Analysis of Bony and Internal Organ Injuries Associated With 26,357 Adult Femoral Shaft Fractures and Their Impact on Mortality

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abstract

The spectrum of injuries associated with femoral shaft fractures and those injuries’ association with mortality have not been well delineated previously. Patients in the National Trauma Data Bank who presented with femoral shaft fractures from 2011 to 2012 were analyzed in 3 age groups (18-39, 40-64, and 65+ years). For each group, modified Charlson Comorbidity Index (CCI), mechanism of injury (MOI), injury severity score (ISS), and associated injuries were reported. Multivariate logistic regression was used to identify predictors of mortality. Among the 26,357 patients with femoral shaft fractures, modified CCIs gradually increased with increasing age category and ISS decreased. Motor vehicle accidents were the most common MOI in the younger age groups, whereas falls were the most common MOI in the 65 years and older age group. The top 3 associated bony injuries for the study cohort as a whole were tibia/fibula (20.5%), ribs/sternum (19.1%), and non-shaft femur (18.9%), of which 5.8% of the total cohort were femoral neck fractures. The top 3 associated internal organ injuries were lung (18.9%), intracranial (13.5%), and liver (6.2%), injuries. A multivariate mortality analysis showed that increasing age, increasing comorbidity burden, and associated injuries all had independent associations with mortality. The injuries most associated with mortality were thoracic organ injuries (adjusted odds ratio [AOR]=3.53), head injuries (AOR=2.93), abdominal organ injuries (AOR=2.78), and pelvic fractures (AOR=1.80). This study used a large, nationwide sample of trauma patients to profile injuries associated with femoral shaft fractures. Associations between injuries and mortality underscore the importance of these findings. [Orthopedics. 2017; 40(3):e506-e512.]

Femoral shaft fractures are common following major traumas, such as motor vehicle accidents.1 In fact, a femoral shaft fracture occurs in approximately 1 in every 10 road injuries.2 A recent study estimated that the incidence of femoral shaft fractures is approximately 1 to 2.9 million per year worldwide.2 The preferred treatment option of these severe injuries is intramedullary nails.3-5 This surgery has been shown to have good healing and recovery.6 Often, fractures are not isolated injuries, and identifying associated injuries is important for patient care, especially for seriously injured patients.7 For given injuries, there are often specific known patterns of associated injuries that can help direct
patient workups and management. For example, such patterns of associated injuries have been described for calcaneus fractures (which have a known association with lumbar fractures)\(^8,9\) and clavicle fractures (which have a known association with lung injuries).\(^10\) Along with comorbidities and the patient’s general condition, associated injuries can impact the fracture management, time to surgery, and outcomes.

Because femoral shaft fractures typically result from major trauma, they are frequently seen in polytrauma patients.\(^11\) However, to the best of the authors’ knowledge, no study has identified the associated injury profile for femoral shaft fractures.

To address the lack of literature in this area, the current study sought to use the National Trauma Data Bank (NTDB), the largest multicenter trauma repository, to define a large cohort of patients with femoral shaft fractures and to assess associated injury profiles. Furthermore, to assess the impact of such associated injuries, the correlations of such associated injuries with mortality were defined and compared with other factors believed to affect mortality in this patient population.

**MATERIALS AND METHODS**

The NTDB, created by the American College of Surgeons, is the largest national, multicenter trauma database and includes registrar abstracted and administratively coded data.\(^12\) It was established as a “repository of trauma related data voluntarily reported by participating trauma centers.”\(^13\) The current study used the NTDB to identify adult patients (18 years and older) with femoral shaft fractures from 2011 and 2012. This was based on *International Classification of Diseases, Ninth Revision* (ICD-9) codes for either open or closed femoral shaft fractures (821.01, 821.11).

Patients’ age, sex, and comorbidities were characterized. Age was stratified into the following groups: 18 to 39 years, 40 to 64 years, and 65+ years. The following comorbidities contained in the NTDB were used to calculate a modified Charlson Comorbidity Index (CCI): hypertension, alcoholism, diabetes mellitus, respiratory disease, obesity, congestive heart failure, coronary artery disease, prior cerebrovascular accident, liver disease, functionally dependent status, cancer, renal disease dementia, and peripheral vascular disease. These variables were used to calculate CCI based on a previously described algorithm.\(^14\) Of note, this modified CCI did not include an age component, and any mention of “CCI” in this article always refers to this modified CCI.

Mechanism of injury was then determined from ICD-9 e-codes. Patients were categorized into fall, motor vehicle accident (MVA), or other. Patients with a fall mechanism of injury were determined based on the following ICD-9 e-code ranges: 880.00 to 889.99; 833.00 to 835.99; 844.7; 881; 882; 917.5; 957.00 to 957.99; 968.1; and 987.00 to 987.99. These primarily contained falls from a standing height, ladders, buildings, and sports. Patients with an MVA mechanism of injury were determined based on the following ICD-9 e-code ranges: 800 to 826; 829 to 830; 840 to 845; 958.5; and 988.5. These included patients who were involved in accidents such as motor vehicle drivers, motorcyclists, bicyclists, and pedestrians. All other e-codes were counted as other; these included firearm and machinery-related injuries, among others.

Injury severity score (ISS) and mortality were data elements directly abstracted from NTDB. Associated injuries were identified by ICD-9 codes. The diagnosis codes that were used to identify associated bony and internal organ injuries are detailed elsewhere.\(^15\)

For analysis, Adobe Photoshop CS3 (Adobe Systems, San Jose, California) was used to visually demonstrate the associated injury frequencies by shadings on the skeleton and internal organ figures. The range of shadings from white to black represented increasing injury frequency. Multivariate logistic regression was used to determine the association of age, modified CCI, and various associated injuries with mortality. All statistical analyses were conducted using Stata version 13.0 statistical software (StataCorp LP, College Station, Texas). All tests were 2-tailed, and a 2-sided $\alpha$ level of 0.05 was taken as statistically significant. A waiver for this study was issued by the Human Investigations Committee at the authors’ institution.

**RESULTS**

**Patient Demographics**

For 2011 and 2012, the NTDB included 26,357 adult patients (16,717
men and 9640 women) who had femoral shaft fractures. The age distribution of all adult patients with femoral shaft fractures is shown in Figure 1. The highest incidences were between the ages of 18 and 39 years. It was found that the younger patients were predominantly men (10,448 men and 3220 women in the 18-39 years age group), whereas the older patients were predominantly women (3823 women and 1586 men in the 65+ years age group). The middle group (40-65 years) included 4683 men and 2597 women.

Comorbidity Index and Injury Severity

The median modified CCI scores for age categories 18 to 39, 40 to 64, and 65+ years were all 0 (Table 1). However, comorbidity burden did generally increase with age for this cohort.

The median ISS for these 3 age groups were between 10 and 19 for the younger 2 age groups and between 0 and 9 for the 65+ age group (Table 2). This is consistent with decreasing injury severity with increasing age for this cohort.

Mechanism of Injury

Mechanism of injury distribution by age group is shown in Figure 2. Younger adults sustained femur fractures and had predominantly been involved in MVAs, whereas older adults had predominantly been involved in falls. The middle age category (40-64 years) had a distribution more similar to the younger adults than the older adults, with MVAs dominating the distribution.

Associated Injuries by Age

On average, younger adults (ages 18-39 years, who as a group had a predominate MVA mechanism of injury) sustained higher frequencies of bony and internal organ associated injuries across the board compared to the older adults (65+ years). The middle age group (40-64 years) had associated injury frequencies more comparable to the younger group (ages 18-39) than the older age group (age 65+ years). Table 3 summarizes the associated injury frequencies by age category.

Figure 3 and Figure 4 show the associated bony and internal organ injury profiles for the total adult femoral shaft fracture population (18 years and older). The darker shadings correspond to higher

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Table 1

<table>
<thead>
<tr>
<th>Charlson Comorbidity Index</th>
<th>18-39</th>
<th>40-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>93.7%</td>
<td>77.8%</td>
<td>56.5%</td>
<td>81.7%</td>
</tr>
<tr>
<td>1</td>
<td>5.6%</td>
<td>15.5%</td>
<td>25.4%</td>
<td>12.4%</td>
</tr>
<tr>
<td>2</td>
<td>0.6%</td>
<td>3.6%</td>
<td>10.0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>3</td>
<td>0.1%</td>
<td>1.7%</td>
<td>4.2%</td>
<td>1.4%</td>
</tr>
<tr>
<td>≥4</td>
<td>0.0%</td>
<td>1.4%</td>
<td>3.9%</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Total 100% 100% 100% 100%

*Median Charlson Comorbidity Index value for age group.

Table 2

<table>
<thead>
<tr>
<th>Injury Severity Score</th>
<th>18-39</th>
<th>40-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>30.7%</td>
<td>41.0%</td>
<td>73.0%</td>
<td>42.2%</td>
</tr>
<tr>
<td>10-19</td>
<td>40.1%</td>
<td>33.9%</td>
<td>18.7%</td>
<td>34.0%</td>
</tr>
<tr>
<td>20-29</td>
<td>16.6%</td>
<td>14.5%</td>
<td>5.4%</td>
<td>13.7%</td>
</tr>
<tr>
<td>30+</td>
<td>12.6%</td>
<td>10.6%</td>
<td>3.0%</td>
<td>10.1%</td>
</tr>
</tbody>
</table>

Total 100% 100% 100% 100%

*Injury severity score range containing median values for age group.

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Figure 2: Distribution of patients with femoral shaft fractures by mechanism of injury and age groups. Abbreviation: MVA, motor vehicle accident.
frequencies. Overall, among associated bony injuries, the top 3 were tibia/fibula (20.5%), ribs/sternum (19.1%), and non-shaft femur (18.9%, of which 5.8% of the total cohort were femoral neck) fractures. Among associated internal organ injuries, the top 3 were lung (18.9%), intracranial (13.5%), and liver (6.2%) injuries. In general, the most common associated injuries were found in the thoracic area (lungs and ribs) and in the lower extremity, especially near the femoral shaft fracture.

**Effects of Associated Injuries on Mortality**

Overall mortality after femoral shaft fractures was 4.3%. Multivariate analysis was used to determine the independent effects of age, modified CCI, and specific associated injuries on mortality (Table 4).

Regarding age (while controlling for modified CCI and associated injuries), compared with the 18 to 39 age group, the 40 to 64 age group had a 1.92 times increased odds of death and the 65+ age group had a 4.29 increased odds of death. Regarding the modified CCI (while controlling for age and associated injuries), values of 2 and above all had increased odds of death compared with a modified CCI of 0. Both age and modified CCI had a statistically significant correlation with mortality ($P<.05$).

Lastly, the effects of associated injuries (by anatomic region) on the odds of death were assessed (while controlling for age and modified CCI). These are shown in the order of increasing odds of mortality in Table 4. The associated injuries by anatomic area that correlated with the greatest increase in odds of death were thoracic organ injuries (adjusted odds ratio [AOR]=3.53), head injuries (AOR=2.93), abdominal organ injuries (AOR=2.78), and pelvic fractures (AOR=1.80).

**Discussion**

Femoral shaft fractures are relatively common injuries that can result from...
Noting that there can be associated injuries with femoral shaft fractures, traditional teaching demands a thoughtful evaluation of the femoral neck because the incidence of this concomitant injury with femoral shaft fractures has been documented anywhere from 2.5% to 9%. However, to the current authors’ knowledge, there has been no reported compelling data defining the likelihood of the overall spectrum of injuries that can be associated with femoral shaft fractures.

The current study used the NTDB to identify a cohort of 26,357 adult femoral shaft fractures patients. This is a much large sample size than those found in previous femoral shaft studies. That said, the demographics of the identified cohort were in line with the prior studies. For example, the majority of these femoral shaft fractures occurred in patients between 18 and 39 years of age, which is comparable to previously identified peak incidences between 15 and 24 years of age. As another example, the identified cohort had a male:female ratio of 1.7:1, which is comparable to a previously reported ratio of 1.4:1. Furthermore, consistent with what would be anticipated, modified CCI was found to increase with age, and the predominant mechanism of injury was found to transition from MVAs to falls with increasing age.

Injury Severity Score provides an overview of the severity of both the femoral shaft fracture and the associated injuries. In the current study, ISS was higher in younger patients than in older patients, which is consistent with the expected higher-energy mechanisms and greater overall injury level for younger patients. However, importantly, ISS alone does not define the specific injuries associated with femoral shaft fractures, which was the focus of the current work. Specific associated injuries were evaluated, and results are presented in tabular and graphic formats in the current article.

As an example of a specific associated injury, femoral neck fractures have been reported to be associated with femoral shaft fractures, with an incidence ranging from 2.5% to 9%. This was confirmed by the current analysis, which showed that 5.8%...
of femoral shaft fractures had concomitant femoral neck fractures (completely in line with prior reports).\textsuperscript{16,23} This is clearly of clinical importance for the treating surgeon, who should be aware of this when managing patients with this combination of injuries.

From the current analyses of bony injuries associated with femoral shaft fractures, it was found that 38.1% had other lower extremity fractures (notably 20.5% had tibia/fibula fractures), whereas 22.4% had upper extremity fractures. These high incidences suggest that the extremities need to be thoroughly assessed for concomitant injuries and that there should be a low threshold for imaging any area of question.

In addition, spinal injuries were relatively common in this population (16.8% of patients with femoral shaft fractures had a concomitant spinal fracture). This is notable because this incidence is comparable to that of patients with a known spinal fracture who also have a noncontiguous spinal fracture (range, 6.4%-19%).\textsuperscript{24,25} For patients with a spinal fracture, conventional teaching promotes a low threshold to evaluate for noncontiguous fractures. The same appears to be true for the need to evaluate for any spinal fracture in the femoral shaft fracture patient as well.

From the current analysis of internal organ injuries associated with femoral shaft fractures, it was found that thoracic (19.5%), abdominal (14.2%), and intracranial (13.5%) injuries were common. This suggests a higher incidence than that from a previous study, which showed concomitant thoraco-abdominal injuries (10.9%) with femoral shaft fractures.\textsuperscript{21} The high incidence of internal organ injuries identified underscores the importance of the “pan scan” for patients with high-energy injuries when clinically appropriate to ensure that such associated internal organ injuries are not missed.

Finally, multivariate analysis showed that increasing age, increasing modified CCI, and many of the associated injuries (most notably thoracic organ, head, and abdominal organ injuries) had significant associations with a higher risk of mortality. This underscores the importance and impact of associated injuries, highlighting the clinical importance of appreciating the associated injuries defined in the current study.

The major limitation of the current study deals with the data acquired from the NTDB. Because the NTDB focuses on trauma patients, the studied population may be biased toward femoral shaft fractures, which occur in the setting of more severely injured patients than in the general population. In addition, because the NTDB is a convenience sample, the data may not be representative of all hospitals.\textsuperscript{13} It is important to note that trauma victims who die before transport to a hospital are not included in the NTDB; therefore, the current study does not represent femoral shaft fractures that result in immediate death.\textsuperscript{13} Finally, although information was gathered for all patients with a femoral shaft fracture in the NTDB using ICD-9 diagnosis coding, it is crucial that the potential variability within this group is emphasize because fracture classification was not available in the data set.

**Conclusion**

Overall, this study characterized the distribution of age, comorbidity burden, ISS, mechanism of injury, and associated injuries in adult patients with femoral shaft fractures, as well as identified the associations of such associated injuries with mortality. It was found that these injuries more commonly occur in younger

<table>
<thead>
<tr>
<th>Table 4 Multivariate Mortality Analysis</th>
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<tbody>
<tr>
<td><strong>Outcome:</strong> Mortality</td>
</tr>
<tr>
<td>Age (reference, 18-39 y)</td>
</tr>
<tr>
<td>40-64 y</td>
</tr>
<tr>
<td>65+ y</td>
</tr>
<tr>
<td>Modified Charlson Comorbidity Index (reference, 0)</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4+</td>
</tr>
<tr>
<td>Associated Injuries (in increasing order of odds of mortality)</td>
</tr>
<tr>
<td>Lumbar spine</td>
</tr>
<tr>
<td>Lower extremity</td>
</tr>
<tr>
<td>Thoracic spine</td>
</tr>
<tr>
<td>Upper extremity</td>
</tr>
<tr>
<td>Cervical spine</td>
</tr>
<tr>
<td>Pelvic fracture</td>
</tr>
<tr>
<td>Abdominal organ</td>
</tr>
<tr>
<td>Head</td>
</tr>
<tr>
<td>Thoracic organ</td>
</tr>
</tbody>
</table>
and healthier patients, who were most likely to have suffered the injury from a high-energy mechanism. High rates of associated bony and internal organ injuries were identified, and rates were defined. Moreover, the mortality associated with femoral shaft fractures is most closely related to such associated injuries and less related to overall health status. This underscores the importance for orthopedists and trauma surgeons to appreciate these associated injuries when assessing, managing, and treating patients with femoral shaft fractures.

REFERENCES