TRAUMA SEVERITY SCORING SYSTEMS AS PREDICTORS OF NOSOCOMIAL INFECTION

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ABSTRACT

OBJECTIVES: To describe the patterns of nosocomial infections in patients with traumatic injuries and to compare the associations between injury severity, derived from various severity scoring systems, and subsequent nosocomial infections.

DESIGN: Prospective observational study.

SETTING: A 750-bed university hospital serving as a medical school and referral center for the southern part of Thailand.

PARTICIPANTS: All trauma patients admitted to the hospital for more than 3 days during 1996 to 1999 were eligible for this study.

METHODS: The severity of injuries was measured in terms of injury severity score (ISS), revised trauma score (RTS), new injury severity score (NISS), and trauma injury severity score (TRISS). Infections acquired during hospitalization were categorized using Centers for Disease Control and Prevention criteria. The association between severity of injury and nosocomial infection was examined with Poisson regression models.

RESULTS: There were 222 nosocomial infections identified among 146 patients, yielding an infection rate of 0.8 infections per 100 patient-days. Surgical-site infection was the most common site-specific infection, accounting for 31.1% of all infections. The incidence of intravenous catheter–related bloodstream infection was 1.6 infections per 100 catheter-days. The bladder catheter–related urinary tract infection rate was 2.8 infections per 100 catheter-days. The rate of ventilator-associated pneumonia was 3.2 infections per 100 ventilator-days. The incidence of infection correlated well with injury severity. The infection incidence rate ratios for one severity category increment of ISS, NISS, RTS, and TRISS were 1.65 (95% confidence interval [CI], 1.42 to 1.92), 1.79 (CI, 1.55 to 2.05), 1.64 (CI 95, 1.43 to 1.88), and 1.32 (CI 95, 1.14 to 1.52), respectively.

CONCLUSIONS: Surgical-site infection was the most common site-specific nosocomial infection. The NISS might be the most appropriate severity scoring system for adjustment of infection rates in trauma patients (Infect Control Hosp Epidemiol 2002;23:268-273).

Patients with traumatic injuries are at increased risk for infection. The risk of infection following trauma is influenced by several factors. The interruption of tissue integrity, hemorrhage and tissue hypoperfusion, frequency of invasive procedures, and impaired host defense mechanisms all have a major impact on subsequent infection. These factors have also been found to be related to the severity of the injury.

Providers of trauma care and researchers have long recognized that qualitative characterizations of injury are essential for the scientific study of trauma. Scoring systems to quantify a patient’s physiologic derangement, anatomic damage, or both have been developed and evaluated. Among the proposed injury severity scoring systems, the injury severity score (ISS), revised trauma score (RTS), and trauma injury severity score (TRISS) have gained popularity and are widely employed. The new injury severity score (NISS) was recently introduced and found to perform better than the conventional ISS.

Because infections acquired by trauma patients lead to both economic loss and death, minimizing infection in this patient population is important. Because effective infection control demands a thorough understanding of the risks and nature of infection, there is a need for epidemiologic studies concerning infections in trauma victims.

Because the reported patterns of nosocomial infections in trauma patients vary widely among institutions and because severity of injury has a profound influence on these patterns, it has been suggested that the infection rates reported should be adjusted for the effect of severity of illness. Although there has been a need for stratification of infection rates by severity of illness, only a few studies have tried to evaluate the performance of certain injury severity scoring systems in predicting the risk of infec-

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Furthermore, only two of those studies made any attempt to compare the relative validity of each system.

This study describes the pattern of nosocomial infections in trauma victims who survived more than 3 days in a university hospital and validates the various injury severity scoring systems as predictors of subsequent nosocomial infection.

METHODS
Setting
Songklanagarind Hospital is the university hospital belonging to the Faculty of Medicine, Prince of Songkla University. It is a 750-bed facility serving as a medical school and referral center for the southern part of Thailand. The emergency department of the hospital treated approximately 38,000 emergency cases, including 8,300 accident cases, per year during the study period.

There is no ambulatory emergency medical service available for the hospital. Trauma patients are taken to the hospital by the first responder. Generally, there is no communication between the trauma scene and the hospital, and no provision for treatment en route to the hospital.

The hospital has maintained an infection control unit since 1986. The hospital’s infection surveillance programs are run by two full-time infection control nurses.

Study Population
All trauma patients admitted to Songklanagarind Hospital from June 1996 through May 1999 were eligible for this study. Patients who had been admitted to other hospitals for some time before transfer to Songklanagarind Hospital were excluded from the study. The study did not include individuals who were dead on arrival or who died in the emergency department. In the analysis for the incidence of hospital-acquired infection, only patients who survived in the hospital for more than 3 days were included.

Data Collection
Data from the emergency department used in the study included the following for each patient: age, gender, time on arrival to the emergency department, time that the injury occurred, cause of the injury, type of injury (blunt or penetrating), provisional diagnosis, history of alcohol intake, blood alcohol level, respiratory rate, blood pressure, Glasgow coma score, and status when discharged from the emergency department. These data were gathered by nurses in the emergency department who had been trained to do so.

Data of patients admitted to the hospital were collected prospectively by the authors to identify injuries and outcomes of treatment. Patients were visited by the authors twice weekly and pertinent data were recorded on preprinted data collection forms. Medical treatments and surgical procedures were reviewed, including antibiotic administration, bladder catheterization, mechanical ventilatory support, and intravascular line placement. The results of diagnostic imaging, blood chemistry, blood alcohol level, urinalysis, microbiology investigation, and other laboratory investigations were reviewed. Centers for Disease Control and Prevention criteria were employed for categorizing nosocomial infections.

Injury Severity Scoring
Injuries were coded according to the Abbreviated Injury Scale, 1990 revision (AIS-90). The severity of injuries was measured in terms of ISS, NISS, RTS, and TRISS. The ISS and NISS are severity scoring systems that are based on anatomic profiles. A larger ISS or NISS value implies a more severe injury. The RTS is a physiologic injury severity scoring system that numerically summarizes assessments of circulatory, respiratory, and central nervous system functions. A smaller RTS value indicates a more severe injury. The TRISS is an injury severity scoring system that combines both anatomic (ISS) and physiologic (RTS) scores with type of injury (blunt or penetrating) and patient age. The TRISS measures the severity of an individual patient’s injury in terms of probability of survival.

Statistical Analysis
Infection rates were reported in terms of person-time incidence and were calculated as the number of episodes of infection per 100 patient-days using the formula: rate = number of infections/total days of hospital stay. The incidence of device-related infection was calculated as the number of episodes of infection per total days of device use. The injury severity scores obtained from various scoring systems were divided into five equal categories according to scores of severity. The association between severity of injury and nosocomial infection was examined with Poisson regression models. The strength of the association was reported in terms of the incidence rate ratio with corresponding 95% confidence interval (CI) and P value. The analysis was first conducted in univariate models for each of the following independent variables: age (years), gender (male = 1, female = 0), ISS (1–5), NISS (1–5), RTS (1–5), TRISS (1–5), duration of indwelling intravenous catheter (days), duration of indwelling urinary bladder catheter (days), duration of mechanical ventilatory support (days), and length of hospital stay (days). A multivariate Poisson regression model was constructed for each of the injury severity scoring systems to control for the influences of age, gender, and medical device placement. The analysis concentrated on whether there was any relation between the injury severity category and the number of subsequent infections.

RESULTS
Patient Characteristics
During the 3-year period from June 1, 1996, to May 31, 1999, there were 1,584 trauma patients admitted to Songklanagarind Hospital who stayed for more than 3 days. The median and the mean lengths of hospital stay were 11
and 17.1 ± 20.3 days, respectively. The average age of the patients was 29.6 ± 16.9 years. There were 112 patients admitted to intensive care units. Patients were more commonly male (75.4%). The first episode of nosocomial infection developed a mean of 10.1 days after admission. The most common causes of injuries were transport accidents (1,090 cases) followed by falls (184 cases), exposures to inanimate mechanical force (139 cases), and assaults (129 cases). Motorcycles were involved in 52.2% of all traffic accidents. The most frequently injured regions of the body were the extremities, accounting for 53.3% of all injuries, followed by the head (16.7%).

Severity of Injury

The distributions of the anatomic severity score (described by the ISS and NISS), the physiologic severity score (described by the RTS), and the combined severity score (described by the TRISS) are detailed in Table 1.

Hospital-Acquired Infection

The study identified 222 episodes of hospital-acquired infection among 146 patients, yielding an infection rate of 0.8 infections per 100 patient-days. Six patients for whom the nosocomial infection developed after hospital discharge were identified when they were readmitted to the hospital.

The common sites of infection are listed in Table 2. Surgical-site infection was the most common, accounting for 31.1% of all infections, followed by urinary tract infection (23.9%) and pneumonia (18.5%). The most frequently isolated pathogens are listed according to site of infection in Table 3. The most commonly identified pathogens were Staphylococcus aureus followed by Pseudomonas aeruginosa, Klebsiella pneumoniae, Acinetobacter baumannii, Escherichia coli, Enterobacter cloacae, and Proteus mirabilis. S. aureus, Pseudomonas aeruginosa, and Escherichia coli were the most common hospital-acquired pathogens among surgical-site infections, lower respiratory tract infections, and urinary tract infections, respectively.

There were 12 primary bloodstream infections related to 766 patient-days of intravenous catheterization, yielding an infection rate of 1.6 infections per 100 catheter-days. There were 51 urinary tract infections among 1,822 patient-days of bladder catheterization, yielding an infection rate of 2.8 infections per 100 catheter-days. There were 41 episodes of pneumonia associated with 1,302 patient-days of mechanical ventilatory support, yielding an infection rate of 3.2 infections per 100 ventilator-days.

Severity of Injury and Infection

The unadjusted associations between injury severity and hospital-acquired infection are detailed in Table 4. Among the severity scoring systems studied, the association was strongest between NISS and infection. The results of univariate Poisson regression analysis indicated that the incidence of infection would increase by a factor of 2.16 for each severity category of NISS. Table 4 also outlines the increment in incidence of infection for a 1-day increment in duration of indwelling intravascular catheter, bladder

### Table 1

**Distribution of Severity Scores, Mean Length of Hospital Stay, and Incidence of Hospital-Acquired Infection, by Scoring System**

<table>
<thead>
<tr>
<th>Severity Score</th>
<th>Severity Category</th>
<th>No. of Patients</th>
<th>Mean Length of Hospital Stay (Days)</th>
<th>Incidence of Infection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISS</td>
<td>1–15</td>
<td>1,326</td>
<td>14.8</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>16–30</td>
<td>238</td>
<td>27.3</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>31–45</td>
<td>16</td>
<td>51.4</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>46–60</td>
<td>1</td>
<td>14.0</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>61–75</td>
<td>3</td>
<td>54.3</td>
<td>3.7</td>
</tr>
<tr>
<td>NISS</td>
<td>1–15</td>
<td>1,219</td>
<td>13.8</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>16–30</td>
<td>295</td>
<td>25.3</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>31–45</td>
<td>58</td>
<td>43.1</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>46–60</td>
<td>8</td>
<td>15.0</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>61–75</td>
<td>4</td>
<td>44.3</td>
<td>4.0</td>
</tr>
<tr>
<td>RTS</td>
<td>&gt; 0.28–7.84</td>
<td>1,425</td>
<td>15.7</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>&gt; 4.71–6.28</td>
<td>122</td>
<td>25.7</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>&gt; 3.14–4.71</td>
<td>22</td>
<td>48.5</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 1.57–3.14</td>
<td>11</td>
<td>26.5</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>0.00–1.57</td>
<td>4</td>
<td>41.8</td>
<td>1.8</td>
</tr>
<tr>
<td>TRISS</td>
<td>&gt; 0.8–1.0</td>
<td>1,539</td>
<td>16.4</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>&gt; 0.6–0.8</td>
<td>16</td>
<td>44.1</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>&gt; 0.4–0.6</td>
<td>14</td>
<td>51.1</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>&gt; 0.2–0.4</td>
<td>10</td>
<td>28.1</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>0.0–0.2</td>
<td>5</td>
<td>44.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

ISS = injury severity score; NISS = new injury severity score; RTS = revised trauma score; TRISS = trauma injury severity score.

*Number of infections per 100 patient-days.

### Table 2

**Common Sites of Hospital-Acquired Infection**

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical site</td>
<td>69</td>
<td>31.1</td>
</tr>
<tr>
<td>Urinary tract</td>
<td>53</td>
<td>23.9</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>41</td>
<td>18.5</td>
</tr>
<tr>
<td>Tracheobronchitis</td>
<td>29</td>
<td>13.1</td>
</tr>
<tr>
<td>Bloodstream</td>
<td>16</td>
<td>7.2</td>
</tr>
<tr>
<td>Sinusitis</td>
<td>8</td>
<td>3.6</td>
</tr>
<tr>
<td>Others*</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>Total</td>
<td>222</td>
<td>100.1</td>
</tr>
</tbody>
</table>

*Gastroenteritis, infection of bedsore.
catheter, and mechanical ventilatory support, and for a 1-year advancement of age.

The associations between injury severity and infection, adjusted for age, gender, and duration of device placement, are detailed in Table 5. The incidence rate ratio derived from multivariate Poisson regression models indicated that all injury severity scoring systems related closely to the risk of infection. This relationship was independent of the duration of device insertion, age, and gender.

DISCUSSION

Injury severity scoring systems were primarily devised to measure the severity of injury in trauma victims. The need for stratification of infection rates by severity of illness led us to investigate the performance of various popular scoring systems in terms of strength of association. This 3-year prospective study describes the pattern of nosocomial infections in trauma victims admitted to a university hospital. Because extremely severely injured patients tended to survive a shorter time than the incubation period of nosocomial infection and thus would bias an estimation of the infection rate, we excluded patients who stayed in the hospital for 3 or fewer days. We used person-time incidence for presenting the incidence rate of infection because severely injured patients tended to stay in the hospital longer (Table 1) and this rendered them more vulnerable to infection.30 By using person-time incidence for presenting the incidence rate of infection because severely injured patients tended to stay in the hospital longer (Table 1) and this rendered them more vulnerable to infection.30 By using person-time incidence, we may be, to some degree, to minimize the confounding effect of the length of hospital stay.

The study identified 222 episodes of nosocomial infection among 146 patients, yielding an infection rate of 0.8 infections per 100 patient-days. The most common site of infection was the surgical site, and the most frequent pathogen isolated was S. aureus. When we combined pneumonia and tracheobronchitis with lower respiratory tract infection, we found an infection rate comparable to that of surgical-site infection. We noted 8 episodes of nosocomial sinusitis in these trauma patients, which seemed to be relatively more frequent than in nontrauma patients. Sinusitis among trauma patients may result from maxillofacial injury and prolonged intubation via the nasal route.

Our study population differed from that of most

![Table Image](image-url)
other studies, which limited their investigations to intensive care units.2,16,18,23 The most common site of infection in those studies was the lower respiratory tract. In other studies that included all trauma patients, the most common site of infection was the urinary tract or the lower respiratory tract.19-22,24

Because of their low cost, motorcycles are a popular means of transportation in Thailand. Trauma from this mode of transportation usually involves the extremities and the head. A large proportion of our patients had been injured in motorcycle accidents and the injuries most commonly involved the extremities. Because most of our patients had relatively minor injuries (Table 1) compared with the patients of other studies, they required less ventilatory support. This may have resulted in a lower incidence of nosocomial respiratory tract infection.

We also estimated the association between the injury severity scores and the incidence of nosocomial infection. For every scoring system, we found that the incidence of infection increased when the severity of injury increased (Table 1). The results of univariate analysis demonstrated that for each increment in category of severity, the incidence of infection increased by a factor of 1.70 to 2.16 (Table 4). After controlling for the effect of age, gender, and invasive devices such as intravascular catheters, bladder catheters, and mechanical ventilators, we found that the associations were still statistically significant. Among the three severity scoring systems evaluated, the NISS had the strongest association with hospital-acquired infection (incidence rate ratio = 1.79; Table 5). In other studies that included all trauma patients, the most common site of infection was the urinary tract or the lower respiratory tract.19-22,24

Most of the studies that evaluated the association between injury severity score and infection used the ISS as a scoring system and multiple logistic regression as a statistical model (Table 6). The results of these studies demonstrated the odds ratios of cumulative incidence for a 1-unit increment of the ISS to be 1.03 to 1.09.

We did not describe the association between infection and another severity scoring system, A Severity Characterization of Trauma (ASCOT).21 The ASCOT is similar to the TRISS, including a description of anatomic injury, the patient’s physiology on admission to the emergency department, and type of injury. However, the ASCOT excludes patients with extremely low or extremely high injury severity, which prevents the evaluation of risk of infections in these patients and the patterns of infections derived may not represent the population of trauma patients.

REFERENCES
12. Brenneman FD, Boulanger BR, McLellan BA, Redelmeier DA.