Falling in the Netherlands: prevention, care, and follow-up of fall-related injury
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Chapter 5

Abdominal Injuries in Free Falls from Height

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Submitted
Abstract

Background
Falls from height are a major cause of morbidity and mortality. Injuries to the extremities and head are common. However, little has been reported on abdominal injuries or their treatment.

Objective
This study aimed to assess the abdominal injuries, treatment and long-term outcome after falls from height.

Methods
The authors identified all patients with a fall of five meters or more, extracted additional information from medical records, and used the EuroQol 6D (EQ-6D) questionnaire to assess long-term outcome.

Results
One hundred and thirty-nine patients (median age 31 years) were included. There were 106 men and 33 women. Forty-one had abdominal injuries. There were thirteen retroperitoneal hematomas, eleven liver lacerations, nine kidney lacerations, and eight spleen lacerations. Eleven patients required emergency laparotomy or endovascular stenting/coiling to stop the bleeding. Abdominal injuries were associated with a higher Injury Severity Score, lower and longer hospital stay. Patients with abdominal injuries had a tenfold higher mortality than those without abdominal injuries (19.5% versus 2.0%). In surviving patients, abdominal injuries were not associated with lower EQ-6D domain scores.

Conclusion
Abdominal injuries were common and associated with a tenfold increase in mortality. In survivors, abdominal injuries were not associated with a worse long-term outcome.
Introduction

Falls from height are an infamous cause of blunt trauma and a major cause of morbidity and mortality. The literature reveals that up to 20% of hospitalized trauma patients have sustained a fall from height.\(^1\) Falls from height are predominantly an urban phenomenon and can be divided into intentional falls and unintentional falls.\(^2,3\) Common examples of intentional falls are suicide attempts, while common examples of unintentional falls are industrial fall-accidents while working at height. The pattern of fall-related injuries tends to be different from the pattern seen in other causes of polytrauma.\(^4\) Injuries to the upper and lower extremities are most commonly reported, and the majority of fractures occur in the distal parts of the extremities.\(^5,6\) The most common site of severe injuries is the head, with a prevalence of up to 20%, followed by the chest and abdomen.\(^2,4,7\) The further the fall, the more severe the associated injury.\(^5,6\) The prevalence of injuries to extremities and head after falls is well known.\(^1,4,5,8\) However, much less has been reported on the abdominal injuries that result from the blunt traumatizing forces after a fall. These forces result from deceleration during landing. This releases a large amount of energy that is responsible for the abdominal injuries.\(^5\) The reported incidence of fall-related abdominal injuries ranges from 3% to approximately 20%.\(^1,8,9\) Some studies report a high frequency of abdominal injuries in people who fall to their death.\(^2,5\) However, no relation has been reported between abdominal injuries and the height of the fall. To our knowledge, no study has reported on the treatment of blunt force abdominal injuries after falls from height. Several studies have shown that the height of the fall is a prognostic parameter of mortality (i.e. higher falls carry a greater mortality risk).\(^2,5,10\) For surviving patients, however, little is known about the long-term functional outcome after a fall from height. The aim of this study was to assess the abdominal injuries, as well as treatment and long-term outcome in patients who have fallen from a great height. We hypothesize that abdominal injuries occur frequently in patients who fall from height. We further hypothesize that the long-term outcome is strongly influenced by the injuries sustained in the fall.

Materials and Methods

In this retrospective study, the authors identified all fall patients by searching our hospital’s Trauma registry from January 2004 through December 2007.
This is a prospectively maintained database containing information on all trauma patients admitted to our hospital. Only those patients in whom it was certain that they had sustained a free fall (i.e. no staircase falls) of at least five meters, were included in this study. The authors used the most reliable source available to establish the height of the fall. If the height of the fall was reported by number of floors, the authors used a floor height of three meters to count the number of meters fallen. The fall was interpreted as a suicide attempt if the first responders reported that the patient had jumped with the intention of committing suicide.

The authors extracted most information directly from the trauma registry, which provided information on age, gender, number and severity of injuries, length of stay in an Intensive Care Unit (ICU), and on hospital stay, and mortality. In addition, trauma scores such as the Glasgow Coma Scale (GCS), Weighted Revised Trauma Score (RTS) at admission, Abbreviated Injury Score (AIS), and Injury Severity Score (ISS) were adopted from the trauma registry. The medical records provided additional information, including imaging and laboratory results, and treatment.

The EuroQol 6D (EQ-6D) questionnaire (including the Visual Analogue Scale (VAS)) was used to assess the long-term outcome. The EQ-6D was mailed to all surviving patients with known addresses. The scores for the six domains were compared to the scores for the general Dutch population.11

**Statistical analysis**

Data were analysed using SPSS version 14.0.2. The main outcome measures were description of age, sex distribution and the injury patterns of those presenting to the Emergency Department (ED) with a staircase fall injury. The length of stay in the ED and in hospital and its correlation with age, sex, and injury pattern was also reported. Our study data were compared with national data to assess the differences in distribution. Statistical significance was assessed using Chi², Fisher’s exact, and Mann-Whitney U tests as appropriate. Correlations were assessed using the Pearson and Spearman correlations as appropriate. In order to compensate for multiple testing, differences were considered to be significantly different if the p-value was less than 0.01.
Results

*General patient characteristics*

One hundred thirty-nine patients fulfilled the inclusion criteria. Table 1 lists the patient characteristics.

**Table 1.** Patient characteristics.

<table>
<thead>
<tr>
<th></th>
<th>n (%)</th>
<th>106</th>
<th>76.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>n (%)</td>
<td>106</td>
<td>76.3</td>
</tr>
<tr>
<td>Age (years)</td>
<td>med (range)</td>
<td>31.0</td>
<td>1 – 80</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>med (range)</td>
<td>8.0</td>
<td>5 – 36</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>med (range)</td>
<td>9.0</td>
<td>0 – 84</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>n (%)</td>
<td>52</td>
<td>37.4</td>
</tr>
<tr>
<td>ISS</td>
<td>med (range)</td>
<td>18.0</td>
<td>0 – 75</td>
</tr>
<tr>
<td>RTS</td>
<td>med (range)</td>
<td>7.8</td>
<td>1.5 – 7.8</td>
</tr>
<tr>
<td>GCS</td>
<td>med (range)</td>
<td>15.0</td>
<td>3 – 15</td>
</tr>
<tr>
<td>Abdominal injuries</td>
<td>n (%)</td>
<td>41</td>
<td>29.5</td>
</tr>
<tr>
<td>Mortality</td>
<td>n (%)</td>
<td>10</td>
<td>7.2</td>
</tr>
</tbody>
</table>

**Table legend:** ICU: Intensive Care Unit; ISS: Injury Severity Score, RTS: Weighted Revised Trauma Score; GCS: Glasgow Coma Scale.

There were 106 men (76.3%) and 33 women (p<0.001) with a median age of 31 years (range, 1 - 80). Seventeen patients (12.2%) had a detectable blood alcohol level and 21 patients (15.1%) were under the influence of drugs (most commonly cannabis and/or cocaine). In 37 patients (26.6%), the fall was the result of attempted suicide. Figure 1 lists the causes of falling in the study cohort.
Abdominal injuries
A total of 41 patients (29.5%) sustained abdominal injuries. Table 2 lists the most prevalent combinations of injuries to the abdomen and bony structures that surround the abdomen. The most prevalent abdominal injuries were retroperitoneal hematomas (n= 13), liver lacerations (n=11), kidney lacerations (n=9), and spleen lacerations (n= 8). Twenty-nine of the 45 patients with pelvic fractures sustained abdominal injuries. Twenty of the 41 patients with rib fractures sustained abdominal injuries. Abdominal injuries were seen in 16 of the 22 patients with rib fractures. The most prevalent combination of abdominal injury was retroperitoneal hematoma and liver laceration.

Abdominal injuries were associated with significantly higher falls, longer hospital stays, higher Injury Severity Scores, lower Revised Trauma Scores and lower Glasgow Coma Scale scores. In addition, mortality in patients...
with abdominal injuries was ten times higher than in patients without abdominal injuries (Table 3). The mortality increased in patients with more severe abdominal injuries. Eight of the 40 patients with an abdominal AIS of 2 or more died. Seven of the 26 patients with an abdominal AIS of 3 or more died. Finally, four of the seven patients with an abdominal AIS of 4 died.

Table 3. Characteristics of patients with abdominal injuries compared with patients with no abdominal injuries.

<table>
<thead>
<tr>
<th></th>
<th>Abdominal injuries N = 41</th>
<th>No abdominal injuries N = 98</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male n (%)</td>
<td>29</td>
<td>77</td>
<td>0.322</td>
</tr>
<tr>
<td>Age (years) med (range)</td>
<td>33.0</td>
<td>5 – 77</td>
<td>0.100</td>
</tr>
<tr>
<td>Height (meters) med (range)</td>
<td>9.0</td>
<td>5 – 36</td>
<td>0.001*</td>
</tr>
<tr>
<td>Hospital stay (days) med (range)</td>
<td>24.0</td>
<td>0 – 84</td>
<td>0.004*</td>
</tr>
<tr>
<td>ICU admission n (%)</td>
<td>2</td>
<td>26</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>ISS med (range)</td>
<td>33</td>
<td>4 – 75</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>RTS med (range)</td>
<td>6.9</td>
<td>1.5 – 7.8</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>GCS med (range)</td>
<td>11</td>
<td>3 – 15</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mortality n (%)</td>
<td>8</td>
<td>2</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Table legend: ICU: Intensive Care Unit; ISS: Injury Severity Score, RTS: Revised Trauma Score; GCS: Glasgow Coma Scale; GOS-E: Extended Glasgow Outcome Scale; * Significant at P<0.010.
Eleven patients with abdominal injuries required an intervention to stop the bleeding. In seven patients, arterial bleeding was controlled by endovascular intervention (stening and/or coiling). Six patients required emergency laparotomy and one patient underwent laparotomy one day after the accident. In two patients, arterial bleeding was controlled with endovascular coiling prior to laparotomy. The most common indication for emergency laparotomy was liver laceration (n=5), often in combination with mesenterial laceration (n=4). Three of these patients suffered a spleen laceration and two of them underwent splenectomy. Of the four patients who underwent emergency laparotomy and died during or directly after the operation, all suffered uncontrollable hemorrhagic shock and three patients suffered severe traumatic brain injury.

**Long-term outcome**

One hundred twenty-one patients (87.1%) were available for follow-up. The patients who were not available for follow-up were either deceased (n=10), temporary visitors (e.g. tourists, n=6), or patients without a permanent residence or whose address was unknown. The 121 patients received the EQ-6D by mail. Fifty-six patients (46.3%) completed and returned the EQ-6D. The follow-up period ranged from 6 to 48 months (median, 20 months). The response rate was 43.3% (n=13) in the group of patients with abdominal injuries, and 47.3% (n=42) in the group without abdominal injuries. Figure 2 shows the scores per domain of the EQ-6D for the patients with abdominal injuries, the patients without abdominal injuries, the total study cohort, and the general Dutch population.

The domain ‘mobility’ was significantly worse in the patients with abdominal injuries. There was no difference in the prevalence of severe problems between the abdominally injured and the non-abdominally injured in any domain. The scores for all domains were significantly lower in the total study cohort than in the general Dutch population (i.e. the patients in the total study cohort reported significantly more problems in all domains). The median VAS score was 70 (range 10-80) in the abdominally injured compared with 75 (range 33-100) in the non-abdominally injured.
This study has shown that more men than women fall from height and that attempted suicide is a common cause. The prevalence of abdominal injuries (29.5%) was high, and approximately one in four required an operative or endovascular intervention to stop the bleeding. Mortality in patients with abdominal injuries was ten times higher than in patients without abdominal injuries. Long-term outcome did not differ substantially between the abdominally injured patients and the other patients. Morbidity and mortality is known to occur at lower falls heights than five meters. However, we choose a cut off of five meters or more because it excludes all patients who fell from one floor. In this series we aimed to describe the higher falls. The gender distribution in this study was similar to that found by other authors. The median age in this study (31 years) was lower than other comparable studies. The median ISS in this cohort was similar to that found in other studies. Only one study reported a markedly higher ISS of 29.

Figure 2. Groups with and without abdominal injuries, total study cohort and general Dutch population.
At 29.5%, this study showed a relatively high prevalence of abdominal injuries which was much higher than reported in other studies. This may be partly because of the meticulous trauma registry in our hospital where the AIS coding is done by the trauma surgeons. All trauma patients who are presented to our hospital undergo a Focused Abdominal Sonography for Trauma (FAST) by a radiologist or radiology resident. Our hospital is equipped with a CAT scan in the resuscitation room. Therefore, all hemodynamically instable patients and patients with suspected abdominal injury undergo an immediate CAT scan with intravascular contrast. The FAST and CAT scan, as well as the findings during laparotomy enable very accurate scoring of abdominal injuries. The high prevalence of liver lacerations was in line with the literature. Retroperitoneal hemorrhage and internal iliac artery lacerations are counted as abdominal injuries because the exact location of the injury is within the abdominal region. Furthermore, AIS coding guidelines classify these injuries as abdominal injuries.

In this cohort, the abdominal injuries were associated with greater fall heights. It seems probable that abdominal injuries are part of a more severe injury pattern and a poorer physiological condition (i.e. lower RTS). In patients with abdominal injuries mortality was not only significantly higher but it also increased markedly in accordance with the severity of the abdominal injuries. This finding is in concordance with the literature. This study is one of the first to describe the treatment of abdominal injuries following this type of blunt force trauma. The number of patients who required an intervention is in line with other reports. Interventional radiological techniques such as endovascular stenting or coiling are readily available at our Trauma Center and were applied to control arterial hemorrhage in 17% of the patients with abdominal injuries. In two patients, the endovascular arterial hemorrhage control was combined with venous hemorrhage control at emergency laparotomy.

The overall mortality in this study (7.2%) was lower than that found in other studies. Two studies reported mortality of 5.2% and 5.8%, however the median fall heights were 5.6 meters and 4.5 meters, compared with 8 meters in our study. Three other studies, in which the median fall height was 10.6 meters, 10.9 meters, and 11.1 meters, reported mortality of 33.3%, 20.4%, and 35.5% respectively.

Despite the fact that the abdominal injuries occurred in patients who were generally more severely injured than those without abdominal injuries, no difference between the groups was seen in four of the five EQ-6D domains. Furthermore, there was no difference in the prevalence of severe problems. This effect could be attributable to the optimal care provided by a Level-1
trauma care facility. However, since the response rate in this study was rather low, the results of the EQ-6D should be seen in perspective. Because long-term outcome data in trauma are important but infrequently reported we felt obliged to report these data. In order to account for the low response rate, we choose to present the raw data rather than analyze it. Comparison of our study data with the data from the general Dutch population revealed that all patients who have fallen from height suffer from the long-term consequences of their injuries.

This study has several limitations. Firstly, it was based on data collected in a single Level-1 Trauma Center. Secondly, the individuals who sustained a fall from height and died on the scene were not included in this study. In the Netherlands, the bodies are taken directly to the mortuary, and not to the hospital. Therefore, it is impossible to calculate the overall mortality falls from height or calculate its relation to the height of the fall. Thirdly, the study suffers from the known disadvantages of retrospective database analyses.

**Conclusion**

Based on the results of this study, we conclude that the majority of patients who fall from height are male and that intentional falls in suicidal people constitute a large percentage of the total group. Abdominal injuries were common (29.5%) and associated with a tenfold increase in mortality. Survivors suffered from significant long-term consequences of their injuries. However, there was no difference in long-term outcome between those with abdominal injuries and those without abdominal injuries.
References


