%, p-value <0.0001) but lower (7.2% versus 11.5%, p-value 0.03) by 1 year after injury(Table 2). These results were no longer significant after adjustment for case-mix, though the relative risk reduction and confidence limits (RR 0.67, 95% CI 0.44-1.01) suggest a trend towards lower overall 1-year mortality with treatment at trauma center (Table 3). Stratification revealed those with combined pelvic and acetabular injuries, unstable pelvic ring injuries (OTA 61-B and 61-C) and more severe acetabular fractures (OTA 62-B and 62-C) to benefit from TC care.

Patient with combined pelvic ring and acetabular injuries treated at TC had lower mortality at 90 days (RR 0.34, 95% CI 0.14-0.82) (CME) and 1 year (RR 0.30, 95% CI 0.14, 0.68) after adjustment for differences in the case mix (Table 3). In-hospital mortality was significantly lower at TC versus NTC (RR 0.10, 95% CI 0.02-0.47), as was death by 90 days (RR 0.10, 95% CI 0.02-0.47) and 1 year (RR 0.21, 95% CI 0.06, 0.76), for patient with more severe acetabular injuries (OTA 62-B and 62-C) (Table 4) (CME).

The results for subjects with pelvic injuries and single column acetabular fractures were mixed. While patients with stable pelvic ring injuries (61-A) had a higher hospital mortality risk at TC versus NTC, this association was reversed and favored TC by 1 year (Table 4). There was no association between TC care and mortality among subjects with single column (62-A) acetabular fractures. Patients with unstable pelvic ring injuries (OTA 61-B and 61-C) had relative risk reductions associated with trauma center care that reached statistical significance by one year (RR 0.71, 95% CI 0.24, 0.91).

Seventy eight percent of patients discharged alive, eligible for NSCOT and included in this study were successfully located and interviewed at twelve months (Figure 1). Average differences in SF-36 physical functioning and Musculoskeletal Functional Assessment at one year were 11.4 (95%CI 5.3 – 17.4) and -13.2 (-24.7 to -1.7) respectively, indicating statistically and clinically significant improved outcomes with treatment at TC for more severe acetabular injuries (Table 5) (CME).

DISCUSSION

We studied the effects of trauma center versus non-trauma center on mortality and functional outcomes among patient with major trauma including pelvic and/or acetabular injuries from the National Study on Cost and Outcomes of Trauma. It is important to note that the inferences drawn from the finding of the present study pertain only to the comparison of level I versus NTC. Conclusion about relative performance of level II and level III centers cannot be made from these data. Despite treating more severely injured patients, trauma center care was associated with reduced risk of mortality for patients with combined pelvic and acetabular injuries and those with severe acetabular injuries. Moreover, these most critically injured patients experience improved physical functioning at one year when care is provided in a trauma center as compared to non-trauma center.

These findings are consistent with a growing body of trauma literature examining the trauma center effect on mortality and functional outcome. One reason for the benefits of dedicated trauma center care is the concentration of expertise cultivated by high volumes of severely injured patients[17]. Much work has focused on elucidating which subsets of severely injured trauma patient benefit most from trauma center care given the ramifications that this knowledge would have on improving triage. An analysis of National Trauma Data Bank (NTDB) data including only those patients with severe cardiovascular, neurological, liver or complex pelvic injuries had mortality and disablement benefits associated with level-1 trauma center care.[18] Patients with complex pelvic injuries had significantly better functional outcomes when treated at level I centers. Similarly, a retrospective cohort analysis from the State of Ohio Trauma Registry analyzing data from 18,103 primary trauma admission demonstrated improved survival associated with level I trauma center care.[19] This survival advantage was present among those with ISS>15 as well as those with head and pelvic injuries. These studies suggest that pelvic injuries define a subset of trauma patients more likely to benefit from treatment at TC.

Given that injuries to the pelvis and acetablum represent among the most life threatening of orthopaedic injuries, these injuries have been implicated as indicators of patients most likely to benefit from the expertise, experience and multidisciplinary resources available at trauma center. Injuries to the pelvis are associated with high rates of blood loss, morbidity and mortality,[20-24] though relatively little has been written about these severe complications in management of high-energy acetabular fracture. Magnussen found that among 289 high-energy isolated pelvic or acetabular injuries, similar rates of subjects required blood transfusion.[25] However, patient with combined pelvic and acetabular injuries among this cohort required transfusions at significantly higher rates (57%) as compared to either isolated pelvic (24%) or acetabular (35%) injuries. These findings were supported by another study of 82 patients with combined pelvic and acetabular trauma compared to matched controls with isolated injuries.[9] In the present study, we benefit from the increased granularity of NSCOT data that classified pelvic and acetabular injuries using the OTA classification scheme in order to make more precise comparisons than were possible from NTDB and registry data. The large mortality risk reductions associated with trauma center we report among those with combined pelvic and acetabular injuries, those with more severe acetabular fractures, and unstable pelvic ring injuries, are consistent with the notion that patients with the most devastating pelvic injuries benefit from the resources and expertise available at TC.

Fewer studies have been conducted on the benefit of trauma center care with respect to functional outcomes or health related quality of life. Demetriades used data from the National Trauma Data Bank (NTDB) to show that patients with complex pelvic fractures (defined by ICD-9 codes: 808.43, 808.53) had significantly better functional outcomes (functional independence measure at discharge) when taken to a level-1 trauma center versus lower level trauma center.[18] Unfortunately, measurement of function at the time of discharge, is a problematic and inconsistent time point for analysis.[26] Gabbe and colleagues[27] used 12-month functional outcomes (Glasgow Outcome Scale - Extended) to show longer term benefits of level-1 trauma center care among survivors of blunt major trauma (Injury Severity Score > 15). While reporting inferior function associated with orthopaedic injuries, no subgroup analysis was conducted to assess whether specific skeletal injuries benefited more or less from trauma center care. Mackenzie et al. analyzed functional outcomes among those with major lower extremity trauma and found that the physical component of the SF-36 and MFA showed greater improvements for those treated at TC.[7] NSCOT patients with at least one injury to a lower limb (including pelvis and acetabulum) with an AIS score of ≥3 points were included for the analysis. In this sub-study, as well as the parent NSCOT study,[6] there were trends towards relative trauma center benefit for those with more severe trauma. However, the functional outcome of patients with specific pelvic and acetabular fractures was not explored separately. We reported improvement in prospectively obtained physical function measurements at one year associated with trauma center care, specifically among those with the most severe acetabular injuries, a finding that is consistent with these prior studies.

Among subjects with less severe injuries such as stable pelvic ring (61-A) or single column acetabular injuries (62-A), there was a less coherent explanation of the findings. For the latter, there was no significant trauma center mortality effect at any time point, whereas the association reversed for stable pelvic ring injuries from favoring NTC in-hospital to favoring TC at one year. Adjustment for case mix has been studied by Nathens and at least when considering mortality outcomes, the consideration of ISS, age, systolic blood pressure at ED arrival, presence of severe head injury (AIS), mechanism, gender and the presence of severe abdominal injury (AIS) have been considered sufficient.[28] Still, one possible reason for this finding is incomplete confounding adjustment for the disproportionately more severe injuries and sicker patients treated at TC (Table 1). The lack of therapeutic benefit of TC for these older patients may be related to their lack of need for surgical management of their pelvic injury and the many related specialized services provided at TC, and their greater need for continuity in care of their complex medical co-morbidities. The findings presented here do not support recommendations to preferentially triage patients with stable A-Type pelvic or acetabular injuries to TC.

This study has several potential limitations. First, this study is observational and despite sophisticated sampling and confounding adjustment to enhance causal inferences, it is still prone to bias from unknown or unmeasured confounding.

Second, multiple subgroup analyses were run which could inflate the possible false positive rate for the hypothesis tests we conducted. Still, this study used high quality prospectively gathered data for the largest ever study of its kind to assess the relationships between level of trauma center care and outcomes. Rather than emphasize the magnitude of effects of trauma center care, we focus on the consistency of finding across subgroups of the most critically injured to convey a coherent finding of improved survival and functional outcomes at TC.

In conclusion, these findings show that risk of mortality is significantly lower for patients with severe acetabular injuries and that these patients also have improved physical functioning at one year when care is provided in a trauma center than in a non-trauma center. Trauma patients with unstable pelvic ring and combined pelvic and acetabular injuries also show reduced mortality risk when treated at trauma centers. Patients with evidence of severe acetabular or pelvic ring injuries should be triaged to a trauma center directly.

FIGURE LEGEND

Figure 1: Subject inclusion and follow-up

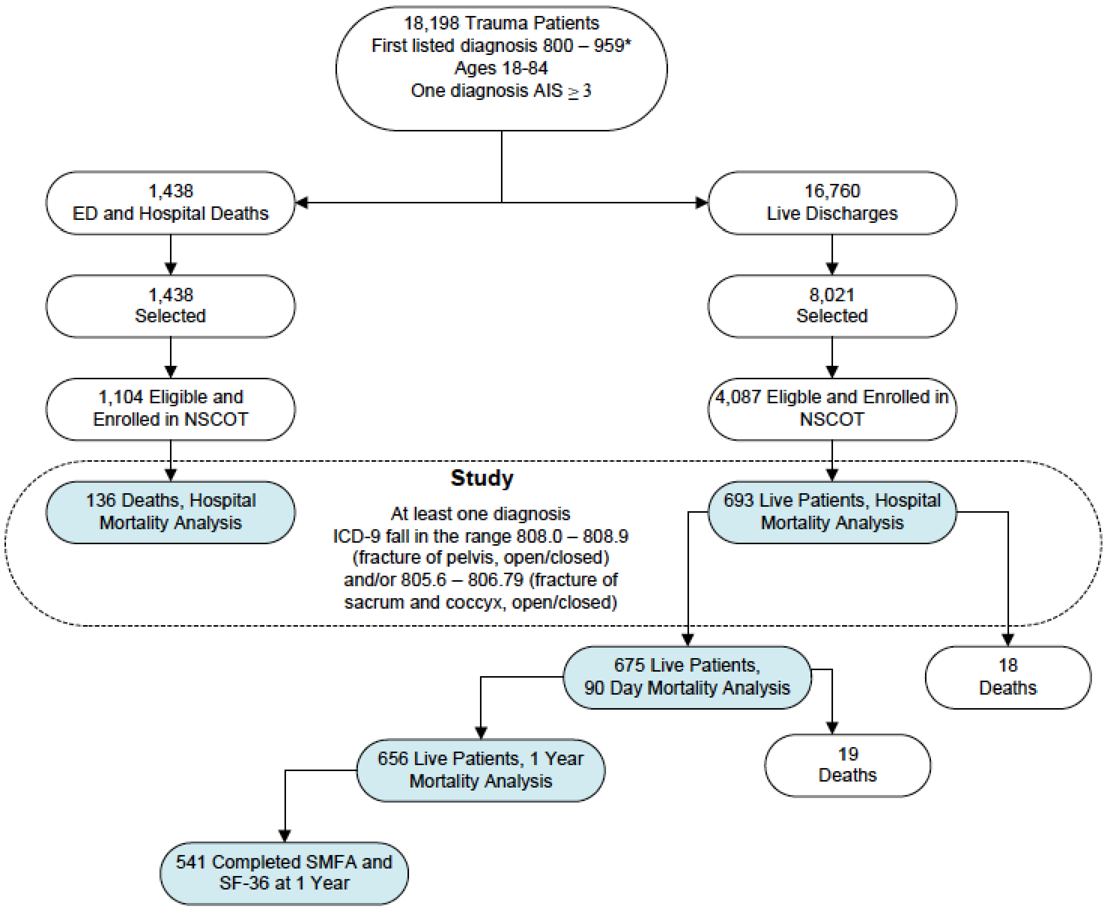

Table 1: Patient Characteristics

		Before Adjustment			After Adjustment		
	Number of Patients (Unweighted)	**Non-trauma Center§ N=278 (n=638) %**	**Trauma Center§ N=551 (n=2006) %**	**P - value**	**Non-trauma Center§ N=278 (n=2331) %**	**Trauma Center§ N=551 (n=2520) %**	**P – value**
Age							
Mean years (SD)		58.3(33.4)	40.0(31.1)	<0.0001	42.3(63.3)	42.2(37.8)	0.96
<55	494	35.6	81.9	<0.0001	68.2	77.1	0.17
55-64	81	12.6	8.9		9.6	9.2	
65-74	114	17.3	5.7		9.0	7.5	
75-84	140	34.5	3.5		13.2	6.2	
Gender				<0.0001			0.003
Male	451	33.5	63.7		41.8	62.4	

Female	378	66.5	36.3		58.2	37.6	
Race				0.09			0.87
Hispanic	107	9.1	17.9		14.0	6.2	
Non-Hispanic,White	594	81.9	61.8		70.5	64.9	
Non-Hispanic, Non-White	128	9.0	20.3		15.5	18.9	
Insurance				<0.0001			0.21
None	162	10.7	30.6		18.4	27.5	
Medicare only	183	38.2	6.9		16.3	10.5	
Medicare+Private	104	15.2	6.3		7.0	7.2	
Private	295	26.4	46.3		41.5	45.4	
Medicaid	52	4.7	5.3		10.0	4.8	
Other	33	4.9	4.6		6.8	4.6	
Injury Mechanism				0.24			0.44
Penetrating	35	3.1	5.5		7.4	4.8	
Blunt	794	96.9	94.5		92.6	95.2	
First ED motor GCS				0.0002			0.24

6	636	93.3	75.5		73.3	78.5	
4,5	50	3.0	7.3		4.3	6.7	
2,3	13	0.4	1.8		1.6	1.6	
1,not paralyzed	49	0.8	4.2		1.5	3.9	
1,paralyzed	81	2.5	11.2		19.3	9.3	
Injury Severity Score							
Mean(SD)		11.3(14.7)	22.5(22.3)	<0.0001	22.3(44.8)	21.0(25.0)	0.80
<16	348	77.4	34.6	<0.0001	42.0	40.8	0.06
16-24	206	12.7	27.5		22.7	25.8	
25-34	165	5.3	22.9		10.3	20.5	
>34	110	4.6	14.9		25.0	12.9	
Maximum Abbreviated Injury Score (AIS)				<0.0001			0.44
Less than or equal to 3	551	89.2	63.6		65.0	67.4	
4	187	7.7	24.6		17.1	22.1	
5,6	91	3.1	11.8		17.9	10.5	

Head Region Maximum AIS ≥3	164	8.2	24.0	<0.0001	28.0	21.7	0.54
Face Region Maximum AIS ≥3	23	1.0	3.3	0.05	3.0	3.0	0.98
Thorax Region Maximum AIS ≥3	319	14.7	42.0	<0.0001	40.9	37.9	0.75
Abdomen Region Maximum AIS ≥3	170	4.4	24.4	<0.0001	11.8	21.3	0.02
Upper Extremity Region Maximum AIS ≥3	111	7.7	15.4	0.002	12.8	14.8	0.53
Lower Extremity Region Maximum AIS ≥3	487	39.5	70.5	<0.0001	50.7	68.9	0.01
Neck Region Maximum AIS ≥3	2	0	0.7	NA	0.0	0.3	NA

Spine Region Maximum AIS ≥3	55	1.7	8.9	0.001	2.9	8.0	0.02
External Region Maximum AIS ≥3	3	0.4	0.4	0.90	0.7	0.3	0.58
Charlson Comorbidity Index				<0.0001			0.07
0	535	50.5	76.0		69.9	72.5	
1	137	17.5	16.0		12.0	16.7	
2	75	13.6	4.5		9.3	6.3	
≥3	83	18.4	3.5		8.8	4.5	

[§]N = number of study subjects, n = weighted number of subjects

Table 2. Unadjusted Mortality

	Number of Patients (weighted number)	Non-trauma Center§ N=278 (n=638) (percentage)	Trauma Center§ N=551 (n=2006) (percentage)	P - value
Hospital death	136(139)	2.5	6.1	<0.0001
Death within 90 days	154(177)	5.9	6.9	0.44
Death within 1 year	173 (218)	11.5	7.2	0.03

§N = number of subjects in study sample, n = weighted number of subjects

Table 3. Adjusted* Mortality (Trauma Center versus Non-trauma Center) among the total cohort of patients with Pelvis (weighted number = 1727), Acetabulum (weighted number = 297) or Combined (weighted number = 620) injuries and by Orthopaedic Trauma Association Classification Fracture Type

Outcomes	Relative Risk (95% Confidence Interval)
Hospital death	
All Subjects Pelvis only	1.39 (0.59, 3.28) 1.89(0.75,4.76)
Acetabulum only	2.20(0.26,18.63)
Combined injury	0.51(0.15,1.72)
Death within 90 days	
All Subjects Pelvis only	0.96 (0.64, 1.46) 1.18(0.60,2.31)
Acetabulum only	4.04(0.53,30.86)
Combined injury	0.34(0.14,0.82)
Death within 1 year	
All Subjects Pelvis only	0.67(0.44,1.01) 0.71(0.43,1.16)
Acetabulum only	5.80(0.80, 42.01)
Combined injury	0.30(0.14, 0.68)

*Propensity Score-based adjustment model including the following covariates: all demographic and injury characteristics listed in Table 1, plus ED first shock, First ED assessment of pulpils, midline shift, flail chest, open skull fracture, obesity and paralysis, together with relevant two-way interaction terms.

Table 4. Adjusted Mortality Effect (Trauma Center versus Non-trauma Center) by Orthopaedic Trauma Association Sub-classification§, Pelvis A-type (weighted number = 1240), Pelvis B or C - Type (weighted number = 941), Acetabulum A-Type (weighted number = 209), Acetabulum B or C-Type (weighted number = 152). Thirty Pelvis and 8 Acetabulum injuries were non sub-classified and excluded from the stratified analysis.

Outcomes	**Relative Risk (95% Confidence Interval)**
Hospital death	
Pelvis A -Type	3.40(1.23,9.39)
Pelvis B or C - Type	0.90(0.22,3.67)
Acetabulum A-Type	2.66(0.32,22.15)
Acetabulum B or C- Type	0.10(0.02,0.47)
Death within 90 days	
Pelvis A -Type	1.08(0.51,2.30)
Pelvis B or C - Type	0.69(0.23,2.06)
Acetabulum A-Type	5.17(0.72,37.02)
Acetabulum B or C- Type	0.10(0.02,0.47)
Death within 1 year	
Pelvis A -Type	0.48(0.26,0.91)
Pelvis B or C - Type	0.71(0.24,0.91)
Acetabulum A-Type	5.17(0.72,37.02)
Acetabulum B or C- Type	0.21(0.06,0.76)

§A-Type is stable with regards to pelvic ring disruptions and involving single column with regards to acetabular injuries; B – Type is partially unstable with regards to pelvic ring disruption and including a transverse component with regards to acetabular injuries; C – Type is unstable (complete disruption of posterior arch) with regards to pelvic ring disruption and complete articular injuries involving both columns with regards to acetabular injuries.

Table 5. Twelve Month Adjusted§ Functional Assessment Differences (Trauma Center vs. Non-trauma Center) by Orthopaedic Trauma Association Sub-classification§§

	SF-36 Physical Component*	SF-36 Mental Component*	Musculoskeletal Functional Assessment**
	Mean Difference (95% Confidence Interval)	Mean Difference (95% Confidence Interval)	Mean Difference (95% Confidence Interval)
Unstratified Sample	0.8(-2.1,3.7)	1.3(-1.4,4.1)	13.8(-2.1,29.7)
Pelvis only	2.3(-0.8,5.3)	2.1(-1.9,6.0)	7.9(-11.3,27.2)
Acetabulum only	-2.8(-9.7,4.0)	-0.5(-7.5,6.5)	12.5(-10.5,35.5)
Combined	1.7(-3.2,6.6)	0.5(-6.7,7.6)	14.7(-10.2,39.6)
Pelvis A-Type	1.5(-1.8,4.7)	2.3(-1.0,5.7)	10.4(-6.6,27.3)
Pelvis B or C-Type	2.9(-7.1,12.9)	-0.7(-8.5,7.1)	16.3(-10.3,42.8)
Acetabulum A-Type	-2.8(-10.5,4.8)	-4.1(-11.2,3.1)	9.4(-13.3,32.1)
Acetabulum B or C-Type	11.4(5.3,17.4)	3.8(-1.7,9.3)	-13.2(-24.7,-1.7)

§ Propensity Score-based adjustment model including the following covariates: all demographic and injury characteristics listed in Table 1, plus ED first shock, First ED assessment of pulpils, midline shift, flail chest, open skull fracture, obesity and paralysis, together with relevant two-way interaction terms.

§§ A-Type is stable with regards to pelvic ring disruptions and involving single column with regards to acetabular injuries; B – Type is partially unstable with regards to pelvic ring disruption and including a transverse component with regards to acetabular injuries; C – Type is unstable (complete disruption of posterior arch) with regards to pelvic ring disruption and complete articular injuries involving both columns with regards to acetabular injuries.

* SF-36 Physical and Mental Health Components - positive score implies improved quality of life.

** Standardized MFA mobility subscale – negative score implies less functional impairment

REFERENCES

1. Dalal SA, Burgess AR, Siegel JH, Young JW, Brumback RJ, Poka A, Dunham CM, Gens D, Bathon H. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma.* Jul 1989;29(7):981-1000; discussion 1000-1002.
2. West JG, Trunkey DD, Lim RC. Systems of trauma care. A study of two counties. *Archives of surgery.* Apr 1979;114(4):455-460.
3. West JG, Williams MJ, Trunkey DD, Wolferth CC, Jr. Trauma systems. Current status--future challenges. *JAMA : the journal of the American Medical Association.* Jun 24 1988;259(24):3597-3600.
4. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma.* Sep 1999;47(3 Suppl):S25-33.
5. Mackenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Weir S, Scharfstein DO. The National Study on Costs and Outcomes of Trauma. *J Trauma.* Dec 2007;63(6 Suppl):S54-67; discussion S81-56.
6. MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Scharfstein DO. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med.* Jan 26 2006;354(4):366-378.
7. Mackenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Egleston BL, Salkever DS, Frey KP, Scharfstein DO. The impact of trauma-center care on functional outcomes following major lower-limb trauma. *J Bone Joint Surg Am.* Jan 2008;90(1):101-109.
8. Grotz MR, Allami MK, Harwood P, Pape HC, Krettek C, Giannoudis PV. Open pelvic fractures: epidemiology, current concepts of management and outcome. *Injury.* Jan 2005;36(1):1-13.
9. Suzuki T, Smith WR, Hak DJ, Stahel PF, Baron AJ, Gillani SA, Morgan SJ. Combined injuries of the pelvis and acetabulum: nature of a devastating dyad. *J Orthop Trauma.* May 2010;24(5):303-308.

10. van Vugt AB, van Kampen A. An unstable pelvic ring. The killing fracture. *J Bone Joint Surg Br.* Apr 2006;88(4):427-433.
11. Committee on Injury Scaling. The Abbreviated Injury Scale: 1998 revision (AIS-98). *Des Plaines, Ill.: Association for the Advancement of Automotive Medicine.* 1998.
12. MacKenzie EJ, Steinwachs DM, Shankar B. Classifying trauma severity based on hospital discharge diagnoses. Validation of an ICD-9CM to AIS-85 conversion table. *Med Care.* Apr 1989;27(4):412-422.
13. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audige L. Fracture and dislocation classification compendium - 2007: Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma.* Nov-Dec 2007;21(10 Suppl):S1-133.
14. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care.* Jun 1992;30(6):473-483.
15. Engelberg R, Martin DP, Agel J, Obremsky W, Coronado G, Swiontkowski MF. Musculoskeletal Function Assessment instrument: criterion and construct validity. *J Orthop Res.* Mar 1996;14(2):182-192.
16. Robins JM, Hernan MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology.* Sep 2000;11(5):550-560.
17. Nathens AB, Jurkovich GJ, Maier RV, Grossman DC, MacKenzie EJ, Moore M, Rivara FP. Relationship between trauma center volume and outcomes. *JAMA : the journal of the American Medical Association.* Mar 7 2001;285(9):1164-1171.
18. Demetriades D, Martin M, Salim A, Rhee P, Brown C, Chan L. The effect of trauma center designation and trauma volume on outcome in specific severe injuries. *Ann Surg.* Oct 2005;242(4):512-517; discussion 517-519.
19. Cudnik MT, Newgard CD, Sayre MR, Steinberg SM. Level I versus Level II trauma centers: an outcomes-based assessment. *J Trauma.* May 2009;66(5):1321-1326.

20. Demetriades D, Karaiskakis M, Toutouzas K, Alo K, Velmahos G, Chan L. Pelvic fractures: epidemiology and predictors of associated abdominal injuries and outcomes. *J Am Coll Surg.* Jul 2002;195(1):1-10.
21. Ben-Menachem Y, Coldwell DM, Young JW, Burgess AR. Hemorrhage associated with pelvic fractures: causes, diagnosis, and emergent management. *AJR Am J Roentgenol.* Nov 1991;157(5):1005-1014.
22. Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS, Jr., Poka A, Bathon GH, Brumback RJ. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma.* Jul 1990;30(7):848-856.
23. Letournel E JR. Fractures of the Acetabulum. 2nd ed. . 1993.
24. Pennal GF, Tile M, Waddell JP, Garside H. Pelvic disruption: assessment and classification. *Clin Orthop Relat Res.* Sep 1980(151):12-21.
25. Magnussen RA, Tressler MA, Obremskey WT, Kregor PJ. Predicting blood loss in isolated pelvic and acetabular high-energy trauma. *J Orthop Trauma.* Oct 2007;21(9):603-607.
26. Gabbe BJ, Simpson PM, Sutherland AM, Williamson OD, Judson R, Kossmann T, Cameron PA. Functional measures at discharge: are they useful predictors of longer term outcomes for trauma registries? *Ann Surg.* May 2008;247(5):854-859.
27. Gabbe BJ, Simpson PM, Sutherland AM, Wolfe R, Fitzgerald MC, Judson R, Cameron PA. Improved functional outcomes for major trauma patients in a regionalized, inclusive trauma system. *Ann Surg.* Jun 2012;255(6):1009-1015.
28. Nathens AB, Xiong W, Shafi S. Ranking of trauma center performance: the bare essentials. *J Trauma.* Sep 2008;65(3):628-635.