Detecting the blind spot: Complications in the trauma registry and trauma quality improvement

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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 comorbidities, complications, and mortality. We sought to apply the NSQIP methodology to collect comorbidity 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 August 1, 2004 to July 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. *Before 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%; odds ratio [OR], 0.7; 95% confidence interval [CI] 0.5-0.9;* $P = .01$*). 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;* $P < .001$*). 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 analyses.*

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 underreport important comorbidity 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. (Surgery 2007;142:439-49.)*

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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 >2 million patients who were treated for

Presentation at the 64th Annual Meeting of the Central Surgical Association, Chicago, Illinois, March 8-10, 2007.

M.R.H. was supported by a Central Surgical Association Foundation Enrichment Grant and an American Association for the Surgery of Trauma Research and Education Foundation Scholarship.

Accepted for publication July 3, 2007.

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0039-6060/$ - see front matter

doi:10.1016/j.surg.2007.07.002

injuries from 1993 to 2005. Supported by the National Highway Traffic Safety Administration and the Health Resources and Services Administration, the ACS 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 are 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 that it represents.[4] From 2004 through 2006, the ACS Subcommittee on Trauma Registry Programs was supported by the US 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 with 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 3 non-VA academic medical centers (Emory University, Atlanta, Ga; University of Kentucky, Lexington; and University of Michigan, Ann Arbor). 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 ACS developed a business plan that 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 preoperative risk and 30-day outcome data on major noncardiac 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 22 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 comorbidity 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 1-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 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 <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 (Boston, Mass). 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 comorbidity and outcome data.

NSQIP comorbidity 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 1327 general surgery patients had complete NSQIP data from this time period. This patient group is identified as UM NSQIP General Surgery. Comorbidity and outcomes data were also abstracted from version 5.0 of the NTDB. Patients ≥18 years of age were selected that were admitted during 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, β-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) comorbidity and outcome measures. There were 15 similar comorbidity measures and 12 outcome measures available for comparison (Table I). 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.

Table I. 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
Alcohol >2 drinks/day	Chronic alcohol abuse
History severe COPD	COPD
Congestive heart failure	Congestive heart failure
History MI	MI
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
Postoperative Occurrences	
Deaths within 30 days	Dead
Wound occurrences	
Superficial incisional SSI	Wound infection
Deep incisional SSI	
Wound disruption	Dehiscence/+evisceration
Respiratory occurrences	
Pneumonia	Pneumonia + aspiration pneumonia
Pulmonary embolism	Pulmonary embolus
Empyema	Empyema
Urinary tract occurrences	
Acute renal failure	Renal failure
Urinary tract infection	Urinary tract infection
Cardiac occurrences	
Cardiac arrest requiring CPR	Cardiac arrest
MI	MI
Other surgical occurrences	
DVT/thrombophlebitis	DVT (lower extremity)
Sepsis	Bacteremia

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

Statistical analysis. Data were compared using both univariate and multivariate statistical measures. Continuous variables were analyzed using an unpaired 2-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 χ^2 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, Wash). All statistical analysis was per-

formed using STATA SE 9.2 software (Stata Corporation, College Station, Tex). Results are presented as mean values unless otherwise noted. Statistical significance was defined as a *P*-value ≤.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 II. No differences were present between the 2 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%; $P < .001$). The NTDB (2004) patients were less severely injured based on ISS and GCS values. To better quantify the differences between the 2 groups with respect to injury and survival, outcomes were stratified based on ISS. 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 III. 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%; $P = .01$; odds ratio [OR], 0.7; 95% confidence interval, [CI], 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%; $P = .001$). Length of stay was considerably higher for the UM NSQIP patients in the 2 lowest ISS ranges (ISS 1-15, 16-25) when compared with the NTDB (2004) data.

Preoperative or pre-injury risk factors present in each of the 3 groups is illustrated in Table IV. When compared with the UM General Surgery patient group, the UM NSQIP Trauma group had significantly higher rates of smoking, alcohol use, impaired sensorium on hospital presentation, coma, open wound, and transfusion of >4 U 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.

Table II. Patient characteristics

Patient characteristics	*UM NSQIP Trauma*	*NTDB (2004)*	P-*value*
N	525	54,478	—
Age	43	43	.9
Gender			
Male	69%	69%	.8
Female	31%	31%	
Blunt mechanism of injury	93%	86%	<.001
Penetrating mechanism of injury	7%	14%	
ISS	21	11	<.001
GCS			
Motor	5.1	5.5	<.001
Verbal	3.9	4.5	<.001
Eye	3.4	3.7	<.001
Total	12.4	13.6	<.001

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

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 >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 with the UM NSQIP General Surgery group (Table V). 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 with the UM NSQIP General Surgery patients. Overall, the trauma patient population represents a group of patients who is at high risk for postoperative or posttrauma 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

Table III. Survival and LOS stratified by ISS

	No. of patients	*% Patients*	*No. of deaths*	*% Mortality*	*Mean LOS*
UM NSQIP Trauma					
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)					
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 <.01 comparing total percent mortality between UM NSQIP Trauma patients and NTDB patients.
†P = .001 comparing percent mortality or mean LOS between UM NSQIP Trauma patients and NTDB patients within ISS groups.

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 resuscitation (CPR), 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 2 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 VI.

When adjusted for age, gender, mechanism of injury, ISS category, and GCS category, the OR for death changed from 0.7 (95% CI, 0.5-0.9; $P = .01$, χ^2) to 2.3 (95% CI, 1.6-3.4; $P < .001$, multivariate logistic regression) when comparing the NTDB (2004) group with 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 CPR, or myocardial infarction between the 2 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, preoperative risk factors (Table IV) and postoperative adverse events (Table V) 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 being more thorough in its data collection efforts than the methodology used in the NTDB database or (2) the University of Michigan trauma patients being sicker than the national sample of trauma patients in the NTDB database, and therefore having more preoperative risk factors and postoperative adverse events. Indeed, the data in Table II suggest that the University of Michigan patients have higher ISS and worse GCS values compared with the national NTDB sample. However, when risk adjustment is performed (Table VI) using age, gender, mechanism of injury, ISS, and total GCS, many postoperative adverse events remain equal to or lower in the NTDB national sample compared with the University of Michigan trauma patients, with the exception of mortality. This suggests that postoperative adverse events might be underreported in the NTDB database. Another explanation for our findings, if the data in the NTDB are accurate and complete, is that the University of

Table IV. Preoperative or preinjury risk factors

	UM NSQIP Trauma (n = 525)		*UM NSQIP General Surgery (n = 1327)*			*NTDB (2004) (n = 54,478)*		
Risk factor	%	*n*	%	*n*	*P-value	%	*n*	**P-value
General risk factors								
Obesity	4.4	18	—	—	—	0.3	168	<.001
Diabetes								
No	94.1	494	88.8	1178	.003	98.0	53410	<.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	<.001	—	—	—
ETOH	15.0	79	2.0	27	<.001	1.4	774	<.001
Pulmonary risk factors								
History of severe COPD	1.3	7	3.2	42	.04	0.7	375	.08
Current pneumonia	0.6	3	0.5	7	.8	—	—	—
Cardiac risk factors								
CHF	1.1	6	1.0	13	1.0	0.5	296	.06
History MI	0.4	2	0.2	3	.9	0.7	372	.4
Previous PTCA	2.5	13	3.2	42	.5	3.8	2043	.4
Previous cardiac surgery	2.3	12	2.9	38	.6			
History angina	0.6	3	0.4	5	.9	1.1	616	.2
Hypertension	16.4	86	32.8	435	<.001	3.9	2101	<.001
Renal risk factors								
Renal failure (dialysis)	0.4	2	0.6	8	.8	0.1	54	.5
Central nervous system risk factors								
Impaired sensorium	13.3	70	0.6	8	<.001	—	—	—
Coma	10.1	53	0.0	0	<.001	—	—	—
History of ischemic attacks	1.5	8	1.3	17	.9	—	—	—
History of seizure disorder	3.4	18	—	—	—	0.5	275	<.001
Nutritional/Immune/Other risk factors								
Disseminated cancer	0.8	4	3.8	50	<.001	0.1	51	<.001
Open wound	55.6	292	3.8	50	<.001	—	—	—
Bleeding disorders	3.6	19	3.2	42	.7	0.04	21	<.001
Transfusion >4 U	4.8	25	0.3	4	<.001	—	—	—
Diagnosed psychiatric disease	21.1	111	—	—	—	1.6	865	<.001
Psychiatric Rx use	16.4	86	—	—	—	—	—	—
Prior admission for trauma	17.5	92	—	—	—	—	—	—
Aspirin	7.6	40	—	—	—	—	—	—
β-Blocker	8.2	43	—	—	—	—	—	—
Coumadin	1.3	7	—	—	—	0.4	233	.002

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

**P*-value comparing patient characteristics for UM NSQIP Trauma and General Surgery patients.

***P*-value comparing UM NSQIP Trauma and NTDB patients.

Michigan trauma patients suffer more complications than the national average and are potential recipients of lower quality care.

Although it may be impossible to prove conclusively our hypothesis that comorbidities 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 with 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%.

Table V. Postoperative occurrences

Postoperative Occurrences	UM NSQIP Trauma (n = 525) %	UM NSQIP Trauma (n = 525) n	UM NSQIP General Surgery (n = 1327) %	UM NSQIP General Surgery (n = 1327) n	*P-value	NTDB (2004) (n = 54,478) %	NTDB (2004) (n = 54,478) n	**P-value
Deaths within 30 days	8.4	44	1.5	20	<.001	5.7	3123	.01
Wound occurrences								
Superficial incisional SSI	1.9	10	4.5	60	.01	0.5	291	<.001
Deep incisional SSI	1.7	9	0.7	9	.07			
Organ/space SSI	1.9	10	2.9	38	.04	—	—	—
Wound disruption	0.6	3	0.8	10	.9	0.05	28	<.001
Respiratory occurrences								
Pneumonia	14.1	74	1.6	21	<.001	2.7	1488	<.001
Unplanned intubation	2.7	14	1.6	21	.2	—	—	—
Pulmonary embolism	1.0	5	0.5	6	.4	0.3	152	.004
Empyema	0.6	3	—	—	—	0.1	60	.002
Urinary tract occurrences								
Acute renal failure	1.0	5	0.4	5	.2	0.4	239	.08
Progressive renal insufficiency	0.6	3	0.2	3	.5	—	—	—
Urinary tract infection	12.6	66	3.5	47	<.001	1.3	701	<.001
Central nervous system occurrences								
Stroke/CVA	1.0	5	0.0	0	.002	—	—	—
Coma >24 hours	2.9	15	0.0	0	<.001	—	—	—
Peripheral nerve injury	1.5	8	0.2	3	.003	—	—	—
Cardiac occurrences								
Cardiac arrest requiring CPR	1.1	6	0.4	5	.1	0.4	206	.005
Myocardial infarction	0.6	3	0.2	2	.3	0.7	372	.8
New-onset major arrhythmia	2.3	12	—	—	—	—	—	—
Other surgical occurrences								
Bleeding/transfusions	5.0	26	0.2	2	<.001	—	—	—
DVT/thrombophlebitis	6.5	34	0.8	11	<.001	0.6	309	<.001
Sepsis	4.8	25	3.1	41	.1	0.4	192	<.001

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

**P*-value comparing patient characteristics for UM NSQIP Trauma and General Surgery patients.

***P*-value comparing UM NSQIP Trauma and NTDB patients.

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 after 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] 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, and age. Surgeons—especially trauma surgeons—are interested in feedback tools that allow them to credibly identify

Table VI. Postoperative occurrences

Postoperative Occurrences with Multivariate Analysis	*UM NSQIP Trauma (%)*	*NTDB (2004) (%)*	*Unadjusted*			*Adjusted*		
			OR	*95% CI*	P-*value*	*OR*	*95% CI*	P-*value*
Deaths within 30 days	8.4	5.7	0.7	0.5-0.9	.01	2.3	1.6-3.4	<.001
Wound occurrences								
Wound infection	3.4	0.5	0.2	0.09-0.3	<.001	0.3	0.2-0.4	<.001
Wound disruption	0.6	0.05	0.09	0.03-0.5	<.001	0.1	0.04-0.4	.001
Respiratory occurrences								
Pneumonia	14.1	2.7	0.2	0.1-0.2	<.001	0.4	0.3-0.5	<.001
Pulmonary embolism	1.0	0.3	0.3	0.1-0.9	.004	0.5	0.2-1.3	.2
Urinary tract occurrences								
Acute renal failure	1.0	0.4	0.5	0.2-1.4	.08	1.1	0.4-2.6	.9
Urinary tract infection	12.6	1.3	0.09	0.07-0.1	<.001	0.2	0.1-0.2	<.001
Cardiac occurrences								
Cardiac arrest requiring CPR	1.1	0.4	0.3	0.1-0.9	.005	0.8	0.3-1.8	.5
MI	0.6	0.7	1.2	0.4-5.8	.8	1.3	0.4-4.2	.6
Other surgical occurrences								
DVT/thrombophlebitis	6.5	0.6	0.08	0.06-0.1	<.001	0.2	0.1-0.3	<.001
Sepsis	4.8	0.4	0.07	0.05-0.1	<.001	0.2	0.1-0.2	<.001

CPR, cardiopulmonary resuscitation; *DVT,* deep vein thrombosis; *GCS,* Glasgow Coma score; *ISS,* Injury Severity Score; *MI,* myocardial infarction; *NSQIP,* National Surgical Quality Improvement Program; *NTDB,* National Trauma Data Bank; *SSI,* surgical site infection; *UM,* University of Michigan.
The odds ratios are comparing NTDB with 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.

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 3-component intervention consisting of feedback of outcomes data, training in quality improvement techniques, and site visits to other medical centers. Following application of these 3 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 comorbidity 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 1 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 of 51 centers experienced complications in <1% of their patient cases.

Why is there chronic and widespread complication underreporting from trauma centers? Although 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 systematically. 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 preexisting medical conditions. This is a process issue for

virtually all trauma centers. Alternatively, mortality is readily recorded because it is easy to define, the information is readily available and straightforward to document.

Why is this an issue? The data within the NTDB are 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 costs and length of stay. In a study of hospital costs after 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 $5,750 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 among trauma patients than general surgery patients. The University of Michigan 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 comorbidity 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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DISCUSSION

Dr Mark A. Malangoni (Cleveland, Ohio): The authors have proven their hypothesis that the National Trauma Data Bank is flawed in that it significantly underreports complications and comorbidities, and they have clearly articulated that accurate, risk-adjusted outcomes data are important for quality improvement purposes as well as accuracy. Their work suggests that the NSQIP, which already has been documented to provide precise and reproducible risk-adjusted outcomes data for surgical patients, may be applicable to injured patients. This application is novel; the NSQIP was designed to measure outcomes in patients who undergo elective or emergent provisions. I really want to focus on the secondary comparison, which shows marked differences in baseline characteristics as well as mortality and morbidity between trauma and general surgical patients at their institution, because I think this is where the true value of this study lies. Is it valid to make this comparison? Many trauma patients do not undergo an operation, and only a minority have a procedure that is within the realm of general and vascular surgery, the dataset used to validate NSQIP and promulgate its use.

Second, do you believe in this concept strongly enough that you advocate validation of your observations with a larger, multi-institutional study? I hope the answer is yes, because I believe that this is important. Although the data dictionary that has just been published within the last year to better outline the complications may provide better definitions, it is unlikely to solve the real problem with data collections of trauma registries, which is that they rely on retrospective chart reviews to identify complications. And the problem with record reviews is that those records generally do not contain sufficient documentation for even well-trained abstract clerks and researchers to identify the parameters needed for risk adjustment, particularly when collected retrospectively.

Last, Dr Hemmila, can you please comment on whether the NSQIP data on trauma patients was collected prospectively at your institution, as it was for your surgical patients? I would not be at all surprised if it is this prospective collection and greater attention to the detail provided in the data that is another major advantage of NSQIP as you seek to broaden its applications. I want to congratulate you again on a fine presentation and thank you for allowing me to discuss it.

Dr Mark R. Hemmila (Ann Arbor, Michigan): With regard to patients not undergoing operation, I think that is a relevant question. NSQIP is actually geared toward evaluating patients who receive an operation. However, many of our patients are injured, receive intensive care, and do not necessarily undergo an operation, but the quality of care delivered to them is important. They also can experience the same complications you see in a patient who gets an operation. So I think that, even though the 2 groups of patients may be different, the methodology can be applied to the 2 groups in a similar fashion.

In terms of a large study, yes, I think it is important to do so. I think the important caveat of a large study is the people who come to the table be intensely interested about it, that they are essentially volunteering because they feel deeply about it and that people are not forced into it.

I think that the value of what NSQIP gives you is you get back out what you put into it. If you put garbage into it, you are not going to get any useful information back out. The same thing applies for what I was doing. What in effect you are trying to do is find out where your problems lie so you can attack them. If you do not have accurate data in the first place, you do not really know what to go after.

In terms of how NSQIP data are collected, I think what I did was a little more prospective than our NSQIP data collectors do. I had access to a physician assistant who rounds on our patients 4 to 5 days a week and also has access to all the sign-out sheets that the trauma service has. So I think there may be even a higher level of data availability than commonly seen in the NSQIP.

As the medical record becomes more and more computerized, I think we are going to have tools that will better enable us to get the data in a prospective fashion, whether used for trauma or NSQIP, and I think that medical records will be integrated with the actual compilation of quality assurance.

Dr. Charles E. Lucas (Detroit, Michigan): Dr Hemmila, your paper compares 2 registries. As you

know, the 1 registry represents a polyglot of cities and towns in rural areas whereas the University of Michigan in Ann Arbor represents a city with a major university. Did you look in the NTDB to look at cities of comparable size with large universities?

Second, the University of Michigan is a level 1 verified trauma center by the ACS. And that means you probably share your trauma data and you probably feed your data into the NTDB, and therefore you have the opportunity to retrieve those 500-some patients from both registries with the data input having been done by University of Michigan people. If you do not feed your registry data to the NTDB, you still have a trauma registry, because that is one of the criteria for verification. And that allows to you go into your registry and look at the data that your people prepared and compare that to the other registry and the data that your people prepare. So I want you to tell the organization here what the comparison is done by your people for both of the data entries into the registry program.

Dr. Mark R. Hemmila (Ann Arbor, Michigan): In terms of trying to look at different size cities and different types of centers, I did not do that. I felt that by obtaining the data for level 1 centers, which we are, was a reasonable comparison. Certainly you could go through many different ways of extracting data to try to find a similar group. I think that there are enough differences in the data that I saw. If you get the data for all of the NTDB and take all centers, it comes out similar. When I first started this project I just took all the complications that I found in the NTDB and a lot of the rates were low.

Yes, we do submit to the NTDB, and I had the ability to extract our data. It was not possible for me to match the NTDB data that I extracted back out of the software with these patients because they were de-identified enough that I could not make one-to-one matches.

But what I could do was go back to our trauma registry data in NTRACS, which we used and find the patient data set, and I did do that analysis, for 12 outcomes that were available to be matched up. Seven of the outcomes had similar rates in NTRACS versus NSQIP trauma, which I did, and 5 had different rates, some of which were 2- or 3-fold different. And they were important things like sepsis. However, pneumonia we seemed to capture pretty well.

I think this highlights a little bit of the problem. It has to do with the training of your registrar. It has to do with the definitions you use. It also has to do with how things are matched up further out at the NTDB level.

When I looked at the NTRACS complication table and compared it to the complication table that you get back out of NTDB, I found the NTDB complication list to be quite truncated. Where do all those definitions go? Which ones are matched up, and which ones are not, I am not sure.

Regarding your last question, I think really it has to do with the level of sophistication of the person extracting the data. It also has to do with whether you are going back in the record to get the data or if you are kind of trying to actively compile the data as you go along. If you have somebody who is actively engaged in this project, which our PA was, she is looking for these problems. She knows, “Okay, Mr. So-and-so had a DVT, put that on my list.” I think that gives you better data in the end.