High Energy Trauma Patients Treated in the Department of General Surgery in a Secondary Emergency Facility in Japan

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https://doi.org/10.15017/27428
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Abstract
Objective: We clarified the characteristics of the high energy trauma patients that entered the general surgery ward of Fukuoka City Hospital (FCH), a 200 bed secondary emergency hospital in Japan.

Patients and Methods: Of the 7,826 total ambulance cases treated from April 2008 to March 2012 in our emergency room, 831 trauma patients who entered our hospital were analyzed. These patients were classified into a non high energy (NHE) and high energy trauma (HE) group based on the mechanisms of injuries.

Results: Of the 831 trauma cases, 741 (89.2%) were in the NHE and 90 (10.8%) were in the HE group. Eleven of the 741 cases (1.5%) in the NHE group and 18 of the 90 cases (20.0%) in the HE group entered the Department of General Surgery as inpatients, with the frequency being significantly higher in the latter group (p < 0.01). 11 of the 18 cases (61.1%) of Department of General Surgery in the HE group were diagnosed to have an injury severity score (ISS) of 15 or higher, and the rate of preventable trauma deaths (PTDs) of those 11 cases was 9.1% (1/11).

Conclusions: The proportion of the patients that entered the Department of General Surgery was higher in the HE group than in the NHE group. The surgical departments of secondary emergency facilities are expected to contribute to the local trauma emergency systems.

Key words: High energy trauma · Department of surgery · A secondary facility · Japan

Introduction

Trauma is the leading cause of death for young people, and it remains a major public health problem in every country, regardless of the level of socioeconomic development1)(2). In Japan, the total number of deaths caused by trauma was about 20,000–30,000 annually, and the trauma is the main cause of death in people aged one to 30 years3).

The concept of ‘high energy trauma’ has been understood to mean trauma that was expected to be life-threatening due to its mechanism of injury. Such trauma is caused by high kinetic energy accidents, such as vehicle accidents, pedestrian–vehicle accidents, falls from a height, assault or industrial accidents4)(5).

In Japan, the approaches for treating such injuries have been slow to develop, however, in 2002, the Japan Association for Acute Medicine (JAAM) and Japanese Association for the Surgery of Trauma (JAST) edited and published Japan

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Advanced Trauma Evaluation and Care (JATEC) as a textbook to standardize the emergency medical treatment for trauma.

Fukuoka City Hospital (FCH) is a 200 bed secondary-care facility located downtown in a city of 1.5 million, with a total of approximately 2,000–2,500 patients taken to the hospital by ambulance annually. For trauma cases, patients are treated with the JATEC technique by emergency room (ER) doctors, and then are treated with definite therapies by specialists from the Department of Orthopedic Surgery, Neurosurgery or General Surgery.

We analyzed the clinical features and the treatments applied for high energy trauma patients that finally entered the Department of General Surgery after they had been transported and treated under the JATEC technique in the ER.

Patients and methods

Patients

This study included 7,826 cases that were admitted to the ER of FCH by ambulance from April 2008 to March 2012.

These 7,826 patients were divided into groups with endogenous and traumatic diseases. The trauma patients that entered the hospital were then divided into a non high energy trauma (NHE) trauma group and a high energy trauma (HE) group based on the mechanism of injury. The actual cases that were predicted to be high energy trauma cases that caused severe injuries for patients are indicated in Table 1.

Patients that needed emergency treatments were finally hospitalized in the Department of Orthopedic Surgery, Neurosurgery or General Surgery. The clinical features of the patients in the HE group that were finally treated in the Department of General Surgery were analyzed. To describe the injury severity, The Trauma and Injury Severity Score (TRISS) was used based on the Registration on Japan Trauma Data Bank (JTDB). The Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), Probability of Survival (Ps) for each patient and the rate of preventable trauma death (PTD) were calculated.

An ISS of more than 15 was generally regarded to indicate a severe injury, and PTD is defined as the death caused by trauma of which Ps is 50% or higher. The cases in cardiopulmonary arrest on arrival (CPAOA) due to the trauma were excluded from the present study.

Statistical analysis

The statistical analyses were performed among the groups using the chi-square test. A P value < 0.05 was considered to be significant.

Results

Numbers of trauma patients and their classifications

The number of patients transported to FCH by ambulance is shown in Figure 1. Of all 7,826

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Criteria related to the mechanism of injury for high energy trauma that predict the severity of patient injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Falls</td>
</tr>
<tr>
<td>2.</td>
<td>Automobile accidents</td>
</tr>
<tr>
<td></td>
<td>Death in the same compartment</td>
</tr>
<tr>
<td></td>
<td>Rollover</td>
</tr>
<tr>
<td></td>
<td>Ejection from automobile</td>
</tr>
<tr>
<td></td>
<td>High level of damage to the vehicle</td>
</tr>
<tr>
<td>3.</td>
<td>Pedestrian or cyclist hit by a vehicle</td>
</tr>
<tr>
<td>4.</td>
<td>Pedestrian thrown or run over by a vehicle</td>
</tr>
<tr>
<td>5.</td>
<td>Motor cycle accident with separation of the rider and bike</td>
</tr>
<tr>
<td>6.</td>
<td>Patient caught by the torso by machinery</td>
</tr>
<tr>
<td>7.</td>
<td>Assault</td>
</tr>
</tbody>
</table>
ambulance cases, 2,175 cases (27.8%) were due to traumatic causes, and of these 2,175, 831 patients (38.2%) entered our hospital. Of these 831 cases, 741 (89.2%) were classified as being in the NHE group and 90 (10.8%) were classified as being in the HE group.

The proportion of NHE and HE patients

Eleven of the NHE patients suffered only bruises in the chest and/or abdominal wall without visceral injury, whereas 18 cases in the HE group had thoracic and/or intra-abdominal visceral organ injuries.

The characteristics of the patients in the Department of General Surgery in the HE group

The features of the 18 patients in the Department of General Surgery in the HE group are shown in Table 2 and are summarized in Table 3. For these 18 cases, the mean age was 45.8 ± 20.6 and the mean ISS was 16.2 ± 6.8, with eleven of the 18 cases (61.1%) being diagnosed with an ISS of 15 or more. Six of the 18 patients (33.3%) had thoracic organ injuries, another six had abdominal organs injuries, and the other six patients (33.3%) had both. The main injury sites of the 18 cases were such as follows: the lungs in 12 cases, the liver and spleen in four cases each, and the small intestine and kidneys in two patients each, with nine patients having multiple injuries.

With regard to the treatments, six cases were treated by the insertion of chest tubes, four underwent interventional radiological (IVR) therapy and three underwent emergency abdominal surgery. All of the patients were treated based on the JATEC techniques, primarily in the ER, with subsequent definitive therapy. The range of the Ps values of the 18 patients was 84.9–99.6% (mean,
Table 2  All 18 high energy trauma cases that became inpatients of the Department of General Surgery

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Mechanism of injury</th>
<th>S. I.</th>
<th>RCC Transfusion (units)</th>
<th>AIS</th>
<th>ISS</th>
<th>Ps</th>
<th>Treatment(s)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>M</td>
<td>traffic accident</td>
<td>1.02</td>
<td>6</td>
<td>liver 4</td>
<td>2</td>
<td>29</td>
<td>84.9</td>
<td>anti-DIC therapy</td>
</tr>
<tr>
<td>21</td>
<td>M</td>
<td>traffic accident</td>
<td>0.59</td>
<td>8</td>
<td>spleen 4</td>
<td>2</td>
<td>29</td>
<td>88.6</td>
<td>chest tube, splenectomy</td>
</tr>
<tr>
<td>60</td>
<td>F</td>
<td>traffic accident</td>
<td>0.57</td>
<td>none</td>
<td>kidney 1</td>
<td>2</td>
<td>25</td>
<td>89.6</td>
<td>chest tube</td>
</tr>
<tr>
<td>26</td>
<td>M</td>
<td>traffic accident</td>
<td>0.92</td>
<td>none</td>
<td>omentum 2</td>
<td>20</td>
<td>86.8</td>
<td>Observation</td>
<td>survived</td>
</tr>
<tr>
<td>82</td>
<td>M</td>
<td>traffic accident</td>
<td>0.91</td>
<td>4</td>
<td>liver 2</td>
<td>2</td>
<td>20</td>
<td>95.4</td>
<td>abdominal IVR</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>fall</td>
<td>0.47</td>
<td>none</td>
<td>spleen 3</td>
<td>17</td>
<td>98.9</td>
<td>abdominal IVR</td>
<td>survived</td>
</tr>
<tr>
<td>51</td>
<td>M</td>
<td>fall</td>
<td>0.40</td>
<td>none</td>
<td>spleen 3</td>
<td>16</td>
<td>98.9</td>
<td>chest tube</td>
<td>survived</td>
</tr>
<tr>
<td>61</td>
<td>M</td>
<td>traffic accident</td>
<td>0.80</td>
<td>none</td>
<td>liver 2</td>
<td>16</td>
<td>92.9</td>
<td>chest tube</td>
<td>survived</td>
</tr>
<tr>
<td>64</td>
<td>M</td>
<td>assault</td>
<td>0.51</td>
<td>none</td>
<td>spleen 3</td>
<td>16</td>
<td>94.3</td>
<td>observation</td>
<td>survived</td>
</tr>
<tr>
<td>61</td>
<td>M</td>
<td>traffic accident</td>
<td>0.64</td>
<td>none</td>
<td>spleen 3</td>
<td>16</td>
<td>94.3</td>
<td>chest tube</td>
<td>survived</td>
</tr>
<tr>
<td>31</td>
<td>M</td>
<td>fall</td>
<td>0.51</td>
<td>none</td>
<td>small intestine 3</td>
<td>2</td>
<td>13</td>
<td>98.9</td>
<td>observation</td>
</tr>
<tr>
<td>48</td>
<td>F</td>
<td>fall</td>
<td>0.86</td>
<td>none</td>
<td>liver 3</td>
<td>13</td>
<td>99.2</td>
<td>abdominal IVR</td>
<td>survived</td>
</tr>
<tr>
<td>33</td>
<td>M</td>
<td>traffic accident</td>
<td>1.16</td>
<td>12</td>
<td>spleen 3</td>
<td>10</td>
<td>92.9</td>
<td>splenectomy</td>
<td>survived</td>
</tr>
<tr>
<td>31</td>
<td>F</td>
<td>traffic accident</td>
<td>0.75</td>
<td>none</td>
<td>small intestine 3</td>
<td>9</td>
<td>99.3</td>
<td>closure of the perforation</td>
<td>survived</td>
</tr>
<tr>
<td>36</td>
<td>M</td>
<td>traffic accident</td>
<td>0.64</td>
<td>none</td>
<td>kidney 3</td>
<td>9</td>
<td>99.4</td>
<td>observation</td>
<td>survived</td>
</tr>
<tr>
<td>62</td>
<td>M</td>
<td>fall</td>
<td>0.48</td>
<td>none</td>
<td>liver 2</td>
<td>9</td>
<td>96.8</td>
<td>observation</td>
<td>survived</td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>assault</td>
<td>0.54</td>
<td>none</td>
<td>spleen 3</td>
<td>9</td>
<td>96.8</td>
<td>observation</td>
<td>survived</td>
</tr>
</tbody>
</table>

*Abbreviations:
S. I.: Shock index = heart rates (beats per minute)/systolic blood pressure (mmHg)
RCC: red blood cells, AIS: abbreviated injury scale. ISS: injury severity score.
Ps: probability of survival, DIC: disseminated intravascular coagulation.
IVR: interventional radiology

95.0 ± 4.6) and only one patient, a 77-year-old male with an ISS of 29 and a Ps of 84.9% died of accelerated disseminated intravascular coagulation (DIC), which was being regarded as a PTD. Therefore, the rates of PTD were 5.6% (1/18) for all 18 patients and 9.1% (1/11) for those with an ISS of 15 or more, respectively.

**Discussion**

Trauma has been reported to be a leading cause of death in young people worldwide. PTDS are included in such deaths caused by trauma and supposed as diseases which could be avoided if optimal care is delivered. The incidence of PTDS is also regarded as an index that can be used to evaluate the ability of a trauma emergency system to treat patients.

In Japan, the peer reviewed value of PTDS in patients with an ISS of more than 15 in trauma care centers was approximately 40% in 2000.
which was very high and was comparable to the level in the 1960’s in the USA. In response to such situation, efforts were made to establish a better trauma system in Japan. The Registration on Japan Trauma Data Bank (JTDB), one branch of Japanese Trauma Care Registry (JTCR) commenced collecting and analyzing the national statistics on traumatic diseases in 2003 to evaluate the details of traumatic diseases statistically. The registration is still ongoing in 2013.

The Japanese emergency medical service centers are classified as tertiary facilities. Primary- and secondary-care facilities are designated to treat ambulatory patients and moderate-acuity patients, respectively. Tertiary-care facilities were specifically developed to treat highly critical patients requiring emergency surgery or admission to the intensive care unit. Therefore, severely injured patients are generally transported to tertiary hospitals. As FCH is a secondary hospital, critically-ill trauma patients are not admitted frequently, however, during a 48-month period, 90 high energy trauma patients with severe injuries were transported. Eighteen (20.0%) of these patients entered the Department of General Surgery due to injuries to thoracic and/or abdominal visceral organs.

Generally, the level of kinetic energy is influenced by both the magnitude and duration of exposure. That is to say a large energy transfer in a very short period brings about a strong external force on the body. The current causes of high energy trauma treated at our hospital were due to unexpected accidents, such as traffic accidents, falls from a height and interpersonal violence, which was similar to the previous reports.

The abdominal cavity has only a musculature-based guard against external force, so compression acutely increases the intra-abdominal pressure, resulting in a rupture of the intra-abdominal viscera, which requires surgery in approximately 20-40% of cases. In contrast, the chest cavity is more compartmentalized with the bony chest wall, so only 10-15% of patients with chest injuries require thoracotomy or sternotomy. Among the 12 patients with abdominal visceral injuries in our present series, three cases (25%) required emergency surgery, but for six patients who had lung injuries, chest tube insertion was sufficient for therapy, and no surgery was required (0%), which was also compatible with the previous reports.

In the transition zone between the abdomen and chest, the lower ribs overlie the intra-thoracic abdomen, including the spleen, liver and biliary apparatus, for protection. This means that the exposure of this area to strong forces often bring about simultaneous injuries of the lungs and these abdominal organs. Among the 18 cases in the present series, six (33.3%) had injuries in the both thoracic and abdominal cavities, simultaneously.

To make a rapid clinical diagnosis, a physical examination has traditionally been an important method for evaluating patients. For example, auscultation for a hemithorax should be performed to note whether there are diminished or absent breath sounds, and patients with abdominal injuries who have significant blood loss will demonstrate systemic signs of hypovolemia, such as hypotension, tachycardia and tachypnea.

Although a physical examination remains the first-line method and will not be replaced in the near future, diagnostic imaging can facilitate the diagnosis. A chest X-ray should be obtained early for thoracic injuries, and Focused Assessment with Sonography for Trauma (FAST) is supposed to be an effective screening tool for the detection of intraabdominal injuries, and has been reported to have high sensitivity. Computed tomography (CT) scans are now frequently used for the initial diagnosis of trunk injuries, as well as head injuries. CT should be performed to completely evaluate patients for intra-abdominal injuries, while concurrently pursuing possible extra-abdominal injury as a cause of patient instability. In our faculty, CT scanning has been actively used to make a definite diagnosis.
The liver and spleen are the most commonly injured organs following blunt abdominal trauma. We performed IVR for two of the four cases with liver injuries and all four of the cases with spleen injuries. Although the IVR treatments for the two patients with liver injuries were successfully performed, the treatment in two of the four spleen cases was inadequate, leading to an unstable hemodynamic state. These two cases with splenic injuries underwent a subsequent splenectomy and successfully recovered.

The rate of PTDS in our series was 9.1% (1/11) for the patients with an ISS of 15 or more (range 16–29), and according to the JTDB data, the PTDS rate of the registered cases with scores ranging from 16–24 was about 9%.

In conclusion, our findings suggest that the secondary emergency facilities in Japan are expected to contribute to the present trauma medical care system in Japan, and should therefore be prepared to accept severely injured patients, at least until a fully-developed trauma care system is in place.

Acknowledgement

The authors report no financial supports or relationships concerning this research.

Competing interests

None declared.

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(Received for publication June 26, 2013)
二次救急病院一般外科に入院となった高エネルギー外傷患者の解析

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救急科1，放射線科2，整形外科3，外科4

奥山稔朗1，松本松栄1，吉野慎一郎1，平川勝之1，岸川政信1，吉田喜策2
齊藤太一3，東貴寛4，森田和宏4，永田茂行4，江口大彦4
遠藤和也4，川中博文4，富川盛雅4，立石雅宏4，是永大輔4，竹中賢治4

【目的】当院は200床の二次救急病院である。救急搬送された外傷症例中、一般外科に入院となった高エネルギー外傷症例の臨床学的特徴を明らかにした。

【対象と方法】08年4月-12年3月の4年間の全救急搬送症例7,826例中、外科系各科に入院となった外傷症例831例を対象とした。対象を非高エネルギー外傷群（非高エ群）、高エネルギー外傷群（高エ群）に分類し、各々につき一般外科入院となった症例を解析した。

【結果】(1)対象831症例は非高エ群741例(88.2%)、高エ群は90例(10.8%)であった。2)一般外科入院は非高エ群で741例中11例(1.5%)、高エ群で90例中18例(20.0%)と後者において高頻度であった(p<0.01)。(3)非高エ群9例は内臓損傷を伴わない症例であったのに対し、高エ群18例は胸腔、腹腔内臓器損傷を伴う症例であった。(4)高エ群18例においてISS15以上の重症患者は11例(61.1%)で、多発外傷は9例(50.0%)であった。(5)胸部、腹部各単独損傷は6例ずつであり、残り6例が胸腹部同時受傷であった。(6)治療法は胸腔ドレーン挿入6例、血管造影下止血術4例、腹部手術3例であった。(7)ISS15以上の症例の防ぎ得た外傷死は9.1%(1/11)で、症例数は少ないものの、三次救急病院を中心とした日本外傷データバンクの報告とほぼ同じ成績であった。

【結論】高エネルギー外傷群では、胸腹腔内臓器損傷を来たしたために一般外科への入院となった症例が高頻度に認められた。治療成績は概ね良好であり、二次救急病院は地域の外傷診療体制において一定の貢献を成し得ると考えられた。