Impact of a tornado on a community hospital

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A significant tornado passed through the Oklahoma City metropolitan area on May 3, 1999. This study was undertaken at St Michael Hospital (Oklahoma City, Okla) to describe the impact on a community hospital's emergency department close to the tornado strike zone. Cases were defined as patients receiving diagnostic procedures, care, and interventions at the study hospital's emergency department for injuries related to the tornado. Medical records were abstracted and entered into a custom database; descriptive analysis was done using Microsoft Excel 97.

A total of 147 patients met the study criteria, with an admission rate of 116 (21%) of 147 patients (6 [19.4%] of 31 to the operating room, 4 [12.9%] of 31 to the intensive care unit, and 31 [67.7%] of 31 to ward beds). In addition, 4 (2.7%) of the 147 patients were transferred to tertiary-care facilities (3 pediatric patients with head injuries and 1 adult patient with spinal cord injury).

Complex soft tissue wounds, head injuries, and fractures were the most common diagnoses. The number of head-injured patients arriving alive to the emergency department was higher than expected. Most soft tissue wounds were closed primarily in the emergency department.

The authors recommend that preexisting referral patterns for trauma and specialty care should be a part of the overall disaster plans for community hospitals.

(Key words: disaster medicine, tornado, tornado-related wounds, trauma)

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n average, 800 tornadic storms occur annually in the United States. On May 3, 1999, a tornado with winds of more than 261 mph passed through the Oklahoma City metropolitan area, substantially damaging property and disrupting utility and transportation services. This storm was in fact the most severe in intensity recorded by the National Weather Service in the past 20 years and rated an F5 on the Fujita-Pearson tornado intensity scale. Only 5% of the tornadic storms occurring in the United States every year reach this level of intensity.1

This article describes the acute injury that resulted from the storm of May 3, 1999, in Oklahoma and its impact on the emergency department (ED) of a community hospital.

Methods
The study design followed principles used to study previous disasters.2 Cases were defined as patients receiving diagnostic procedures, care, and interventions for tornado-related trauma at the study hospital, St Michael Hospital in Oklahoma City, Okla, in the 12 hours after the impact of the tornado. Patients injured during this period as the result of rescue or recovery activities were also included in the study. Patients were excluded from the study if they were seen outside of the 12-hour study period. Approval for this study was obtained through the executive committee of St Michael Hospital.

A custom database was created using Microsoft Excel 97 (Microsoft Corp, Redmond, Wash). A data-collection instrument was designed from this database to be used for abstraction from the medical charts. Written evidence of the patients’ visits to St Michael Hospital was sequestered to include the ED roster, disaster tags, emergency medical service run sheets, and ED and inpatient medical charts. Written encounters with patients were then abstracted by the emergency physician investigators, and data were entered into the custom database. Descriptive analysis was performed and rates calculated by use of the statistical features in Microsoft Excel 97.

Results
A total of 147 patients met the criteria for entry into the study. Of these, 97 (65.9%) subjects had documented ages (mean, 35.7 years; range, 2 months to 86 years). The gender distribution consisted of 67 (45.5%) males, 79 (53.7%) females, and 1 subject of undocumented gender (0.6%).

Prehospital care was documented for only 21 (14.3%)
cases: application of dressings in the field in 6 (28.6%) cases; spinal immobilization in 6 (28.6%) cases; intravenous therapy in 6 (28.6%) cases; placement of splints in 4 (19.0%) cases; and administration of oxygen in 3 (14.3%) cases. One case had more than one intervention.

Documentation of the diagnostic procedures, care, and interventions provided in the ED existed for 73 (49.6%) of 148 diagnoses. Many of these injuries were commonly reported diagnosis (26 [17.5%] of 148 diagnoses). Many of these injuries were contaminated with soil and debris. Most of the soft tissue wounds seen at St Michael Hospital were closed primarily.

The types of injuries seen were generally consistent with those in previous reports of tornadic storms. The most common injuries seen were soft tissue wounds, which accounted for 71 (47.9%) of 148 diagnoses. Many of these injuries were contaminated with soil and debris. Most of the soft tissue wounds seen at St Michael Hospital were closed primarily. Previous reports strongly suggest that tornado-related wounds have high infection rates when closed primarily. In addition, it has been suggested that prophylactic antibiotics have been ineffective in preventing infections in tornado-related wounds closed primarily.

Head injury as a result of this storm was the second most commonly reported diagnosis (26 [17.5%] of 148 diagnoses) in our study, compared with an average of 7.1% in reports of previous storms. This variance may be due to the close proximity of the study hospital to the strike zone and the single-source nature of the study. In addition, the criteria used for the diagnosis of head injury were not well defined. The diagnosis of head injury in our study included a spectrum of wounds, scalp lacerations and contusions, concussions (all grades), skull fractures, and intracranial bleeding. Similar inconsistencies have been noted in the criteria for diagnosing head injury as a result of the storm.
“head injury” in reports of previous disasters.2

Orthopedic injuries were the third most commonly reported diagnosis in the study. Fractures and dislocations accounted for 18 (12.2%) injuries. This rate is lower than the average of 29.1% reported after previous storms.15 However, the diagnosis of soft tissue orthopedic trauma (sprains and strains) accounted for an additional 18 (12.2%) cases, which is higher than the previously reported average of 2.2%.15 This variance may be due to differences in defining and diagnosing these injuries among the various reporting sources.

Blunt abdominal and chest trauma combined occurred at a rate of 8.8% (13 of 148 diagnoses) in our study, which is consistent with the average rate of 7.3% reported in previous storms.15 Previous studies provide conflicting evidence on the severity of blunt trauma from tornadic storms. While some studies14,16 have suggested that the severity of these injuries is low, with few patients requiring laparotomy, one notable study7 compared the severity of tornado-related blunt trauma with that sustained in motor vehicle crashes and found the rates of intra-abdominal injury and hemorrhagic shock comparatively higher for tornado victims. Our study found 7 (0.05%) of 147 patients requiring acute operative intervention for blunt trauma; 1 of these 7 was transferred to a pediatric facility for care.

One patient with penetrating trauma was found to have a Brown-Sequard lesion. This patient was transferred to a neurosurgical service at a tertiary-care facility.

Interventions provided in the St Michael Hospital ED were documented in 72 (48.6%) of 148 diagnoses. The rate of documentation is consistent with those of previously reported disasters.2 A total of 117 specific ED interventions and diagnostic maneuvers were done in the documented injuries treated at St Michael Hospital. The nature of these activities and the presenting injuries is consistent with those in reports of previous disasters.17 These interventions indicate that radiologic studies and wound care predominated and should be anticipated in the tornado disaster plans of healthcare institutions. The frequency of acute resuscitative interventions in our study is relatively small (9 [7.7%] of 117), consisting of 4 endotracheal intubations, 3 diagnostic peritoneal lavages, 1 chest tube thoracostomy, and 1 blood transfusion. This frequency is indicative of the generally low severity of injury found in the population of tornado victims and is consistent with that found in previous disasters.2,15

The fact that four patients required transfer from the hospital to a tertiary-care facility points out the need for hospitals to have planned referral mechanisms in place prior to disasters. During disaster response, usual routes of patient transport to other care facilities may be unavailable because of physical obstructions (eg, traffic congestion, fallen power lines). Some community hospitals that are not equipped to manage multiple trauma cases will nonetheless receive them. Plans for transferring these patients to primary and alternate referral sites must be arranged before disaster strikes.

### Table 2

<table>
<thead>
<tr>
<th>Injury and diagnosis</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wounds</strong></td>
<td></td>
</tr>
<tr>
<td>Abrasion/contusion</td>
<td>38 (25.6)</td>
</tr>
<tr>
<td>Laceration</td>
<td>31 (20.9)</td>
</tr>
<tr>
<td>Eye injury</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>Scalp avulsion</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td><strong>Head injury</strong></td>
<td></td>
</tr>
<tr>
<td>Closed head injury</td>
<td>21 (14.2)</td>
</tr>
<tr>
<td>Skull fracture</td>
<td>4 (2.7)</td>
</tr>
<tr>
<td>Intracerebral bleeding</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td><strong>Strains/sprains</strong></td>
<td>18 (12.2)</td>
</tr>
<tr>
<td><strong>Fracture/dislocation</strong></td>
<td>18 (12.2)</td>
</tr>
<tr>
<td>Axial</td>
<td>9 (6.1)</td>
</tr>
<tr>
<td>Appendiceal</td>
<td>9 (6.1)</td>
</tr>
<tr>
<td><strong>Abdominal trauma</strong></td>
<td>9 (6.1)</td>
</tr>
<tr>
<td>Blunt</td>
<td>5 (3.4)</td>
</tr>
<tr>
<td>Hemoperitoneum</td>
<td>3 (2.0)</td>
</tr>
<tr>
<td>Spleen</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td><strong>Chest trauma</strong></td>
<td>5 (3.4)</td>
</tr>
<tr>
<td>Blunt</td>
<td>3 (2.0)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td><strong>Spinal cord injury</strong></td>
<td>1 (0.7)</td>
</tr>
</tbody>
</table>

*All percentages are those of the total number (148) of emergency department diagnoses of tornado-related injuries. Percentages of subcategories may not equal percentage for total in all categories as the result of rounding.*

### Comment

The injuries documented in the patients’ charts abstracted in this study were consistent with those previously reported for tornados. The type and number of ED procedures reported are consistent with those seen in tornadic disasters. Such information should guide hospital disaster planners and healthcare providers in preparing for tornadic disasters.

Documentation in medical records was poor, also consistent with rates of documentation in previous disasters. Because of the significant potential for long-term morbidity after tornadic disasters, measures should be taken to improve ED documentation.

The number of patients with head injuries arriving alive
in the ED was higher than expected. As the study hospital was close to the tornado strike zone, it is clear that it suffered from geographic effect.

Most wounds were closed primarily in the ED, a practice contrary to existing recommendations in the medical literature. However, such recommendations are based on reports made before 1985. A study of rates of wound infection from the storm of May 3, 1999, may provide new insight into wound care after a tornado and has been initiated.

Trauma and specialty service agreements must be established and accounted for in community hospital plans for managing disaster-related injuries.

References