Spinal Injuries After Improvised Explosive Device Incidents: Implications for Tactical Combat Casualty Care

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Background: Tactical Combat Casualty Care aims to treat preventable causes of death on the battlefield but deemphasizes the importance of spinal immobilization in the prehospital tactical setting. However, improvised explosive devices (IEDs) now cause the majority of injuries to Canadian Forces (CF) members serving in Afghanistan. We hypothesize that IEDs are more frequently associated with spinal injuries than non-IED injuries and that spinal precautions are not being routinely employed on the battlefield.

Methods: We examined retrospectively a database of all CF soldiers who were wounded and arrived alive at the Role 3 Multinational Medical Unit in Kandahar, Afghanistan, from February 7, 2006, to October 14, 2009. We collected data on demographics, injury mechanism, anatomic injury descriptions, physiologic data on presentation, and prehospital interventions performed. Outcomes were incidence of any spinal injuries.

Results: Three hundred seventy-two CF soldiers were injured during the study period and met study criteria. Twenty-nine (8%) had spinal fractures or dislocations identified. Of these, 41% (n = 12) were unstable, 31% (n = 9) stable, and 28% indeterminate. Most patients were injured by IEDs (n = 212, 57%). Patients injured by IEDs were more likely to have spinal injuries than those injured by non–IED-related mechanisms (10.4% vs. 2.3%; p < 0.01). IED victims were even more likely to have spinal injuries than patients suffering blunt trauma (10.4% vs. 6.7%; p = 0.02). Prehospital providers were less likely to immobilize the spine in IED victims compared with blunt trauma patients (10% [22 of 212] vs. 23.0% [17 of 74]; p < 0.05).

Conclusions: IEDs are a common cause of stable and unstable spinal injuries in the Afghan conflict. Spinal immobilization is an underutilized intervention in the battlefield care of casualties in the conflict in Afghanistan. This may be a result of tactical limitations; however, current protocols should continue to emphasize the judicious use of immobilization in these patients.

Key Words: Spinal Fracture, Military, Tactical Combat Casualty Care, Spinal Immobilization.

In general, the basic priorities in the prehospital management of civilian trauma patients remain airway and spinal precautions, breathing, circulation, stabilization of fractures, and transport. However, on the battlefield, certain elements of this paradigm are deemphasized, because different patterns of injury occur in the combat setting. Building on data from the conflict in Vietnam, a military prehospital trauma management strategy called Tactical Combat Casualty Care (TCCC) was developed that focused on treating preventable causes of death on the battlefield, namely exsanguinating extremity hemorrhage, tension pneumothoraces, and airway obstruction. TCCC interventions consist of tourniquet placement for extremity hemorrhage, needle decompression for tension pneumothoraces, and surgical cricothyrotomy for airway obstruction.

One area that has been deemphasized in classic TCCC teaching is spinal stabilization. Immobilization was advocated as far back as the US civil war, but subsequent work suggests that stabilization in penetrating missile injuries is not necessary, as patients either have complete, irreversible neurologic injury or no significant injury. Furthermore, the time to complete spinal immobilization may place casualties and medics in undue jeopardy while “under fire,” without any perceived benefit.

Unlike previous conflicts, however, improvised explosive devices (IEDs) now account for the majority of our battlefield injuries. Spinal fractures are observed in casualties of IED incidents. As spinal immobilization in the prehospital setting has been deemphasized in TCCC teaching, there is a potential that spinal injuries from IED incidents may be exacerbated by lack of stabilization on the battlefield.

We conducted a retrospective study of Canadian Forces (CF) members who were injured in Afghanistan to determine whether mechanism of injury was related to the likelihood of spinal injury and the likelihood that the member received spinal immobilization in the field. We hypothesize that IED incidents are more likely to cause injury than even motor vehicle crashes and that IED-related casualties are less likely to receive spinal immobilization than motor vehicle crash victims.

METHODS

Using the Joint Theater Trauma Registry (JTTR), the national trauma nurse coordinator (TNC) for the CF (based in Ottawa, Canada) identified all CF personnel who were injured in Afghanistan from February 7, 2006, to October 14, 2009. This study period corresponded to the period that Canada was lead nation of the Role 3 Multinational Medical Unit (Role 3 MMU), the field hospital based at Kandahar.
Airfield Base. Patients were included if they were assessed and treated by the trauma team at the Role 3 MMU at Kandahar Airfield Base. We excluded all CF personnel who were killed in action in Afghanistan and who were brought directly to the morgue. Moreover, we excluded all CF personnel who were injured in Kandahar but only assessed by a primary care physician (either at their own facility or at the Role 3 MMU). We also excluded all patients brought to the Role 3 MMU with non–trauma-related problems. When analyzing for spinal immobilization, we also excluded CF patients transferred from another surgical facility, as we could not ascertain whether spinal immobilization had been performed or not in the field but removed at the other facility.

Care to Injured CF Members

In general, CF members injured “outside the wire” of Kandahar Airfield Base were first provided buddy aid by other nonmedical members of their unit. In regular combat units, a small proportion of all nonmedical soldiers are trained to provide an elementary level of TCCC. These soldiers are designated TCCC providers. Their skill set includes placing tourniquets, applying dressings, and inserting nasopharyngeal airways. TCCC providers are also trained to decompress tension pneumothoraces. Advanced airway management and spinal immobilization are not taught to TCCC providers, although they are taught to be aware of potential spinal injuries.

Combat medical technicians (hereafter call medics) are also attached to each unit and provide more advanced prehospital care. Medics are comparable to civilian paramedics in their treatment ability and can provide the full spectrum of TCCC care. Specifically, combat medical technicians can apply tourniquets, field dressings, and hemostatic dressings. Moreover, they can infuse crystalloid and colloid fluids through intravenous or intraosseous access. They can also decompress tension pneumothoraces and perform an open surgical cricothyrotomy. Antibiotic and analgesic administrations (including narcotics) are also within their delegated scope of practice, and they are also trained in at least one nonsurgical advanced airway maneuver. Combat medical technicians are all capable of performing spinal immobilization.

After buddy aid and prehospital medic care, injured CF members were then either transferred to a Role 2 surgical facility or directly to the Role 3 MMU. In the majority of cases, CF members were transferred directly to the Role 3 MMU. Transport may have occurred using armored ambulances, staffed by Canadian combat medical technicians. However, in the majority of the cases, Allied US Forces provided helicopters and crew for forward aero medical transport to the Role 3 MMU. If injury occurred on the Kandahar Airfield Base, injured CF members were treated by the nearest personnel, and either a Canadian military ambulance (with CF medical technicians) or a civilian ambulance staffed by civilian paramedics transported them to the Role 3 MMU. After treatment at the Role 3 MMU, CF patients were either discharged back to their unit or evacuated to Landstuhl Regional Medical Centre (LRMC) a US Army hospital in Germany. From LRMC, patients were transported back to civilian trauma centers across Canada.

Spinal Immobilization Protocol

During the study period, Canadian TCCC providers (nonmedical soldiers) did not perform spinal immobilization. Earlier CF TCCC protocol regarding spinal immobilization for combat medical technicians was in keeping with the original TCCC program. Medics were taught to consider spinal immobilization for patients suffering from blunt trauma mechanism, only if the tactical situation permits and if it is safe to do so. For penetrating missile trauma, they were taught that the likelihood of spinal injuries is extremely small, and therefore, they were taught not to perform spinal immobilization for these cases in the tactical setting. No specific mention was made for IED-related events. In more recent Canadian TCCC recommendations, protocols were amended to state that “Care should be directed to the c-spine … for casualties of blunt and blast trauma and casualties with symptoms of spinal cord injury if equipment is available and tactically feasible. Otherwise, careful movement of the casualty with particular attention to the spine should be standard for all casualties with a mechanism of injury presenting a higher risk for spinal injury.”

Data Collection

At the Role 3 MMU, a Canadian TNC, who was trained to be a TNC at the US Army Institute for Surgical Research, prospectively followed up all patients from admission to evacuation (or discharge). The TNC entered all data fields into the JTTR, using the Joint Theater Trauma System data dictionary. The National TNC, who was also trained at the US Army Institute for Surgical Research, collected data from LRMC and civilian Canadian trauma centers for entry into the JTTR. Copies of the files from the Role 3 MMU and from civilian hospitals were scanned into the Canadian Forces Health Services Information System and stored as a PDF file. Hard copies of all files are stored with the patients’ home unit or at the Canadian Forces Health Services Group Headquarters.

Using the JTTR database, we identified patient demographics, injury mechanism, Injury Severity Score, Abbreviated Injury Scale Scores, total and types of blood products transfused, and in-hospital outcome (dead/alive). We also identified all prehospital interventions applied to the patient using the JTTR database; we paid particular attention to whether spinal immobilization had been performed or not. Using the JTTR, we also reviewed the text description of all injuries incurred by study patients. One reviewer (H.T.) identified all cases of spinal injuries, using the key words “spinal fracture,” “cervical spine fracture,” “thoracic spine fracture,” or “lumbar spine fracture.” The files of these patients with spinal fractures were then retrieved and reviewed by a CF spine surgeon (S.C.). On the basis of the injury description, he determined whether the fractures were unstable, stable, or indeterminate.

Our primary outcome was the proportion of CF patients injured in Kandahar who suffered any spinal fractures. Secondary outcomes included the proportion of study patients who suffered unstable spinal fractures. We also analyzed for the association between mechanism of injury and likelihood of spinal fractures. We also reported the proportion of pa-
RESULTS

During the study period, 372 CF members were wounded while deployed in Afghanistan, transferred to the Role 3 MMU, and assessed by its trauma team. Not surprisingly, most injured soldiers were young males. Many were not seriously injured, and ~35% of all wounded CF members were kept in Afghanistan. Most soldiers were injured as a result of IEDs. The baseline characteristics of the study patients detailed given in Table 1.

When only considering combat-related injuries, 212 (57%) patients suffered IED-/mine-related injuries, and 86 (23%) suffered other non-IED combat injuries (rocket-propelled grenade, mortar, artillery, rockets, and gunshot wounds). The remaining 74 patients (20%) suffered blunt force trauma. On univariate analysis, we compared clinical and physiologic differences between CF members presenting after IED versus non-IED combat injury. There was a trend to suggest that victims of IED events were more seriously injured than victims of non-IED combat injury. IED victims presented with a significantly lower systolic blood pressure. Otherwise, there were trends suggesting that IED victims had higher Injury Severity Scores, blood product use, and in-hospital (Role 3 MMU) mortality (Table 2).

Spinal Injuries

Of the 372 patients who arrived at the Role 3 MMU after injury, a total of 29 were identified as having suffered some level of spinal fracture, which represented ~8% of all CF members injured in Afghanistan, requiring trauma team evaluation. Patients suffering spinal fractures were more severely injured than those without spinal fractures. Their mean Injury Severity Score was 13.3, compared with 5.2 for those without spinal fractures (p < 0.001). Based on the provided information, 41% (n = 12) were deemed unstable fractures and 31% (n = 9) were considered stable. Spinal stability was not determinable for the remaining 28% of cases (see Table 3).

When considering only combat-related injuries, patients suffering from IED-related events were much more likely to sustain any spinal fracture compared with non-IED combat-injured patients. Twenty-two of 212 (10.4%) IED patients had some form of spinal fracture, which represented 8% of all wounded CF members injured in Afghanistan. In comparison, 20% of non-IED combat-injured patients had some form of spinal fracture, which represented 17%. The specificity was 88.4% (of those without spinal fractures, 92% were not applying spinal precautions to patients without spinal fractures) and the sensitivity was 22% (of patients with spinal fractures, 88% were applying spinal precautions). Therefore, the sensitivity of our current spinal immobilization protocol was 22%, but the specificity was 92% (of patients without spinal fractures, 92% were not applying spinal precautions to patients without spinal fractures).

Spinal Immobilization

Nine patients were referred from another surgical facility and were excluded from analysis. None of these nine patients had spinal injuries, and none arrived at the Role 3 MMU with spinal immobilization. Of the remaining 363 injured CF members, 11.8% (n = 43) arrived with cervical spine precautions. Only 5 of 29 patients with any spinal fracture arrived at the Role 3 MMU with cervical spine precautions. Therefore, the sensitivity of our current spinal immobilization protocol was 17%. The specificity was 88.4% (of patients without spinal fractures, 92% were not applying spinal precautions to patients without spinal fractures).

Although patients were more likely to have a spinal fracture from an IED event compared with blunt trauma,
TABLE 3. Spinal Injuries Suffered by CF Members

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Mechanism</th>
<th>Description of Spinal Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstable fractures</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Gunshot wound</td>
<td>C7 burst #, with foreign body in canal</td>
</tr>
<tr>
<td>2</td>
<td>IED/mine</td>
<td>C3 TP # with bony fragment in canal, impinging on vert artery</td>
</tr>
<tr>
<td>3</td>
<td>IED/mine</td>
<td>T12 and L1 burst # with canal compromise</td>
</tr>
<tr>
<td>4</td>
<td>IED/mine</td>
<td>L4 burst #</td>
</tr>
<tr>
<td>5</td>
<td>IED/mine</td>
<td>C6 burst #, with C7# (no other details)</td>
</tr>
<tr>
<td>6</td>
<td>IED/mine</td>
<td>T8 burst #, multiple Lumbar #s (no other details)</td>
</tr>
<tr>
<td>7</td>
<td>IED/mine</td>
<td>“Unstable” T7 burst #, T6, T8 fractures (no other details)</td>
</tr>
<tr>
<td>8</td>
<td>Motor vehicle crash</td>
<td>C4/5 Jump Facett</td>
</tr>
<tr>
<td>9</td>
<td>Motor vehicle crash</td>
<td>“Unstable” C3/4 subluxation</td>
</tr>
<tr>
<td>10</td>
<td>IED/mine</td>
<td>“Unstable” L4 burst #</td>
</tr>
<tr>
<td>11</td>
<td>IED/mine</td>
<td>L5 bilateral laminar fractures</td>
</tr>
<tr>
<td>12</td>
<td>IED/mine</td>
<td>C6 # with associated cord hematoma</td>
</tr>
<tr>
<td></td>
<td>Stable fractures</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>IED/mine</td>
<td>“Stable” T10-L5 #s</td>
</tr>
<tr>
<td>14</td>
<td>IED/mine</td>
<td>“Stable” L1 #</td>
</tr>
<tr>
<td>15</td>
<td>IED/mine</td>
<td>L2-L5 TP #</td>
</tr>
<tr>
<td>16</td>
<td>IED/mine</td>
<td>L1-L5 TP #</td>
</tr>
<tr>
<td>17</td>
<td>IED/mine</td>
<td>L2-L4 TP #</td>
</tr>
<tr>
<td>18</td>
<td>IED/mine</td>
<td>“Stable” L3 #</td>
</tr>
<tr>
<td>19</td>
<td>Motor vehicle crash</td>
<td>C7 endplate #</td>
</tr>
<tr>
<td>20</td>
<td>IED/mine</td>
<td>C7 TP #</td>
</tr>
<tr>
<td>21</td>
<td>Motor vehicle crash</td>
<td>Lumber (unknown level) TP #</td>
</tr>
<tr>
<td></td>
<td>Unknown stability</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>IED/mine</td>
<td>L1, L2 # (no other details)</td>
</tr>
<tr>
<td>23</td>
<td>IED/mine</td>
<td>T12-L3 fractures (no other details)</td>
</tr>
<tr>
<td>24</td>
<td>IED/mine</td>
<td>L5 TP #, L1 fracture (no other details)</td>
</tr>
<tr>
<td>25</td>
<td>IED/mine</td>
<td>“Closed” T spine # (no other details)</td>
</tr>
<tr>
<td>26</td>
<td>IED/mine</td>
<td>T5 # (no other details)</td>
</tr>
<tr>
<td>27</td>
<td>IED/mine</td>
<td>Undisplaced L5 posterior arch #</td>
</tr>
<tr>
<td>28</td>
<td>Fall</td>
<td>Thoracic spine # (unknown level and no other details)</td>
</tr>
<tr>
<td>29</td>
<td>Rocket propelled grenade</td>
<td>C1 arch # (no other details)</td>
</tr>
</tbody>
</table>

prehospital providers were less likely to immobilize the spine in IED victims compared with blunt trauma patients (22 of 212 vs. 17 of 74, with \( p < 0.05 \)).

**DISCUSSION**

Overall, spinal fractures were common among CF members injured in Afghanistan; 8% of all injured CF members had at least one spinal fracture and at least 41% of these were unstable fractures. More importantly, IED-related incidents were found to be more likely to cause spinal injuries than non-IED trauma. Surprisingly, even when compared with classic blunt trauma mechanisms such as motor vehicle collisions and falls, IED-related incidents were still more likely to cause spinal injuries. Most worrisome, however, was the finding that spinal immobilization was infrequently performed in the field. Only 12% of all injured CF members arrived to hospital with spinal immobilization. Prehospital providers were more likely to perform spinal immobilizations on patients suffering blunt trauma than those involved in an IED event, even though IED-related incidents were found to be more likely to cause spinal injuries.

On the basis of our literature review, we think that our article presents novel findings. Previous articles on prehospital battlefield care of spinal injuries have focused on spinal injuries from penetrating missile injuries. However, recent experience in Afghanistan and Iraq has shown that IEDs account for the majority of injuries. The Journal of Trauma® Injury, Infection, and Critical Care described patterns of injuries observed in British casualties from IED-related incidents but did not specifically report the incidence of spinal injuries in this study. Ragel et al. specifically reported on thoracolumbar fractures in soldiers involved in IED versus armored vehicle incidents and found that the incidence of thoracolumbar chance fractures was high but only made comparisons to historical controls from civilian reports. Bell et al. reports that 9.5% of all US casualties from Operation Iraqi Freedom who were referred to a neurosurgical service had spinal cord or spinal column injuries. Many reports from the civilian trauma literature have analyzed the likelihood of spinal injuries with different mechanisms of injury. We are the first to compare the likelihood of spinal fractures caused by different mechanisms of injury on the modern battlefield, particularly from IEDs.

Our findings have implications on TCCC recommendations for spinal immobilization on the battlefield. In a classic article, Bellamy and coworkers reported that only 1.4% of all casualties in the Vietnam war who suffered penetrating war injuries to the neck might have benefited from spinal immobilization. He further argued that the risk of performing immobilization was substantial because about 10% of casualties are incurred while helping other casualties. Other authors, writing about their experiences from more recent conflicts, have echoed these findings. As a result, the only mention of spinal immobilization in the original 1996 TCCC guidelines was that “cervical spine immobilization is not necessary for casualties with penetrating head or neck trauma” during Tactical Field Care phase. In both the 2003 and 2006 TCCC updates, discussion of spinal immobilization was relegated to the CASEVAC section and limited to a recommendation that “spinal immobilization is not necessary for casualties with penetrating trauma.”

We think future TCCC guidelines and courses need to specifically add IEDs as a specific mechanism of injury that is discrete from blunt and penetrating injury. We also think that future TCCC guidelines need to specifically address the need for spinal immobilization in IED-related incidents. Spinal injuries are more likely to occur in IED-related events than in blunt trauma, but medics are less likely to perform spinal immobilization on IED casualties than on blunt trauma casualties. As such, we recommend that TCCC guidelines teach medics that spinal injuries are common with IED-related injury events and that they should treat these victims...
with spinal precautions during the Tactical Field Care Phase of treatment on the battlefield, if the tactical situation permits. We certainly recognize that medics are in jeopardy while treating casualties on the battlefield and therefore, do not recommend that spinal immobilization be considered during “Care Under Fire” phase. However, both the 2003 and 2006 updates allow for fracture stabilization during the Tactical Field Care phase of care. Therefore, we think it is also reasonable to consider spinal immobilization during this phase of care, especially for IED casualties.

Limitations

The major limitation of this study is that we were unable to perform a detailed chart review of the majority of patients’ medical files. The primary data source used in this study was JTTR data. We were unable to perform chart reviews on the health records for study patients, as all were repatriated to different locations and hospitals across Canada. Therefore, we did not have complete data characterizing the type of fractures observed, presence or absence of neurologic findings immediately after injury and upon arrival at the Role 3 MMU, the need for spinal surgery, and functional outcomes. Many of spinal fractures are stable and do not require immobilization. Even so, we think that the high incidence of spinal injuries with IED-related events still requires spinal immobilization on the battlefield, if the tactical situation permits.

CONCLUSIONS

IEDs account for most injuries in CF members serving in Afghanistan and are commonly associated with spinal injuries. Current TCCC guidelines de-emphasize spinal immobilization in the field. We recommend that spinal immobilization be performed on all patients injured in an IED-related incident during the Tactical Field Care phase of TCCC, if the tactical situation permits.

REFERENCES


