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Incidence and Impact of Risk Factors in Critically Ill Trauma Patients

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Abstract
There is a paucity of data describing the incidence of pre-existing diseases or risk factors and their effects in trauma patients. We conducted a prospective study to determine the incidence of such factors in critically ill trauma patients and to evaluate their impact on outcome. The study, performed over a 2-year period, examined the hospital course of all trauma patients admitted to the ICU. Multiple risk factors were evaluated and analyzed via multivariate regression analysis. Outcome was evaluated by infection rate, hospital length of stay, ventilator days, and mortality matched for age and Injury Severity Score (ISS). A total of 1172 patients (73% blunt injury) were enrolled over the study period. Of these, 873 (74.5%) were male. The mean age was 42.5 years with an ISS of 19.8. Tobacco use (24%) was the most common risk factor identified, followed by hypertension (HTN, 17%), coronary artery disease (9%), chronic obstructive pulmonary disease (COPD)/reactive airway disease (4%), non-insulin-dependent diabetes (NIDDM) (4%), insulin-dependent diabetes (IDDM) (3.2%), cancer (3%), liver disease (2%), and HIV/AIDS (1.4%). Of these risk factors, IDDM was found to be an independent risk factor for infection (0.004) and ventilator days (0.047), increasing age was found to be an independent risk factor for hospital length of stay (0.023) and mortality (<0.001), and HTN was found to be an independent risk factor for increased ventilator days (0.04). In addition, COPD/reactive airway disease was found to be an independent predictor of ventilator days, infection, and ICU days ($P < 0.05$). Thus, increased age, IDDM, COPD, and HTN are most predictive of outcome in critically ill trauma patients. With our aging population it is becoming increasingly important to identify pre-existing risk factors on admission in order to minimize their effects on outcome.

Four factors influence mortality after major injury: (1) injury severity, (2) host factors, (3) time to definitive care, and (4) quality of care.[1–4] The concept of host factors has been described as a patient's "physiologic reserves" which include age, gender, and pre-injury medical status.[3,5] Although several of these factors have been investigated, there is a paucity of prospective data describing the specific host factors and their impact on patient outcome.

In 1956, Miller and Norris first suggested that a patient's chronic illness may be more important than that patient's injury in determining outcome after trauma.[6] Morris and MacKenzie have also described an interaction between host factors and mortality in trauma patients.[7] These retrospective studies relied on computerized patient data from medical records to describe the pre-existing medical conditions. In addition, only computerized discharge abstracts were employed to calculate injury severity scores (ISS) for these patients. Both studies suggest that age,

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gender, and pre-existing disease influence mortality, even when these factors are adjusted for injury severity.[7] Patients with pre-existing disease had stayed in the hospital much longer.[7]

The objective of the present study was to prospectively evaluate the incidence of pre-existing disease in critically ill trauma patients. In addition, we examined each of these risk factors individually to determine if it had an effect on patient outcome.

METHODS

Prospective data were evaluated on all patients admitted to the R. Adams Cowley Shock Trauma Center Intensive Care Unit for greater than 48 hours over the 2-year period August 2000–August 2002. Common risk factors that were evaluated are outlined in Table 1. Past medical history was obtained directly from the patient or from the family if the patient was unable to be interviewed. Patients who were physically unable to provide a history at admission were interviewed at a later time (if their medical condition and mental status improved) to validate the history provided by their family. Each patient was screened daily by an infectious disease specialist. A diagnosis of infection was based on Centers for Disease Control and Prevention (CDC) criteria. The incidence of a pre-existing disease and infection was calculated from a formula using number of patients with disease or infection as the numerator and population at risk as the denominator. Outcome was measured by hospital length of stay (HLOS) and intensive care unit length of stay (ILOS) and mortality. Multivariate linear regression models were used to determine whether a specific risk factor was an individual predictor of outcome in relation to other potential risk factors, including age and injury severity as defined by ISS. This study was approved by the Institutional Review Board.

RESULTS

A total of 1172 patients were enrolled over the 2-year study period. The mean patient age was 42.5 ± 12 years with a mean ISS of 19.8 ± 12. Of the total, 873 patients (74.5%) were male. The majority of injuries were the result of blunt trauma (n = 1078, 84%), but 199 patients (16%) sustained penetrating trauma. The mean ILOS and HLOS were 12 ± 11 days and 16 ±14 days, respectively, and the mean number of ventilator days was 8.2 ± 10. The overall incidence of infection was 38%, with respiratory infections being the most common, followed by genitourinary, bloodstream, and intra-abdominal infections (Fig. 1). The mortality rate in the total study cohort was 14.7%.

Table 1.
Incidence of risk factors

Risk factor	Number (percent)
Tobacco use	281 (24%)
Hypertension	199 (17%)
Coronary artery disease	105 (9%)
COPD/ reactive airway disease	48 (4%)
Non-insulin dependent diabetes	47 (4%)
Insulin-dependent diabetes	37 (3%)
Cancer	36 (3%)
Liver disease	23 (2%)
HIV/AIDS	16 (1.4%)

COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus; AIDS: acquired immunodeficiency disorder.

Tobacco use (24%) was the most common risk factor, followed by hypertension (HTN) (17%), coronary artery disease (9%), chronic obstructive pulmonary disease (COPD(/reactive airway disease (4%), non-insulin-dependent diabetes (NIDDM) (4%), insulin-dependent diabetes (IDDM) (3.2%), cancer (3%), liver disease (2%), and HIV/AIDS (1.4%) (Table 1). Each risk factor was evaluated for its potential impact on morbidity and mortality via multivariate regression analysis adjusted for age and injury severity (Table 2–5). Increasing age was found to be an independent risk factor for HLOS [RR = 2.3 CI (1.7–2.9) $P = 0.023$] and for mortality [RR = 2.5 CI = 1.8–3.1) $P < 0.001$]. IDDM was found to be an independent risk factor for infection ($P = 0.004$), ventilator days ($P = 0.047$), and ICU days ($P = 0.03$), and HTN was found to be an independent risk factor for increased ventilator days (0.04). COPD/reactive airway disease was predictive of increased ventilator days ($P < 0.05$), infection ($P < 0.05$), and ILOS ($P < 0.05$) (Table 2–5). The combination of smoking history and COPD/reactive airway disease was predictive of increased ventilator days ($P < 0.01$), infection ($P < 0.01$), and ILOS ($P < 0.01$) when analyzed by multivariate linear regression analysis controlling for age and ISS. None of the nine risk factors were identified as independent predictors for mortality when controlled for age and ISS.

DISCUSSION

The incidence of pre-existing diseases or risk factors in critically ill trauma patients is an area that has not been

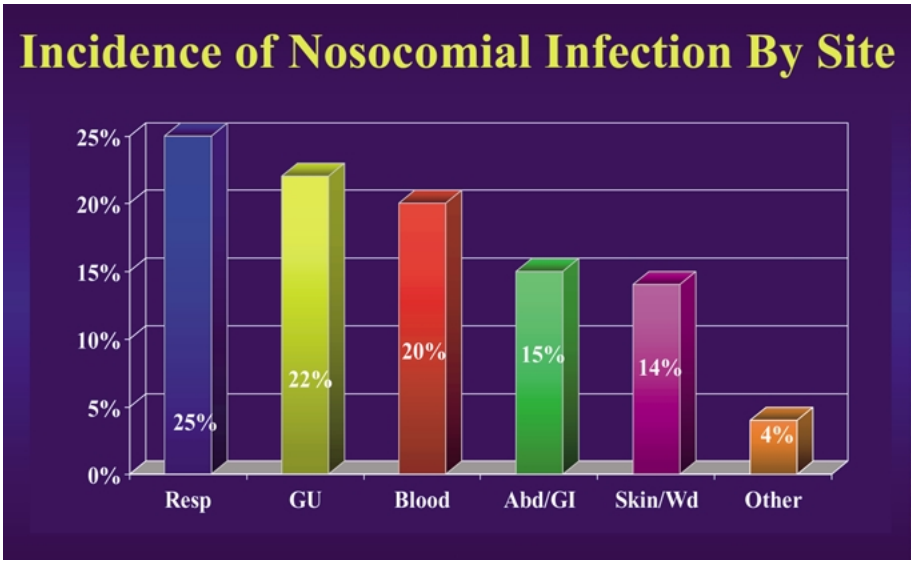

Figure 1. Incidence of nosocomial infection by site. Resp: respiratory; GU: genitourinary; Abd/GI: intra-abdominal/gastrointestinal; WD:wound. Resp = Respiratory.

Table 2.
Multivariate regression analysis evaluating relative risk (RR) for infection, controlling for age and injury severity

Risk factor	RR (confidence interval)	*P* Value
Tobacco use	0.8 (0.5–4.2)	NS
Hypertension	0.9 (0.6–4.9)	NS
Coronary artery disease	1.1 (0.7–5.2)	NS
COPD/reactive airway disease	1.2 (1.0–.35)	< 0.05
Non-insulin-dependent diabetes	1.0 (0.5–4.8)	NS
Insulin-dependent diabetes	2.1 (1.4–3.2)	0.004
Cancer	0.5 (0.1–1.1)	NS
Liver disease	0.5 (0.1–1.2)	NS
HIV/AIDS	0.6 (0.1–1.4)	NS

NS: not significant.

Table 4.
Multivariate regression analysis evaluating relative risk (RR) for ICU length of stay, adjusted for age and injury severity

Risk factor	RR (confidence interval)	*P* Value
Tobacco use	0.8 (0.5–4.2)	NS
Hypertension	0.9 (0.6–4.9)	NS
Coronary artery disease	1.1 (0.7–5.2)	NS
COPD/reactive airway disease	1.3 (1.2–1.41)	<0.05
Non-insulin-dependent diabetes	1.0 (0.5–4.8)	NS
Insulin-dependent diabetes	2.3(1.6–3.2)	0.03
Cancer	0.5 (0.1–1.1)	NS
Liver disease	0.5 (0.1–1.2)	NS
HIV/AIDS	0.6 (0.1–1.4)	NS

ICU: intensive care unit.

Table 3.
Multivariate regression analysis evaluating relative risk (RR) for hospital length of stay, controlling for age and injury severity

Risk factor	RR (confidence interval)	*P* Value
Tobacco use	0.9 (0.3–4.2)	NS
Hypertension	0.8 (0.5–5.1)	NS
Coronary artery disease	1.0 (0.5–5.7)	NS
COPD/reactive airway disease	1.0 (0.5–5.5)	NS
Non-insulin-dependent diabetes	1.1 (0.6–4.4)	NS
Insulin-dependent diabetes	1.2 (0.6–3.2)	NS
Cancer	0.9 (0.1–3.6)	NS
Liver disease	0.8 (0.1–2.6)	NS
HIV/AIDS	0.8 (0.1–3.5)	NS

extensively researched. Studies related to pre-existing disease have been retrospective or have focused primarily on severity of injury by scoring methods such as Injury Severity Score (ISS) or RTS (revised trauma score) and age. In 1956, Miller and Norris first presented the idea that a patient's chronic illness may be more influential than severity injury in determining the outcome after trauma. Using a case-control design, Morris further evaluated the effects of pre-existing chronic conditions on in-hospital mortality in adult trauma patients. The cases studied included all trauma deaths (n = 3074) that occurred in 1983 in 331 acute care hospitals in California. Three to four control patients (injured survivors) were matched to each case patient on the basis of injury severity, age, and individual hospital (n = 9869). The data source consisted of hospital discharge abstract data

Table 5.
Relative risk for mortality adjusted for age and injury severity

Risk factor	RR (confidence interval)	P Value
Tobacco use	0.9 (0.6–4.7)	NS
Hypertension	1.1 (0.7–5.1)	NS
Coronary artery disease	1.1 (0.7–5.2)	NS
COPD/reactive airway disease	1.0 (0.7–4.2)	NS
Non-insulin-dependent diabetes	1.0 (0.5–4.8)	NS
Insulin-dependent diabetes	1.7 (0.9–6.2)	NS
Cancer	0.8 (0.1–3.1)	NS
Liver disease	0.9 (0.4–4.2)	NS
HIV/AIDS	0.8 (0.5–4.4)	NS

uniformly collected on all admissions to acute care hospitals in the state. Conditional logistic regression techniques were used to estimate the relative odds of dying for patients with and without one or more of 11 pre-existing chronic conditions identified as potentially detrimental to outcome. The presence of cirrhosis (relative odds = 4.5), congenital coagulopathy (relative odds = 3.2), ischemic heart disease (relative odds = 1.8), COPD (relative odds = 1.8), and diabetes (relative odds = 1.2) all significantly increased the risk of dying.[8]

Milzman examined specific historical and laboratory criteria to define pre-existing disease (PED) states and to determine if they were independent predictors of outcome in trauma victims.[3] Of 7798 adult patients admitted from July 1986 through June 1990, 16.0% (1,246) had at least 1 PED. The most common PED was hypertension (7.7%), followed by pulmonary disease (3.7%), cardiac disease (2.9%), and diabetes (2.5%). There was no significant difference in ISS (15.7 versus 15.6) and admission Glasgow Coma Scale (GCS) scores (13.9 versus 13.8) when patients with PEDs were compared to those without PEDs. Those with PEDs, however, were significantly older (49.2 versus 30.6 years) and had a significantly higher mortality rate (9.2% versus 3.2%) than patients without PEDs. Mortality rates were also high for patients with at least two PEDs (18%) and for those with renal disease (38%), malignancy (20%), or cardiac disease (18%) compared with those without PED. Multivariate regression controlling for age and ISS showed that the presence of a PED was an independent predictor of mortality ($R^2 = 0.1918$; $P < 0.0001$). The greatest increases in mortality were found among patients younger than 55 years of age who had an ISS < 20. The authors concluded that improvements in the management of trauma victims with chronic disease may decrease mortality rate.[3]

MacKenzie *et al.* evaluated chronic problems stratified by age groups from hospital discharge data for all adult trauma admissions (n = 27,029) to acute care hospitals in a five-county area to examine the effect of pre-existing chronic conditions (PECs) on HLOS).[9] The most common pre-existing diseases were hypertension (6.7%), ischemic heart disease (3.4%), chronic alcohol/drug use (3%), diabetes (3%), and COPD (3%). The percent increase in mean HLOS and the relative odds of an extended HLOS (i.e., ≥3 weeks) were estimated for surviving trauma patients with and without one or more of 11 PECs, taking into account both the ISS and patient age. Of the trauma cases studies, 19% (n = 5224) had one or more of the 11 PECs and 5% (n = 1384) had two or more PECs. Mean HLOS was shown to be 69% higher for those with PECs versus those without PECs ($P < 0.001$). Furthermore, patients with PECs were more than twice as likely as those without PECs to have stayed in the hospital 3 weeks or longer. The size of the effect, however, varied by patient age and injury severity; the effect of PECs on length of stay was greater among younger patients and patients with less severe injuries.

As the U.S. population ages, the number of geriatric trauma victims continues to grow. Outcomes have been known to be worse for these patients, in large part because of pre-existing conditions. Grossman *et al.* abstracted data from 33,781 patient records from a large statewide trauma database to evaluate the impact of PECs in the elderly trauma population.[10] For each 1-year increase in age beyond age 65, the odds of dying after trauma increased by 6.8% (95% confidence interval, 6.1–7.5). When vital signs on admission, Glasgow Coma Score, and ISS were controlled, PECs with the strongest effect on mortality were hepatic disease (odds ratio [OR], 5.1), renal disease (OR, 3.1), and cancer (OR, 1.8).

McGwin *et al.* most recently conducted a retrospective cohort study examining PECs in patients 50 years of age or older, using data from the National Trauma Data Bank, a registry of trauma patients admitted to 131 trauma centers across the United States. The main outcome measure studied was in-hospital mortality. The authors concluded that the presence of one or more PECs had a greater impact on mortality among patients with minor injuries than among patients with severe injuries. Therefore, PECs have a greater impact on outcome when patients were subjected to minor or moderate injuries. For those severely injured, the high mortality rate due to the injuries themselves superseded any influence a PEC may have had on the patients' outcome.[11]

The limitation of all of these studies is that they were all retrospective in nature, using trauma registry data or data banks as the basis for analysis. Because PECs are frequently underreported in medical records, the use of this type of data collection represents a major limitation.

For this reason, we sought to prospectively evaluate the impact of pre-existing risk factors in critically ill trauma patients. In our study, tobacco use was found to be the most common risk factor followed by hypertension and coronary artery disease. Smoking history had not been evaluated in prior studies that have examined the incidence of risk factors in trauma patients. Several studies have proven the negative effects of smoking, as it is associated with 16% of all cardiovascular mortality (NIH). In addition, long-term smoking may affect lung compliance and decrease pulmonary reserve. In the setting of critical injury, these effects of smoking may influence the need for mechanical ventilation. Although smoking was the most common risk factor in our study, it did not independently affect outcome. However, smokers who have already manifested signs of lung/reactive airway disease were found to be at a significantly greater risk of ventilator days, infection, and ICU length of stay after traumatic injury.

As in the previous studies, increased age, IDDM, COPD, and HTN were predictive of outcome in our patients. Our data support the conclusions of McGwin that mortality from the injuries themselves superseded any influence that a PEC may have had on a patient's outcome.[11] Because we limited our study to critically ill trauma patients, we cannot comment about the impact of pre-existing medical conditions in the less severely injured. In addition, the present study may be limited because we defined risk factors according to what we were told by the patient or a family member, not on the basis of medical records. This method may underdiagnose certain conditions, for example, cirrhosis, or it may overdiagnose, for example, when patients state that they have a history of hypertension and yet have not been evaluated for the condition for several years. One final limitation of this study is its size. Although this was a large sample (n = 1172), the overall incidence of individual risk factors did not exceed 9%, with the exception of tobacco use and hypertension. A large multi-center study applying strict criteria to establish the presence or absence of each disease would address these limitations and is thus warranted.

CONCLUSIONS

Increased age, IDDM, COPD, and HTN were the pre-existing risk factors most predictive of outcome in critically ill trauma patients. As physicians, we are unable to change the severity of injury or the pre-existing conditions in our patient population, but if we are aware of the potential for complications the patient will certainly benefit. Although there were limitations to this study, it does present a strong argument for identify pre-existing diseases in trauma patients early during the admission process and thus minimize their impact, thereby reducing morbidity and mortality.

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