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Detecting the Blind Spot: Complications in the Trauma Registry and Trauma Quality Improvement

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Abstract

Background—The National Surgical Quality Improvement Program (NSQIP) has reduced complications for surgery patients in the Department of Veterans Affairs Healthcare System. The American College of Surgeons Committee on Trauma maintains the National Trauma Data Bank (NTDB) to track injured patient co-morbidities, complications, and mortality. We sought to apply the NSQIP methodology to collect co-morbidity and outcome data for trauma patients. Data were compared to the NTDB to determine the benefit and validity of using the NSQIP methodology for trauma.

Study Design—Utilizing the NSQIP methodology, data were collected from 8/1/2004 to 7/31/2005 on all adult patients admitted to the trauma service at a Level 1 trauma center. NSQIP data were collected for general surgery patients during the same time period from the same institution. Data were also extracted from v5.0 of the NTDB for patients ≥ 18 years old admitted to Level 1 trauma centers. Comparisons between University of Michigan (UM) NSQIP Trauma and UM NSQIP General Surgery patients and between UM NSQIP Trauma and NTDB (2004) patients were performed using univariate and multivariate analysis.

Results—Prior to risk-adjustment, there was a difference in mortality between the UM NSQIP Trauma and NTDB (2004) groups with univariate analysis (8.4 vs. 5.7%, OR 0.7, 95% CI 0.5–0.9, p=0.01). This survival advantage reversed to favor the UM NSQIP Trauma patient group when risk-adjustment was performed (OR 2.3, 95% CI 1.6–3.4, p<0.001). The UM NSQIP Trauma group had more complications than the UM NSQIP General Surgery patients. Despite having a lower risk-adjusted rate of mortality, the UM NSQIP Trauma patients had significantly higher rates of complications (wound infection, wound disruption, pneumonia, urinary tract infection, deep vein thrombosis, and sepsis) than the NTDB (2004) patients in both univariate and multivariate analysis.

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Conclusion—Complications occurred more frequently in trauma patients than general surgery patients. The UM NSQIP Trauma patients had higher rates of complications than reported in the NTDB. The NTDB data potentially underreports important co-morbidity and outcome data. Application of the NSQIP methodology to trauma may present an improved means of effectively tracking and reducing adverse outcomes in a risk-adjusted manner.

INTRODUCTION

In 1994 the American College of Surgeons (ACS) established the National Trauma Data Bank (NTDB) as a repository of trauma data for use by trauma program directors, hospital administrators, health planners, and government agencies. The current data set (Version 6.0) consists of records from over 2 million patients who were treated for injuries from 1993 to 2005. Supported by the National Highway Traffic Safety Administration and the Health Resources and Services Administration, the American College of Surgeons publishes an annual report from the NTDB data detailing the current status of trauma care in the United States.[1] Submission of data to the NTDB is voluntary. All of the data entered into the NTDB is collected and transferred to the database using a variety of existing commercial and "home grown" trauma registry programs. Until recently, there has existed no national standard data dictionary to ensure consistency across all of these registry programs. Studies have documented serious differences between separate hospital-based trauma registries.[2,3] The NTDB inherits the individual deficiencies of each contributing trauma registry. Because it inherits individual trauma center registry deficiencies and is a voluntary data bank the NTDB has the limitations of the convenience sample which it represents.[4] From 2004 through 2006, the American College of Surgeons Subcommittee on Trauma Registry Programs was supported by the U.S. Health Resources and Services Administration to devise a uniform trauma registry set. Publication of the National Trauma Registry Data Dictionary in August of 2006 by this committee created a uniform set of trauma registry variables and associated variable definitions as a future tool for registry software development, registry data collection and data transfer into the NTDB.[5]

The National Surgical Quality Improvement Program (NSQIP) was initiated in 1994 to evaluate the risk-adjusted performance of all Department of Veterans Affairs (VA) hospitals performing major surgery. It was created in response to Public Law 99–166 passed by the US Congress in 1986, mandating that the VA report its surgical outcomes in comparison to the national average, and that these outcomes be risk-adjusted to account for differences in severity of illness between VA and non-VA patient populations.[6] Data are adjusted for patient preoperative risk and a validated statistical program generates reports for each hospital in the VA system comparing hospitals by the ratio of observed to expected adverse events for 30-day mortality and morbidity. The impact of the NSQIP is measurable and since 1991 the unadjusted 30-day mortality rate for major noncardiac surgery within the VA has decreased by 27% and morbidity has declined by 45%.[7]

In 1999 the NSQIP methodology was introduced to the private sector at three non-VA academic medical centers (Emory University, Atlanta GA; University of Kentucky, Lexington, KY; and University of Michigan, Ann Arbor, MI). Preliminary analysis suggested no differences in risk-adjusted mortality between the non-VA and VA cohorts.[8] The NSQIP methodology was expanded to 18 private-sector medical centers as part of a pilot study that began in 2001. As a result of this success the American College of Surgeons developed a business plan which currently offers the NSQIP to all interested and qualified private sector hospitals.

The hallmark of the NSQIP is utilization of a trained dedicated nurse reviewer at each facility, working under the guidance of the chief of surgery, who prospectively collects the pre-operative risk and 30-day outcome data on major non-cardiac surgery patients and transmits

the data via a web-based program to a coordinating center for storage and analysis. NSQIP data collection uses concrete endpoints and has standardized definitions for the twenty-two postoperative occurrences defined as "morbidity". Risk-adjustment models are developed from the pooled data at the coordinating center and subjected to periodic review by the NSQIP executive committee. Outcome variables analyzed include death and complications within the first 30 days postoperatively.[9]

Our hypothesis is that the NTDB underreports important co-morbidity and complication data. To test this we utilized the NSQIP methodology to collect data on all adult trauma patients admitted to the trauma service for > 24 hours over a one year period. Data were abstracted from the NSQIP for the same institution for general surgery patients from the same time period. Comparisons were made to data from ACS verified level 1 trauma centers in the NTDB for patients admitted during the year 2004.

METHODS

Patient Data

From August 1, 2004 to July 31, 2005, 525 adult trauma patients 18 years of age or older were admitted to the University of Michigan Trauma Service. Patients admitted directly to other services such as Orthopedics, Neurosurgery, or Internal Medicine were excluded. Patients admitted for less than 24 hours or with only burn injuries and no trauma injuries were also excluded. Data were collected on each patient using the NSQIP methodology and data definitions published for general surgery patients. This patient group is identified as UM NSQIP Trauma in the results and data analysis. Our data collector was a trauma service physician assistant who underwent NSQIP training at the West Roxbury VA NSQIP training center in Boston, Massachusetts. Trauma registry data were abstracted from the ACS National Trauma Registry System (NTRACS) for Injury Severity Score (ISS), Glasgow Coma Scale Score (GCS), and mechanism of injury. No comorbidity or outcome data were obtained from the trauma registry and the separate trauma registry and UM NSQIP Trauma study data collectors were blinded to each other's co-morbidity and outcome data.

NSQIP co-morbidity and outcomes data for University of Michigan General Surgery patients were obtained from the NSQIP web site for the same time period from August 1, 2004 to July 31, 2005. A total of 1,327 General Surgery patients had complete NSQIP data from this time period. This patient group is identified as UM NSQIP General Surgery. Co-morbidity and outcomes data were also abstracted from version 5.0 of the NTDB. Patients ≥ 18 years of age were selected that were admitted during the year 2004, to ACS verified Level 1 trauma centers, for trauma injuries only. Patients with missing data for ISS, GCS, mechanism of injury, gender, or discharge status outcome were dropped. This resulted in a data set of 54,478 patients extracted from the NTDB. This group is labeled as NTDB (2004).

Additional data points not included in NSQIP but utilized in this study were as follows: obesity, history of seizure disorder, diagnosed psychiatric disease, psychiatric medicine use, prior admission for trauma, aspirin use, beta blocker use, Coumadin use, empyema, and new onset major arrhythmia. Written definitions were created for these added data points. Based on the existing definitions from the NSQIP and NTDB, at the time of the study, matches were made for UM NSQIP Trauma and NTDB (2004) co-morbidity and outcome measures. There were 15 similar co-morbidity measures and 12 outcome measures available for comparison (Table 1). The previous percutaneous transluminal coronary angioplasty and previous cardiac surgery cohorts in the UM NSQIP Trauma data were combined to match with history of cardiac surgery group for the NTDB (2004) patients. Patients with superficial and/or deep incisional surgical site infection in the UM NSQIP Trauma dataset were combined and matched with the wound infection group from the NTDB (2004) data for analysis.

Statistical Analysis

Data were compared using both univariate and multivariate statistical measures. Continuous variables were analyzed using an unpaired two-tailed Student's *t*-test for data with a normal distribution. Continuous data exhibiting a skewed distribution such as length of stay were analyzed using the Wilcoxon Rank Sum test. Patients who died were excluded from length of stay calculations. Discrete variables were compared using a Chi-square analysis. Multivariate analysis of outcome variables were performed using multiple logistic regression and adjusting for age, gender, mechanism of injury, ISS, and total GCS score. Database management and querying were performed using Microsoft Access software (Microsoft Corporation, Redmond, WA). All statistical analysis was performed using STATA SE 9.2 software (Stata Corporation, College Station, TX). Results are presented as mean values unless otherwise noted. Statistical significance was defined as a p-value ≤ 0.05. Approval for this study was obtained from the University of Michigan Health System Institutional Review Board.

RESULTS

Patient characteristics for the University of Michigan NSQIP Trauma patient and the NTDB (2004) patient groups are listed in Table 2. No differences were present between the two groups for mean age and gender. The UM NSQIP Trauma group had fewer patients with a penetrating mechanism of injury than the NTDB (2004) group (7% vs. 14%, p<0.001). The NTDB (2004) patients were less severely injured based on ISS and GCS values. To better quantify the differences between the two groups with respect to injury and survival, outcomes were stratified based on injury severity score. Categories used were ISS 1–15, 16–25, 26–35, and > 35. The number of patients in each ISS group, percent of the total group, raw number of deaths, percent mortality within the ISS category, and mean length of hospital stay are tabulated in Table 3. The UM NSQIP Trauma group had 29% of patients with an ISS > 25 whereas the NTDB (2004) group had only 9% of patients with an ISS > 25.

When univariate analysis was performed there was a significant difference in overall mortality between the UM NSQIP Trauma group and the NTDB (2004) group (8.4% vs. 5.7%, p=0.01, odds ratio 0.7, 95% confidence interval 0.5–0.9). However, mortality rates were the same between UM NSQIP Trauma and NTDB (2004) groups for the stratified ISS categories except for patients in the ISS 16–25 range which favored UM NSQIP Trauma in univariate analysis (3% vs. 11%, p=0.001). Length of stay was considerably higher for the UM NSQIP patients in the two lowest ISS ranges (ISS 1–15, 16–25) when compared to the NTDB (2004) data.

Pre-operative or pre-injury risk factors present in each of the three groups is illustrated in Table 4. When compared to the UM NSQIP General Surgery patient group the UM NSQIP Trauma group had significantly higher rates of smoking, ETOH use, impaired sensorium on hospital presentation, coma, open wound, and transfusion of > 4 units of blood products in the first 24 hours of admission. The UM NSQIP Trauma group demonstrated significantly lower rates of diabetes, chronic obstructive pulmonary disease, hypertension, and disseminated cancer than the patients in the UM NSQIP General Surgery group.

Similar univariate comparisons were conducted between the UM NSQIP Trauma group and the NTDB (2004) group. The NTDB group had substantially lower rates of obesity, diabetes, alcohol abuse, hypertension, history of seizure disorder, disseminated cancer, bleeding disorders, diagnosed psychiatric disease, and Coumadin use. Obesity, alcohol use, bleeding disorders, and diagnosed psychiatric disease all differed by an order of magnitude greater than 10-fold, with considerably fewer cases recorded in the NTDB.

Based on univariate analysis the UM NSQIP Trauma patients had a higher incidence of death within 30 days of discharge, pneumonia, urinary tract infection, stroke/cerebral vascular

accident, coma > 24 hours, peripheral nerve injury, bleeding/transfusions, and deep venous thrombosis/thrombophlebitis when compared to the UM NSQIP General Surgery group (Table 5). Interestingly, the UM NSQIP Trauma patient group had a lower incidence of superficial incisional surgical site infection and organ/space surgical site infection when compared to the UM NSQIP General Surgery patients. Overall the trauma patient population represents a group of patients who is at high risk for post-operative or post-trauma complications based on the data collected. They certainly have a higher rate of complications than the general surgery patient population which includes both elective and emergent operative cases. When data were compared between the UM NSQIP Trauma and NTDB (2004) patient groups the NTDB (2004) patients had markedly lower rates of occurrence for wound infection, wound disruption, pneumonia, pulmonary embolism, empyema, urinary tract infection, cardiac arrest requiring cardiopulmonary resuscitaiton, deep venous thrombosis/thrombophlebitis, and sepsis.

To further test our hypothesis that complications are potentially underreported in the NTDB we sought to adjust for differences in the two groups of data using multivariate logistic regression. ISS and GCS data were converted into categorical variables. Multiple logistic regression analysis was performed to compare outcomes between the UM NSQIP Trauma and NTDB (2004) patient groups. The outcome variables studied included death, wound infection, wound disruption, pneumonia, pulmonary embolism, acute renal failure, urinary tract infection, cardiac arrest requiring CPR, myocardial infarction, deep venous thrombosis/ thrombophlebitis, and sepsis. Potential confounding variables for which risk adjustment was performed are age, gender, mechanism of injury, ISS category, and GCS category. Results of both the uncorrected and corrected outcomes are listed in Table 6.

When adjusted for age, gender, mechanism of injury, ISS category, and GCS category the odds ratio for death changed from 0.7 (95% CI, 0.5–0.9, p=0.01, χ^2) to 2.3 (95% CI,1.6–3.4, p<0.001, multivariate logistic regression) when comparing the NTDB (2004) group to the UM NSQIP Trauma group of patients. Despite this increased risk of death in the NTDB (2004) group, the risk of complications such as wound infection, wound disruption, pneumonia, urinary tract infection, deep venous thrombosis/thrombophlebitis, and sepsis all favored the NTDB (2004) with adjusted odds ratios ranging between 0.1 and 0.4. No significant difference was detected for the rates of pulmonary embolism, acute renal failure, cardiac arrest requiring cardiopulmonary resuscitation, or myocardial infarction between the two groups in the multivariate analysis.

DISCUSSION

The data in this paper suggest that when the NSQIP methodology was applied to trauma patients at the University of Michigan pre-operative risk factors (Table 4) and post-operative adverse events (Table 5) were reported more frequently than in all trauma patients at comparable trauma centers nationwide in the NTDB database. This might be due either to: (1) NSQIP methodology is more thorough in its data collection efforts than the methodology used in the NTDB database; or (2) The University of Michigan trauma patients are sicker than the national sample of trauma patients in the NTDB database, and therefore have more pre-operative risk factors and post-operative adverse events. Indeed, the data in Table 2 suggest that the University of Michigan patients have higher ISS and worse GCS values compared to the national NTDB sample. However, when risk-adjustment is performed (Table 6) using age, gender, mechanism of injury, ISS, and total GCS, many post-operative adverse events remain equal to or lower in the NTDB national sample compared to the University of Michigan trauma patients, with the exception of mortality. This suggests that post-operative adverse events might be underreported in the NTDB database. Another explanation for our findings, if the data in the NTDB is accurate and complete, is that the University of Michigan trauma patients suffer more complications than the national average and are potential recipients of lower quality care.

While it may be impossible to prove conclusively our hypothesis that co-morbidities and complications are underreported in the NTDB, our study certainly raises the strong possibility that this could be the case. Rates of complications within the NTDB are astonishingly low especially when compared to the UM NSQIP General Surgery group which represents a reference cohort of largely elective operative cases. An example is the fact that in the NTDB (2004) data 192 patients had sepsis/bacteremia out of a total of 54,478 cases. This corresponds to a sepsis rate of 0.4% in the trauma patient population. The UM NSQIP General Surgery group had a rate of sepsis of 3.1%, and the rate for all sites in the private sector ACS NSQIP is 2.6%. Given that 25 trauma patients had bacteremia in the UM NSQIP Trauma group, this would mean that a single hospital potentially accounts for 12% of the cases of sepsis among all ACS verified Level 1 trauma centers in the United States submitting data to the NTDB.

A recent study of electronic alerts to prevent venous thromboembolism among hospitalized patients demonstrated a rate of deep vein thrombosis in patients who received prophylaxis of 5.1% at 90 days following admission to the hospital.[10] This correlates well with our finding that 6.5% of the UM NSQIP Trauma patients were diagnosed with deep venous thrombosis. The rate discovered in the NTDB for trauma patients admitted in 2004 was 0.6% or just 309 out of 54,478 cases. Again, given that 34 trauma patients had deep venous thrombosis in the UM NSQIP Trauma group this would mean that our institution accounted for 10% of all cases of deep venous thrombosis among ACS Level 1 trauma centers in the NTDB. This would be astounding given that the UM NSQIP Trauma patient group represents only 525 patients or 1% of the total 55,003 trauma patients in our study.

Assessment of quality has received increasing attention for all healthcare providers with special emphasis directed at surgeons in recent years.[11] In order to accurately gauge the quality of care delivered, data must be uniformly collected in a complete and consistent manner for the desired population to be studied. Risk-adjustment between groups of patients to be compared is usually conducted to minimize differences that can arise from uncontrollable variables such as illness severity, age, etc. Surgeons and especially trauma surgeons are interested in feedback tools that allow them to credibly identify problems in their processes of care and offer useful corrective actions. This is the foundation upon which the weekly death and complications conference is based at every teaching hospital in the United States. Use of prospective clinical datasets for quality improvement has been performed with positive results. There has been a real reduction in morbidity and mortality for surgical patients in the VA hospitals since the implementation of NSQIP.[7,12] In Northern New England differences were discovered between hospitals (3.1 to 6.3%) and surgeons (1.9 to 9.2%) for mortality in patients with cardiovascular disease undergoing coronary artery bypass grafting.[13] Investigators implemented a three-component intervention consisting of feedback of outcomes data, training in quality improvement techniques, and site visits to other medical centers. Following application of these three measures, hospital mortality declined 24% in participating institutions.[14]

Trauma registries were created to record patient data at trauma centers so that reliable information could be obtained as to the activities of the trauma center for research and monitoring.[15] As trauma registries have evolved national standards for data collection by trauma registries have been created.[16] However, until the recent publication of a data dictionary the definitions for co-morbidity and complications have been open to interpretation by each individual registry.[5] This has led to confusion and lack of consistency in what data should be collected by all trauma centers. If one hospital has incomplete recorded information on patients with regard to complications it may incorrectly appear to be providing better quality care than another hospital that diligently collects and records information on all its patient complications. Within the NTDB v5.0 142 institutions recorded no complications at all for

data from 2000 to 2004.[4] A total 51 centers experienced complications in less than 1% of their patient cases.

Why is there chronic and widespread complication underreporting from trauma centers? While there are no objective data, our belief is that most centers do not have the infrastructure to track and document complications as they emerge. Specifically, the current manual registrar-based data collection process does not readily allow most institutions to identify their complications in a systematic way. In reality complications are only recorded when they can easily be found and accurately interpreted by a registrar during retrospective review of the written medical record. Unfortunately, many institutions administrative resources are stretched thin and the registrar is overwhelmed with identifying new patients, coding injuries and collecting basic registry data. They simply do not have the time to appropriately identify, codify and report complications and pre-existing medical conditions. This is a process issue for virtually all trauma centers. Alternatively, mortality is readily recorded as it is easy to define, the information is readily available, and straightforward to document.

Why is this an issue? The data within the NTDB is being used for research purposes and calculation of prevalence for complications and risk factors. If the prevalence of serious complications like sepsis, deep venous thrombosis or pneumonia is inaccurately recorded it can severely underestimate the scope of a clinical problem. These are crucial data for allocation of health care resources and documentation of the actual cost of caring for complex patients. Complications add to hospital cost and length of stay. In a study of hospital costs following surgical complications using NSQIP data, after adjusting for patient differences, major surgical complications were associated with an increase of $11,626 in costs.[17] Respiratory complications were associated with the largest increase in cost ($52,466), followed by thromboembolic ($18,310), cardiovascular ($7,789), and infectious ($1,398) complications. At a Level 1 Trauma Center, in trauma patients who developed any of six complications (adult respiratory distress syndrome, acute kidney failure, sepsis, pneumonia, decubitus ulceration, or wound infection) costs exceeded reimbursements by an average of $5750 per patient.[18]

Understanding the actual costs associated with the care delivered sets the stage for providers, hospital administrators and third party payers to work together to reduce the incidence of complications. Moreover as many trauma centers are increasingly capacity constrained, developing the capability to accurately forecast patient length of stay and cost, allows for better budgeting and utilization of human resources. Over time accurate clinical and financial data will allow trauma centers to better understand, manage, and staff their trauma centers. The goal is to optimize the utilization of the entire trauma system directing the right patient to the right center at the right time.

The results of this study demonstrate that important complications appear to be underrepresented in the NTDB. This should not in any way be construed as a fatal flaw with the NTDB. Rather it should represent an opportunity for improvement in data collection and risk-adjusted analysis for trauma patients. The fact that trauma patients suffer complication rates higher than those for general surgery patients in the NSQIP should awaken health care providers as to where the largest potential improvements in quality may lie.

CONCLUSIONS

Complications occurred more frequently in trauma patients than general surgery patients. The UM NSQIP Trauma patients had higher rates of complications than reported in the NTDB, but demonstrated a significantly lower risk-adjusted mortality than similar patients in the NTDB. The NTDB data potentially underreport important co-morbidity and outcome data and as such represents a blind spot in the trauma registry. Application of the NSQIP methodology to trauma

represents a more effective means of tracking and reducing adverse outcomes in a risk-adjusted manner.

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ABREVIATIONS

ACS
American College of Surgeons

NTDB
National Trauma Data Bank

NSQIP
National Surgical Quality Improvement Program

VA
Department of Veterans Affairs

ISS
Injury Severity Score

GCS
Glasgow Coma Scale Score

UM
University of Michigan

Table 1

UM NSQIP Trauma and NTDB Data Matches

UM NSQIP Trauma	**NTDB**
Risk Factor	
Obesity (BMI > 40)	Obesity
Diabetes	Diabetes Mellitus
Oral	Non-insulin Dependent
Insulin	Insulin Dependent
ETOH > 2 Drinks/day	Chronic Alcohol Abuse
History Severe COPD	COPD
Congestive Heart Failure	Congestive Heart Failure
History MI	Myocardial Infarction
Previous PTCA	History of Cardiac Surgery
Previous Cardiac Surgery	
History Angina	Coronary Artery Disease
Hypertension	Hypertension
Renal Failure (Dialysis)	Dialysis
History of Seizure Disorder	Seizures
Disseminated Cancer	Concurrent or Existence of Metastasis
Bleeding Disorders	Acquired Coagulopathy
Diagnosed Psychiatric Disease	History of Psychiatric Disorders
Coumadin	Coumadin Therapy
Post-Operative Occurences	
Deaths within 30 Days	Dead
Wound Occurences	
Superficial Incisional SSI	Wound Infection
Deep Incisional SSI	
Wound Disruption	Dehiscence/+Evisceration
Respiratory Occurences	
Pneumonia	Pneumonia+Aspiration Pneumonia
Pulmonary Embolism	Pulmonary Embolus
Empyema	Empyema
Urinary Tract Occurences	
Acute Renal Failure	Renal Failure
Urinary Tract Infection	Urinary Tract Infection
Cardiac Occurences	
Cardiac Arrest Requiring CPR	Cardiac Arrest
Myocardial Infarction	Myocardial Infarction
Other Surgical Occurences	
DVT/Thrombophlebitis	DVT (Lower Extremity)
Sepsis	Bacteremia

UM, University of Michigan; NSQIP, National Surgical Quality Improvement Program; NTDB, National Trauma Data Bank; ETOH, ethanol; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; SSI, surgical site infection; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis.

Table 2

Patient Characterisitics

Patient Characteristics	UM NSQIP Trauma	NTDB (2004)	*p*-value
N	525	54478	--
Age	43	43	0.9
Gender			
Male	69%	69%	0.8
Female	31%	31%	
Blunt Mechanism of Injury	93%	86%	< 0.001
Penetrating Mechanism of Injury	7%	14%	
ISS	21	11	< 0.001
GCS			
Motor	5.1	5.5	< 0.001
Verbal	3.9	4.5	< 0.001
Eye	3.4	3.7	< 0.001
Total	12.4	13.6	< 0.001

UM, University of Michigan; NSQIP; National Surgical Quality Improvement Program; NTDB, National Trauma Data Bank; ISS, Injury Severity Score; GCS, Glasgow Coma Scale Score.

Table 3

Survival and LOS stratified by ISS

UM NSQIP Trauma	**# Patients**	**% Patients**	**# Deaths**	**% Mortality**	**Mean LOS**
ISS 1 – 15	191	36	0	0	7.2†
ISS 16 – 25	185	35	6	3†	11.5†
ISS 26 – 35	98	19	17	17	13.0
ISS > 35	51	10	21	41	28.6
Total	525	--	44	8.4%*	11.1†
NTDB (2004)	# Patients	% Patients	# Deaths	% Mortality	Mean LOS
ISS 1 – 15	41024	75	553	1	4.1
ISS 16 – 25	8430	16	891	11	9.7
ISS 26 – 35	3208	6	817	25	17.3
ISS > 35	1816	3	862	47	26.5
Total	54478	--	3123	5.7%	6.0

LOS, length of stay; ISS, Injury Severity Score; UM, University of Michigan; NSQIP, National Surgical Quality Improvement Program; NTDB, National Trauma Data Bank.

*p<0.01, comparing total % mortality between UM NSQIP trauma patients and NTDB patients.

†p=0.001, comparing % mortality or mean LOS between UM NSQIP trauma patients and NTDB patients within ISS groups.

Table 4

Pre-Operative or Pre-Injury Risk Factors

Risk Factor	UM NSQIP Trauma N=525		UM NSQIP General Surgery N=1,327			NTDB (2004) N=54,478		
	%	N	%	N	*p-value	%	N	**p-value
General Risk Factors								
Obesity	4.4	18	--	--	--	0.3	168	< 0.001
Diabetes								
No	94.1	494	88.8	1178	0.003	98.0	53410	< 0.001
Oral	3.2	17	6.4	85		1.4	768	
Insulin	2.7	14	4.7	62		0.6	300	
Current Smoker	42.3	222	13.8	183	<0.001	--	--	--
ETOH	15.0	79	2.0	27	<0.001	1.4	774	< 0.001
Pulmonary Risk Factors								
History Severe COPD	1.3	7	3.2	42	0.04	0.7	375	0.08
Current Pneumonia	0.6	3	0.5	7	0.8	--	--	--
Cardiac Risk Factors								
Congestive Heart Failure	1.1	6	1.0	13	1.0	0.5	296	0.06
History MI	0.4	2	0.2	3	0.9	0.7	372	0.4
Previous PTCA	2.5	13	3.2	42	0.5			
Previous Cardiac Surgery	2.3	12	2.9	38	0.6	3.8	2043	0.4
History Angina	0.6	3	0.4	5	0.9	1.1	616	0.2
Hypertension	16.4	86	32.8	435	<0.001	3.9	2101	< 0.001
Renal Risk Factors								
Renal Failure (Dialysis)	0.4	2	0.6	8	0.8	0.1	54	0.5
Central Nervous System Risk Factors								
Impaired Sensorium	13.3	70	0.6	8	<0.001	--	--	--
Coma	10.1	53	0.0	0	<0.001	--	--	--
History of Ischemic Attacks	1.5	8	1.3	17	0.9	--	--	--
History of Seizure Disorder	3.4	18	--	--	--	0.5	275	< 0.001
Nutritional/Immune/Other Risk Factors								
Disseminated Cancer	0.8	4	3.8	50	<0.001	0.1	51	< 0.001
Open Wound	55.6	292	3.8	50	<0.001	--	--	--
Bleeding Disorders	3.6	19	3.2	42	0.7	0.04	21	< 0.001
Transfusion > 4 units	4.8	25	0.3	4	<0.001	--	--	--
Diagnosed Psychiatric Disease	21.1	111	--	--	--	1.6	865	< 0.001
Psychiatric Rx Use	16.4	86	--	--	--	--	--	--
Prior Admission for Trauma	17.5	92	--	--	--	--	--	--
Aspirin	7.6	40	--	--	--	--	--	--
Beta Blocker	8.2	43	--	--	--	--	--	--
Coumadin	1.3	7	--	--	--	0.4	233	0.002

UM, University of Michigan; NSQIP, National Surgical Quality Improvement Program; NTDB, National Trauma Data Bank; ETOH, ethanol; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; Rx, medication.

* p-value comparing patient characteristics for UM NSQIP trauma and general surgery patients.

** p-value comparing UM NSQIP trauma and NTDB trauma patients.

Table 5

Post-Operative Occurrences

Post-Operative Occurrences	UM NSQIP Trauma N=525		UM NSQIP General Surgery N=1,327			NTDB (2004) N=54,478		
	%	N	%	N	*p-value	%	N	**p-value
Deaths within 30 Days	8.4	44	1.5	20	<0.001	5.7	3123	0.01
Wound Occurences								
Superficial Incisional SSI	1.9	10	4.5	60	0.01	0.5	291	<0.001
Deep Incisional SSI	1.7	9	0.7	9	0.07			
Organ/Space SSI	1.9	10	2.9	38	0.04	--	--	--
Wound Disruption	0.6	3	0.8	10	0.9	0.05	28	<0.001
Respiratory Occurences								
Pneumonia	14.1	74	1.6	21	<0.001	2.7	1488	<0.001
Unplanned Intubation	2.7	14	1.6	21	0.2	--	--	--
Pulmonary Embolism	1.0	5	0.5	6	0.4	0.3	152	0.004
Empyema	0.6	3	--	--	--	0.1	60	0.002
Urinary Tract Occurences								
Acute Renal Failure	1.0	5	0.4	5	0.2	0.4	239	0.08
Progressive Renal Insufficiency	0.6	3	0.2	3	0.5	--	--	--
Urinary Tract Infection	12.6	66	3.5	47	<0.001	1.3	701	<0.001
Central Nervous System Occurences								
Stroke/CVA	1.0	5	0.0	0	0.002	--	--	--
Coma > 24 Hours	2.9	15	0.0	0	<0.001	--	--	--
Peripheral Nerve Injury	1.5	8	0.2	3	0.003	--	--	--
Cardiac Occurences								
Cardiac Arrest Requiring CPR	1.1	6	0.4	5	0.1	0.4	206	0.005
Myocardial Infarction	0.6	3	0.2	2	0.3	0.7	372	0.8
New Onset Major Arrhythmia	2.3	12	--	--	--	--	--	--
Other Surgical Occurences								
Bleeding/Transfusions	5.0	26	0.2	2	<0.001	--	--	--
DVT/Thrombophlebitis	6.5	34	0.8	11	<0.001	0.6	309	<0.001
Sepsis	4.8	25	3.1	41	0.1	0.4	192	<0.001

UM, University of Michigan; NSQIP, National Surgical Quality Improvement Program; NTDB, National Trauma Data Bank; SSI, surgical site infection; CVA, cerebral vascular accident; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis.

* p-value comparing patient characteristics for UM NSQIP trauma and general surgery patients.

** p-value comparing UM NSQIP trauma and NTDB trauma patients.

Table 6

Post-Operative Occurrences

Post-Operative Occurrences w/Multivariate Analysis	UM NSQIP Trauma %	NTDB (2004) %	Unadjusted			Adjusted		
			Odds Ratio	95% Conf. Interval	*p*-value	Odds Ratio	95% Conf. Interval	*p*-value
Deaths within 30 Days	8.4	5.7	0.7	0.5–0.9	0.01	2.3	1.6–3.4	<0.001
Wound Occurences								
Wound Infection	3.4	0.5	0.2	0.09–0.3	<0.001	0.3	0.2–0.4	<0.001
Wound Disruption	0.6	0.05	0.09	0.03–0.5	<0.001	0.1	0.04–0.4	0.001
Respiratory Occurences								
Pneumonia	14.1	2.7	0.2	0.1–0.2	<0.001	0.4	0.3–0.5	<0.001
Pulmonary Embolism	1.0	0.3	0.3	0.1–0.9	0.004	0.5	0.2–1.3	0.2
Urinary Tract Occurences								
Acute Renal Failure	1.0	0.4	0.5	0.2–1.4	0.08	1.1	0.4–2.6	0.9
Urinary Tract Infection	12.6	1.3	0.09	0.07–0.1	<0.001	0.2	0.1–0.2	<0.001
Cardiac Occurences								
Cardiac Arrest Requiring CPR	1.1	0.4	0.3	0.1–0.9	0.005	0.8	0.3–1.8	0.5
Myocardial Infarction	0.6	0.7	1.2	0.4–5.8	0.8	1.3	0.4–4.2	0.6
Other Surgical Occurences								
DVT/Thrombophlebitis	6.5	0.6	0.08	0.06–0.1	<0.001	0.2	0.1–0.3	<0.001
Sepsis	4.8	0.4	0.07	0.05–0.1	<0.001	0.2	0.1–0.2	<0.001

NTDB, National Trauma Data Bank; UM University of Michigan; NSQIP, National Surgical Quality Improvement Program; SSI, surgical site infection; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis.

The odds ratios are comparing NTDB vs. UM NSQIP trauma patients with UM NSQIP trauma patients as the reference group.

Adjustment variables include age, gender, mechanism of injury, ISS and GCS scores.