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Development and Validation of the Mortality Risk for Trauma Comorbidity Index

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Abstract

Objective—The aim of this study was to develop and validate a comorbidity index to predict the risk of mortality associated with chronic health conditions following a traumatic injury.

Summary Background Data—Currently available comorbidity adjustment tools do not account for certain chronic conditions, which may influence outcome following traumatic injury or they have not been fully validated for trauma. Controlling for comorbidity in trauma patients is becoming increasingly important as the population ages and elderly patients are more active, as well as to adjust for bias in trauma mortality studies.

Methods—Cohort study using data from the National Study on the Costs and Outcome of Trauma. Subject pool (N = 4644/Weighted Number = 14,069) was randomly divided in half; the first half of subjects was used to derive the risk scale, the second to validate the instrument. To construct the Mortality Risk Score for Trauma (MoRT), univariate analysis and odds ratios were performed to determine relative risk of mortality at hospital discharge comparing those persons with a comorbid condition to those without. Conditions significantly associated with mortality ($P < 0.05$) were included in the multivariate model. The variables in the final model were used to build the MoRT. The predictive ability of the MoRT and the Charlson Comorbid-ity Index (CCI) for discharge and 1-year mortality were estimated using the c-statistic in the validation sample.

Results—Six comorbidity factors were independently associated with the risk of mortality and formed the basis for the MoRT: severe liver disease, myocardial infarction, cerebrovascular disease, cardiac arrhythmias, dementia, and depression. The MoRT had a similar overall discrimination as the CCI for mortality at hospital discharge in injured adults (c-statistic: 0.56 vs. 0.56) although neither by itself performed well. The addition of age and gender improved the

predictive ability of the MoRT (0.59; 95% CI: 0.56, 0.62) and the CCI (0.59; 0.56, 0.62). Similar results were seen at 1-year postinjury. The further addition of Injury Severity Score significantly improved the predictive ability of the MoRT (0.77, 95% CI: 0.74, 0.79) and the CCI (0.77, 95% CI: 0.75, 0.80).

Conclusions—The MoRT's primary advantage over current instruments is its parsimony, containing only 6 items. In the present study, the comorbid conditions found to be predictive of mortality had some overlap with the CCI, but this study identified 2 novel predictors: cardiac arrhythmias and depression. Inclusion and reporting of these items within trauma registries would therefore be an important step to allow further validation and use of the MoRT.

The issue of comorbidity in traumatic injury is becoming increasingly important with the “graying” of the population, as in the United States, approximately 80% of all persons aged ≥ 65 years have at least 1 chronic condition, and 50% have at least 2.¹ The age-adjusted prevalence of diabetes, which increased 43% in the United States during 1997–2005 from 3.7% to 5.3%,² is a clear example of the potential synergy of preexisting health conditions in traumatic injury. There is an association between diabetes and risk for injury and an association between glucose regulation and outcome, including mortality following injury.^{3–6} Additionally in adults, resuscitation efforts following a traumatic injury are frequently made more complex because of the high incidence of comorbid conditions, such as diabetes and hypertension, which may affect the responsiveness and perfusion needs of the vasculature. The presence of comorbid health conditions may be associated with difficulty diagnosing new conditions or adverse responses to therapeutic interventions,⁷ which may result in complications.

Trauma patients with certain comorbid health conditions have been shown to be at higher risk for development of secondary complications (eg, pneumonia), lengthened overall hospital stay, and increased mortality.^{8,9} In comparative effectiveness studies of trauma, it is therefore important to control for comorbidity to reduce the treatment bias resulting from conditions other than the injury itself¹⁰ and to avoid inappropriate assignment of disease burden to injury.¹¹ Currently available comorbidity adjustment tools, such as the Charlson comorbidity index¹² (CCI), do not account for chronic conditions such as hypertension and obesity which may influence outcome following traumatic injury. These conditions are prevalent, with age adjusted rates of obesity of persons 20 to 74 years of age in the US population of 32% and 30% for hypertension in 2001–2004.¹³ The CCI contains 17 conditions, uses a weight-based measure, and has been criticized for being somewhat dated as it was developed more than 20 years ago.^{14,15} Recent studies using the CCI in trauma populations are conflicting as to its utility for predicting mortality.^{16–19} More recently, the Elixhauser comorbidity score²⁰ containing 30 conditions has been used in studies of traumatic injury^{20–24} as it does contain commonly seen conditions such as acquired coagulopathy which may influence outcomes, but it has not been fully validated. It has been suggested that comorbidity indexes be individually tailored to the population under investigation.²⁵ Thus, the aim of this study was to develop and validate a comorbidity index to predict the risk of mortality associated with chronic health conditions following a traumatic injury, the Mortality Risk Score for Trauma (MoRT), using the CCI as the standard for validation.

METHODS

The current study is a cohort study using data from the National Study on the Costs and Outcomes of Trauma (NSCOT), a multicenter, prospective cohort study of outcomes following traumatic injury conducted in 14 states in the United States.²⁶ The study protocol was approved by the institutional review boards at all participating centers. Patients were eligible for NSCOT if they were between 18 and 84 years of age, arrived alive at a

participating hospital, and had at least 1 injury of 3 or higher on the Abbreviated Injury Scale (N = 18,198). A detailed description of the enrollment and data collection procedures has been published previously.^{26,27} In brief, using a quota sampling strategy, a group of patients who were discharged alive (n = 8021) were selected for postinjury follow-up interviews and all patients who died in hospital (n = 1438) were included in the sample. This was used to enroll adequate numbers of patients across age groups and to ensure even distribution across hospital type (trauma/nontrauma center) and by severity and principal body region injured. To correctly represent the population, this sampling strategy required data to be weighted according to the population of eligible patients^{28,29} because (a) only a sample of patients who were discharged alive was selected whereas all patients who died in-hospital were included and (b) not all selected patients were enrolled. The weights consisted of the reciprocal product of the probability of being selected for the study and the probability of being enrolled and having complete data given selection. The actual number of subjects (n) and the weighted number (wn) are presented for all analyses.

Subjects for the current study were identified from the NSCOT dataset and defined as patients who survived >24 hours postinjury to allow for the most complete information on comorbid health conditions (n = 4644/wn = 14069). The subject pool was randomly divided in half; the first half of subjects were used to derive the MoRT (n = 2322/wn = 7205), the second to validate the instrument (n = 2322/wn = 6864).

Injury Severity Score (ISS) was derived from individual anatomic injury severity scores and is a measure of the overall severity of multiple trauma and is scored on a scale of 1 (least severe) to 75 (most severe).^{30,31}

Comorbid health conditions within the NSCOT were collected using 3 methods in the parent study. (1) Data were abstracted from the medical record by trained research nurses on pre-existing conditions recorded in the medical record of the index hospitalization; (2) the CCI¹² for preinjury conditions was included in the 3-month interview, which was expanded to include comorbidities not included in the original CCI but that have been shown to correlate with mortality in trauma patients (eg, coagulopathy, obesity),^{32–35} and (3) for adults aged 65 years and older, inpatient and outpatient Medicare claims were obtained for at least 6 months prior to injury to identify pre-existing conditions.²⁷ Scores on the CCI range from 0 to 31, with a score greater than 5 being severe.^{10,12} For the purposes of this study, we began with a list of 41 pre-existing conditions that were derived from 3 commonly used instruments in the trauma and comorbidity literature: the CCI, the Elixhauser score, and the APACHE II (Tabular listings and descriptors of the conditions found in the 3 instruments can be found in Ho et al³⁶).

The primary outcome used to develop the mortality risk score was death from any cause at time of hospital discharge. No treatment-related variables were included in the analyses. Death at 1-year post injury was a secondary outcome of interest. Deaths from any cause, after discharge were documented either by proxy interview or through the National Death Index.³⁷

Statistical Analysis

Frequencies of comorbid conditions as dichotomous variables were examined in the total population sample. Only conditions with a prevalence of $\geq 1\%$ in the total population were included in further analyses. The study population of 4644 (wn = 14,069) were then randomly divided in half. This allowed us to build the models in the derivation sample and test in the validation sample. Baseline characteristics of patients in the derivation and validation samples were compared using student *t* test for continuous variables and χ^2 tests for categorical variables.

To construct the MoRT, for each chronic health condition, first univariate analysis was conducted and odds ratios performed to determine relative risk of mortality at hospital discharge comparing those persons with a comorbid condition to those without. Only those conditions that were significantly associated with mortality ($P < 0.05$) were included in the multivariate model. Using multivariate logistic regression, a second model was developed that also included age (categorically in decades) and gender, as potential confounders as they are well established in the literature. In a third multivariate model, we evaluated the influence on mortality of specific combinations of comorbid conditions determined a priori. We examined the influence of any cardiac disease (myocardial infarction, congestive heart failure, valvular heart disease, or coronary artery disease) occurring together. We also examined the influence of any cardiac disease (vide supra) and each of the following diseases: cerebrovascular disease, chronic pulmonary disease, severe liver disease, diabetes, and renal disease. We examined the interaction of dementia with each of the comorbidities listed above based on the literature and our prior work³⁸ as well as the interaction of age with each of these conditions. The variables in the final multivariate model were then used to build the MoRT. Using the coefficients from the final multivariate logistic regression model, weights were assigned to each variable. To convert the coefficient into an integer weight, the coefficient was multiplied by 3 and then rounded to the nearest integer. A final model was developed, which also included age, gender, and ISS as potential confounders.

The second half of the data was then used to estimate the predictive ability of the MoRT. Comparison of the predictive ability of the new instrument, the MoRT, was compared with the standard CCI for mortality at hospital discharge and 1-year postinjury using change in the area under the receiver-operating characteristic (c-statistic) for each instrument. About 95% confidence intervals were also calculated.³⁹ Statistical analyses were performed using SAS 9.2 (SAS Institute, Cary, NC) and Stata 10 (StataCorp, College Station, TX).

RESULTS

The demographic characteristics of the subjects in the derivation and validation samples were similar on all characteristics except maximum Face anatomic injury severity (Table 1). The mean age of the sample was 43 years old, were predominantly male, and had a mean ISS of about 17, indicating a moderate injury. The primary mechanism of injury for subjects was motor vehicle collision (>45%). In-hospital mortality was similar in the derivation and validation samples (4.5% vs. 5.5%).

About 28 conditions had an overall prevalence of $\geq 1\%$ (Table 2). The most prevalent conditions in the sample were hypertension (20.1%), alcohol abuse (17.3%), chronic pulmonary disease (8.9%), diabetes (6.1%), and depression (5.2%). In the sample, only 2.6% of subjects had 2 or more comorbid conditions. We ran crosstabs on the 6 parameters to evaluate frequency of comorbid condition coexistence and in no case did the prevalence of exceed 1% (range, 0.02%–0.52%) therefore it was deemed noncontributory.

Nine factors were individually significantly associated with the risk of mortality at hospital discharge postinjury and included several cardiac related diseases: prior myocardial infarction, cardiac arrhythmias, hypertension, and coronary artery disease (Table 3). Nervous system and psychiatric diseases included cerebrovascular disease, dementia, and depression.

Six factors were independently associated with the risk of mortality and formed the basis for the MoRT (Table 4). Of these 6, a single factor, depression, was protective whereas the remaining 5 were associated with increased risk of mortality. The performance of the MoRT with 6 conditions in comparison to the CCI with 17 conditions is shown in Table 5. The

range of the CCI scores in the validation sample was 0 to 11, whereas the MoRT ranged -4 to 8. Both scales demonstrated a right skew in the median score. The MoRT had a similar overall discrimination to the CCI for in-hospital mortality (Table 5). Adding age and gender improved the ability of both models to discriminate although this was not statistically significant ($P \geq 0.05$). At 1-year postinjury, the CCI was better at detecting risk of mortality than the MoRT (0.64 vs. 0.58), but this discriminatory advantage was eliminated once gender and age were added to the model (Table 5). The further addition of ISS significantly improved the predictive ability of the MoRT (0.77, 95% CI: 0.74, 0.79) and the CCI (0.77, 95% CI: 0.75, 0.80) for in-hospital mortality (Table 5). A similar predictive ability was seen with this model (injury, age, gender, and comorbidity) for both in-hospital and 1-year postinjury in contrast to other models which did not include injury.

In an exploratory analysis, the effect of being on treatment for depression was examined. About 66% of those with comorbid depression in the sample were receiving antidepressant therapy at the time of injury. The odds of death in-hospital for depressed persons on an antidepressant were 0.29 (0.09, 0.90; $P = 0.03$) whereas the odds of death for those not on antidepressant were 0.25 (0.06, 1.06).

DISCUSSION

We compared the predictive ability of a tailored comorbidity index for trauma, the MoRT to the CCI on mortality at 2 different time points. We found that although individual comorbidities are prevalent and related to in-hospital mortality, comorbidity alone had a limited ability to distinguish between being alive or dead at discharge; ie, use of the indices for prediction of mortality at discharge was not much better than chance alone (0.5). Only the models that included injury severity (ISS) reached an acceptable level for predictive ability (0.7–0.8 per Hosmer and Lemeshow⁴⁰). The present finding for the predictive ability of the CCI at hospital discharge in a US population is similar to those previously reported from Australia (0.57, 95% CI: 0.54–0.61).¹⁸ At 1-year postinjury, the predictive ability of the models improved, suggesting that comorbidity alone contributes more substantively to mortality in the postacute phase and this time period offers an opportunity for improvement in care in these patients.

The MoRT was able to discriminate as well as the CCI for both hospital discharge and 1-year postinjury mortality and with only 6 factors compared with the CCI's 17. The main advantage of the MoRT is its parsimony. Chart review is expensive and time consuming,⁴¹ and in populations such as trauma where it is difficult to obtain history prospectively, the use of only 6 conditions could be of particular benefit for both research and clinical applications.

Future predictive models should include gender, age (in decades), and ISS, as these significantly improved the performance of both the CCI and the MoRT, and these variables are easily discernable at admission and do not substantively increase data collection burden.

The weights in the MoRT are different for those conditions appearing in the CCI, likely reflecting the differences in the populations that each was developed in (medical inpatient vs. trauma). In comparing the CCI and MoRT, differential weighting is seen for severe liver disease and myocardial infarction. In the CCI, the lowest weight is given for MI (a base score of 1) whereas in the MoRT, a weight of 3 is given (or $1.5 \times$ the base weight score). This difference is opposite in the case of severe liver disease, where the CCI provides a weight of 3 (or 3 times the base weight, whereas the MoRT provides a weight of 5 or 2.5 times the base weight. These prognostic differences are likely because of either differences

in prevalence of the conditions in trauma patients versus medical patients or differential effects on hospital versus 1-year mortality.^{25,39}

Both comorbidity indices had better predictive ability for mortality at 1-year. Previous studies in patients post-coronary artery bypass graft surgery have also found that the effect of comorbidity on postdischarge survival is also greater than in-hospital and may reflect the low prevalence of some conditions.²⁵

In the present study, the comorbid conditions found to be predictive of mortality had some overlap with those found in the CCI, but there were 2 conditions identified which are novel predictors. Cardiac arrhythmias were found to be associated with increased risk of death, and depression was found to be protective. Although the MoRT includes cardiac arrhythmia, it does not include use of blood thinners/coagulopathy. As warfarin is usual treatment for patients with atrial fibrillation, which is a frequently occurring cardiac arrhythmia, it would have been expected to be correlated. However, we did not distinguish between cardiac arrhythmias and this is an area for further work. Additionally, in persons with acquired coagulopathy, the odds of death at hospital discharge were 2.4 times higher than those persons without the condition at time of injury although this was not significant. We do not have specific information on the measured anticoagulation status of the individuals, which has been shown to be predictive of mortality whereas self-report or administrative data may not.^{9,42,43} Other reasons for acquired coagulopathy not entering the final model include a relatively low prevalence of this condition (1.1%) in the sample and our conservative method of modeling, which included entering conditions only when there was a significant univariate relationship. Recent revisions to the Centers for Disease Control field guidelines for injury triage have maintained decision criteria for patients with anticoagulation and bleeding disorders because of their increased risk of mortality.³³ Another reason in the present study for finding no relationship between acquired coagulopathy and in-hospital mortality may have been our decision to exclude early deaths from the current study. Lastly, contrary to previous studies which found hypertension to be protective,^{44,45} we found pre-existing hypertension to be associated with a slightly increased odds (1.4) of death at hospital discharge. Previous studies have suggested that the protective effect of hypertension seen may be related to the effect of beta-blocker use within their samples; however as those studies did not directly address that issue, our study suggests that incomplete modeling of the involved variables (residual confounding) may actually be responsible for the results seen and further work is required to clarify this issue.

The relationship between preexisting depression and disability following injury has been previously established.^{46–48} However, the finding in the present study that comorbid depression was protective was not expected. Although a protective effect cannot be ruled out, another possible explanation is bias against documenting in the medical record the diagnosis of depression in patients who died in-hospital. We further note that the present findings were not related to current treatment for depression, so this condition is not appearing to serve as a proxy for variables such as insurance status or preinjury health care not entered into the model. No data on adherence to or efficacy of prescribed antidepressant treatment are available, nor did we have data on DSM supported diagnosis or the severity of depression which may also be of importance in further understanding this relationship. In a population-based study in Canada, injured persons had a mental health claim rate in the year prior to injury 3.5 times higher than that of noninjured persons, with the majority of these claims being for conditions such as depression or anxiety.¹¹ Of those injured in that sample, more than 85% suffered only minor injury (ISS, 1–8), although no data were specifically provided on the relationship between preexisting depression and severity of injury. Further work is needed to understand the relationship between preexisting depression, level of

injury, and mortality to understand whether injury-related or treatment-related variables are mediating this effect.

A previously identified issue with the CCI has been right skew in the distribution with relatively low median scores.¹⁰ This also occurred with the MoRT, despite restricting to conditions with >1% prevalence in the sample. In addition, the conditions that the MoRT identifies as predictive of mortality are also those that are increasingly prevalent with age eg, dementia, myocardial infarction, cardiac arrhythmias, and cerebrovascular disease. Trauma remains a young person's disease, so the right skew in the comorbidity scores seen in this study is not wholly unexpected. Although the parent NSCOT study did not include persons over 85 in whom conditions like dementia are more prevalent, the present study restricted prediction of mortality to those persons <85 so this was not a factor in the predictive ability of the comorbidity indices alone. In fact, the prevalence rates reported for comorbid conditions in the CCI in the present report are similar to those reported in a recent study of injured persons 65 and older in Italy.¹⁹ Our a priori decision to evaluate the combined association of dementia with other comorbid conditions was primarily based on our prior traumatic brain injury work and was exploratory within the context of all-cause trauma. However, no additional interaction effects were seen between any comorbidity combinations tested and were noncontributory in the final model.

The use of split halves allowed for improved validity by reduced bias, and reducing model potential over-fitting. In addition, the NSCOT is a large, multicenter study which improves the generalizability of the findings to the larger US population. Although we would have preferred to have validated the MoRT in a separate dataset, this was not possible. We attempted to use the National Trauma Data Bank (NTDB) research dataset for validation purposes, but neither cardiac arrhythmia nor depression are specifically measured within the NTDB currently. Ultimate verification of the MoRT and its predictive utility will require testing it with an independent dataset, preferably one such as the NTDB with multiple data sources and all ages, including the "oldest old" represented.

Other limitations of the current study include the exclusion of other case-mix variables from our prediction models. Recent robust predictive models have been based on both injury-related factors and socioeconomic and demographic factors.^{18,49,50} However, the point of the MoRT was to develop an injury-specific comorbidity index and to compare it to the CCI. Future case-mix studies using the MoRT could build additional predictive models to include variables such as socioeconomic status and preinjury functioning.

The inclusion of subjects who survived greater than 24 hours postinjury may have resulted in some loss of patients who die as a result of an interaction between comorbid health conditions and injury severity. However, information on comorbidity in these patients is likely to have had incomplete or missing documentation, therefore any analysis that included these patients would likely have underestimated this effect.

CONCLUSIONS

The MoRT's primary advantage over current instruments is its parsimony, containing only 6 items compared with the CCI. In the present study, the comorbid conditions found to be predictive of mortality had some overlap with the CCI, but this study identified 2 novel predictors: cardiac arrhythmias and depression. Inclusion and reporting of these items within trauma registries would therefore be an important step to allow further validation and use of the MoRT.

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TABLE 1

Characteristics of Trauma Patients Used in Analyses (N = 4644/wn = 14069)*

	Tool Derivation Sample (n = 2322/wn = 7205)	Validation Sample (n = 2322/wn = 6864)
Age mean (SD)	43.4 (33.4)	43.6 (33.4)
Male	68.8	68.2
ISS mean (SD)	17.5 (17.8)	17.4 (17.3)
New ISS mean (SD)	23.1 (23.7)	22.8 (23.0)
Maximum AIS mean (SD)	3.4 (1.4)	3.4 (1.4)
Head AIS ≥ 3	33.1	34.0
Abdomen AIS ≥ 3	11.1	10.3
Thorax AIS ≥ 3	32.4	33.6
Spinal AIS ≥ 3	8.7	7.4
Face AIS ≥ 3	2.8	4.6
Neck AIS ≥ 3	0.9	0.9
Upper extremity AIS ≥ 3	12.3	10.6
Lower extremity AIS ≥ 3	31.2	32.6
External AIS ≥ 3	0.6	0.6
Injury mechanism		
Penetrating-firearm	9.3	9.0
Penetrating-other	4.2	4.2
Blunt-MVC	45.8	49.2
Blunt-fall	30.4	28.7
Blunt-other	10.2	8.9
Trauma center care	72.5	71.2
Insurance status		
No insurance	29.6	26.7
Private + medicare	12.1	13.2
Medicare only	8.6	7.6
Private only	37.1	40.0
Medicaid	8.3	7.7
Other	4.2	4.8
Mortality at hospital discharge	4.5	5.5
Mortality at 1-yr postinjury	7.5	9.3

* Data provided as percent (%) unless otherwise noted.

SD indicates standard deviation; wn, weighted number; ISS, injury severity score; AIS, anatomic injury severity score; MVC, motor vehicle collision.

TABLE 2

Percent Distribution of Baseline Comorbid Conditions for Entire Sample

Comorbid Condition	N (Weighted N)	%
Hypertension	1183 (2824)	20.1
Alcohol abuse	754 (2438)	17.3
Chronic pulmonary disease	440 (1257)	8.9
Diabetes	343 (860)	6.1
Depression	239 (736)	5.2
Other neurological disease	251 (659)	4.7
Hypothyroidism	214 (559)	4.0
Coronary artery disease	268 (571)	4.1
Cancer-solid tumor	265 (552)	3.9
Peptic ulcer disease	209 (516)	3.7
Cerebrovascular disease	247 (481)	3.4
Chronic IV drug abuse	141 (464)	3.3
Cardiac arrhythmias	211 (412)	2.9
Myocardial infarction	160 (366)	2.6
Congestive heart failure	157 (327)	2.3
Renal disease	141 (323)	2.3
Dementia	160 (291)	2.1
Severe diabetes	126 (275)	2.0
Peripheral vascular disease	131 (280)	2.0
Rheumatoid arthritis	100 (260)	1.8
Liver disease	78 (259)	1.8
Other substance abuse	72 (241)	1.7
Psychoses	72 (219)	1.6
Other psych disorder	71 (215)	1.5
Chronic pain	75 (194)	1.4
Severe liver disease	72 (168)	1.2
Obesity	65 (172)	1.2
Blood thinner/coagulopathy	70 (149)	1.1
Other anemia	50 (129)	0.9
Paralysis	51 (118)	0.8
Valvular heart disease	44 (105)	0.7
AIDS	34 (84)	0.6
Metastatic cancer	38 (58)	0.4
Leukemia	12 (20)	0.1
Lymphoma	5 (10)	0.1
Fluid and electrolyte disorder	4 (14)	0.1
Weight loss	3 (4)	0.03
Deficiency anemia	1 (2)	0.02
Blood loss anemia	1 (2)	0.01

Comorbid Condition	N (Weighted N)	%
On steroids	0	0

Items below line had prevalence of <1% and were not included in further analysis.

TABLE 3

Univariate Logistic Regression Modeling for Mortality at Hospital Discharge Based on Comorbid Condition for the Derivation Sample

Variable	At Hospital Discharge		
	OR	95% CI	P
Hypertension	1.41	1.06, 1.87	0.02
Alcohol abuse	0.78	0.53, 1.17	0.24
Chronic pulmonary disease	0.79	0.53, 1.19	0.26
Diabetes	1.39	0.89, 2.18	0.15
Depression	0.28	0.11, 0.67	0.004
Other neurological problem	1.58	0.92, 2.71	0.09
Hypothyroidism	0.53	0.20, 1.38	0.19
Coronary artery disease	1.68	1.04, 2.71	0.03
Cancer-solid tumor	2.08	1.14, 3.80	0.02
Peptic ulcer disease	1.06	0.57, 1.96	0.85
Cerebrovascular disease	2.87	1.86, 4.43	<0.001
Chronic IV drug abuse	1.80	0.85, 3.80	0.13
Cardiac arrhythmias	2.55	1.38, 4.68	0.003
Myocardial infarction	2.95	1.87, 4.65	<0.001
Congestive heart failure	1.83	0.88, 3.81	0.10
Renal disease	1.60	0.86, 3.00	0.14
Dementia	2.38	1.36, 4.15	0.002
Severe diabetes	1.33	0.57, 3.10	0.52
Peripheral vascular disease	1.24	0.56, 2.76	0.60
Rheumatoid arthritis	0.29	0.07, 1.18	0.08
Liver disease	0.78	0.29, 2.08	0.61
Other substance abuse	0.68	0.18, 2.54	0.57
Psychoses	1.32	0.58, 2.97	0.51
Other psych disorder	0.77	0.20, 2.97	0.71
Chronic pain	—	—	—
Severe liver disease	4.97	2.72, 9.09	<0.001
Obesity	1.67	0.70, 3.97	0.24
Blood thinner/coagulopathy	2.40	0.86, 6.64	0.09

TABLE 4
Multivariate Logistic Regression Model Developed Using Only Derivation Sample*

Comorbid Condition	OR (95% CI)	P	β	$\beta \times 3$	Weight
Severe liver disease	5.21 (2.87, 9.48)	<0.001	1.6509	4.95	5
Myocardial infarction	2.43 (1.48, 3.97)	<0.001	0.8864	2.66	3
Cerebrovascular disease	2.18 (1.40, 3.41)	0.001	0.7813	2.34	2
Cardiac arrhythmias	2.08 (1.13, 3.85)	0.02	0.7336	2.20	2
Dementia	1.76 (1.08, 2.87)	0.02	0.5647	1.69	2
Depression	0.24 (0.10, 0.58)	0.002	-1.4311	-4.29	-4

* Model is based upon univariate comorbid conditions that were significant at hospital discharge as predictors for mortality.

TABLE 5

Predictive Ability of the MoRT in Comparison to the Charlson Comorbidity Index for In-Hospital and 1-Year Mortality

Score	In-Hospital C-Statistic (95% CI)	1-yr Postinjury C-Statistic (95% CI)
Charlson	0.56 (0.54, 0.59)	0.64 (0.61, 0.66)
MoRT	0.56 (0.54, 0.59)	0.58 (0.56, 0.61)
Charlson + age group + gender	0.59 (0.56, 0.62)	0.68 (0.65, 0.71)
MoRT + age group + gender	0.59 (0.56, 0.62)	0.67 (0.64, 0.70)
Charlson + age + gender + ISS	0.77 (0.75, 0.80)	0.78 (0.75, 0.80)
MoRT + age + gender + ISS	0.77 (0.74, 0.79)	0.76 (0.74, 0.78)

MoRT indicates mortality risk for trauma.