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# Trauma Volume and Performance of a Regional Trauma Center in Korea: Initial 5-Year Analysis

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**Purpose:** We aimed to evaluate the trauma volume and performance indicators during the first 5-year period of operation in a single regional trauma center.
**Methods:** We analyzed prospectively collected data from the Korean Trauma Data Bank for a single regional trauma center between January 2014 and December 2018. More than 250 variables were analyzed. We calculated the predicted survival rates using the trauma and injury severity score (TRISS) method.
**Results:** In total, there were 16,103 trauma admissions during the first 5 years; trauma activation was performed in 5,105 of these cases. Over 70% of the patients were men, and most of the admitted patients were within the age groups of 55–59 years for men and 75–79 years for women. Analyses were performed considering two patient groups: the total patient group and the group of those with severe trauma (injury severity score [ISS] >15). The median ISS, revised trauma score, and TRISS of the two groups were 5 (interquartile range [IQR] 4–10), 22 (IQR 17–27), and 7.6±0.99 and 6.74±1.9, 0.95±0.13, 0.81±2.67, respectively. Of the total patient group, 801 patients (5%) died in the hospital, whereas of the group of patients with ISS >15, 526 (19.5%) died. The direct transportation of patients to the regional trauma center increased year by year. The emergency room stay time and time to entering the operating room showed a decrease until 2017; however, these parameters increased again in 2018.
**Conclusions:** The trauma volume in the regional trauma center is appropriate, and some improvements could be observed after its establishment. However, performance indicators reveal the prematurity of the trauma center and its potential for further improvements. Moreover, the development of a national trauma system, beyond regional trauma centers, is required.

**Keywords:** Trauma; Trauma center; Performance

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## INTRODUCTION

Trauma is a leading cause of death for young people in Korea. According to the 2018 Census Bureau report on causes of death, the number of deaths due to trauma and injury was 28,040 (9.4% of total deaths) [1]. In addition, the preventable trauma death rate was much higher than that in other developed countries, despite declining from 50.4% in 1997 to 39.6% in 2003, 32.6% in 2007, and 35.2% in 2011 [2-4]. Therefore, the Ministry of Health and Welfare and medical professionals agreed to establish regional trauma centers for severely injured patients in 2012. Subsequently, the first regional trauma center opened in 2014, with plans to establish 17 regional trauma centers in Korea by 2021.

There are several advantages of dedicated trauma centers. First, owing to a restricted trauma center designation, these centers can have an appropriate trauma volume. Higher patient volume leads to greater personnel experience, which subsequently translates into better outcomes. As polytrauma patients require complex, multidisciplinary surgical care, appropriate management decreases the impact of particular individuals and increases the importance of institutional experience [5]. Second, performance, including time to definitive care, is a critical factor affecting patient survival. To achieve this goal, centers require highly concentrated resources for a relatively small patient volume. The establishment of designated regional trauma centers can improve the efficient utilization of resources [6]. Finally, trauma centers can contribute to the regionalization of the trauma system, and such regionalization involving multiple trauma centers can lower the risk of death [7].

We aimed to evaluate trauma volume and performance indicators in the Trauma Center of Gachoun University Gil Medical Center (GMC), which was one of the first regional trauma centers to be established in Korea, during its first 5-year period of operation.

## METHODS

### Setting

GMC is an academic hospital in Incheon City, South Korea. It has 1,500 beds and serves a population of 3 million people. The regional trauma center of the city was the first trauma center to be established in Korea. The overriding goal was to establish a designated regionalized trauma center, similar to level I trauma centers in the United States (US). The trauma center established in 2014 is equipped with a trauma bay, two operating rooms (ORs) dedicated to trauma management, a dedicated 20-bed trauma intensive care unit, and a trauma interventional radiology suite. Nineteen full-time trauma surgeons, four trauma coordinators, and nine physician extenders currently work at the center. Emergency physicians, anesthesiologists, and neurosurgeons are contacted during a trauma call to serve as members of the trauma team. Furthermore, orthopedic consultants are available at all times. There is no lower level trauma (like level II-IV) center in Korea; instead, there are only regional emergency (highest level) and local emergency (lower level) centers for the management of trauma patients.

### Patients and data collection

The Korean Trauma Data Bank (KTDB) was developed by the Korean government and the trauma society. It is mandatory for every regional trauma center to collect data from all trauma admissions and add it to the KTDB, regardless of the injury severity score (ISS). We analyzed prospectively collected data for GMC Trauma Center between January 2014 and December 2018 using the KTDB dataset. More than 250 variables, including demographics, pre-hospital information, time factors, clinical characteristics, initial and worst vital signs, trauma scores, in-hospital information, and final outcome information, were recorded. The predicted survival rates were calculated using the trauma and injury severity score (TRISS) method.

Statistical analysis was performed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA) and a $p$-value <0.05 was considered statistically significa nt. Continuous variables were expressed as medians with an interquartile range (IQR; 25–75th percentile); categorical variables were expressed as percentages. For nominal variables, the chi-squared test was used, and for continuous variables, the independent sample $t$-test and one-way ANOVA were used.

Our Institutional Review Board waived the requirement for obtaining informed patient consent because we used

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existing materials and documents. Data were collected and processed anonymously (IRB No. 2019-036).

## RESULTS

### Study cohort demographics

In total, there were 16,103 trauma admissions during the first 5 years; trauma activation was performed in 5,105 of these cases. The annual number of trauma admissions ranged from 3,000 to about 3,400 and the number of patients with severe trauma (ISS>15) ranged from 510 to 557 (Table 1). Trauma team activation was performed for one-third of the admitted patients. The mean age in the total patient group was 49.1 years; among patients with ISS>15, the mean age was 51.1 years. In these groups, 65% and 74.1% of patients, respectively, were men. Most patients admitted were within the age group of 55–59 years for men and 75–79 years for women. The mean age of the patients increased yearly (Fig. 1). Most were transported using a ground ambulance; however, 2.2% of the total patient group and 5.0% of the severe trauma patients were

**Table 1.** Patient characteristics

| | Total | ISS>15 |
|---|---|---|
| Patient number | 16,103 | 2,703 |
| 2014 | 3,269 | 552 |
| 2015 | 3,180 | 510 |
| 2016 | 3,013 | 531 |
| 2017 | 3,421 | 553 |
| 2018 | 3,220 | 557 |
| Trauma activation | 5,105 | 2,256 |
| Age | 49.1±21.9 | 51.1±19.4 |
| Men | 10,460 (65) | 1,591 (74.1) |
| Blunt injuries | 89.1 | 96.5 |
| Mechanism of injury | | |
| Road traffic injury | 4,942 (30.7) | 1,229 (45.5) |
| Fall from a height | 3,067 (19) | 707 (26.2) |
| Slip down | 3,270 (20.3) | 308 (11.4) |
| Stabbing | 1,271 (7.9) | 48 (1.8) |
| Mode of transportation | | |
| EMS ground | 8,303 (51.6) | 1,602 (59.3) |
| Transferred | 2,472 (15.4) | 782 (29) |
| EMS helicopter | 350 (2.2) | 135 (5) |
| Others | 4,978 (30.8) | 184 (6.7) |
| Initial GCS score | 10.9±6.7 | 9.1±6.6 |
| Initial SBP | 129.1±36 | 118.4±46.6 |
| ISS | 5 (4–10) | 22 (17–27) |
| RTS | 7.6±0.99 | 6.74±1.9 |
| TRISS | 0.95±0.13 | 0.81±2.67 |
| Death | 801 (5) | 526 (19.5) |

Values are presentd as mean±standard deviation or number (%) or median (interquartile range).

SD: standard deviation, EMS: emergency medical service, GCS: Glasgow Coma Scale, SBP: systolic blood pressure, ISS: injury severity score, IQR: interquartile range, RTS: revised trauma score, TRISS: trauma injury severity score.

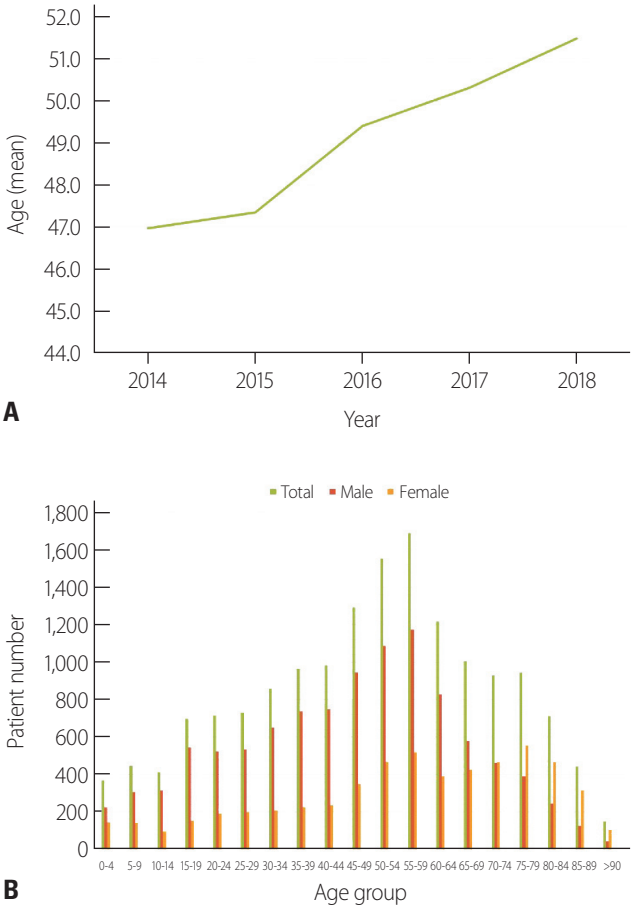


**Fig. 1.** Patient distribution by age. (A) The mean age of the patients and (B) number of patients by sex and age group. The mean age is increasing constantly and most frequent age group for female patients was age group of 75–79 years.

transferred by helicopter. Direct transportation from the scene increased each year (Fig. 2). Most cases involved blunt injuries (total: 89.1%, ISS>15: 96.5%). The most common mechanism of injury was road traffic accidents, followed by slip down, fall, and stabbing. The median ISS, mean revised trauma score, and mean TRISS of the two groups (total patient group and patients with severe trauma, i.e., ISS>15) were 5 (IQR: 4–10) and 22 (IQR: 17–27), 7.6±0.99 and 6.74±1.9, and 0.95±0.13 and 0.81±2.67, respectively. In the hospital, 801 (5%) of patients in the total patient group and 526 (19.5%) patients in the ISS >15 group died. The proportion of those with mild to moderate ISS (1–15) was 83%. The case fatality rate increased with the ISS (Table 2).

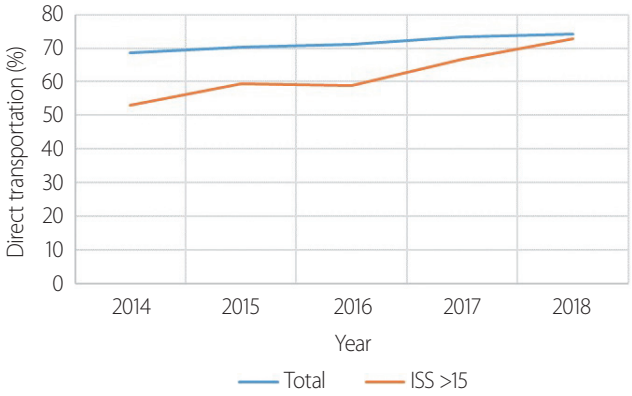


**Fig. 2.** Direct transportation to the trauma center. The percentage of directly transported patients is increasing annually. An increase was more significant in severely injured patients (ISS >15). ISS: injury severity score.

**Table 2.** Number of patients and number of deaths according to injury severity

| ISS | Total | Death |
|---|---|---|
| 1–8 | 8,883 (55.3) | 114 (1.2) |
| 9–15 | 4,491 (27.9) | 143 (3.2) |
| 16–24 | 1,480 (9.2) | 174 (11.8) |
| 25–40 | 1,084 (6.7) | 286 (26.4) |
| 41–75 | 139 (0.9) | 66 (47.5) |

Values are presented as number (%).
VISS: injury severity score.

### Annual performance parameters

The number of severely injured patients who were initially triaged to the trauma bay and the under-triage rate decreased annually (Fig. 3). The mean time of stay in the

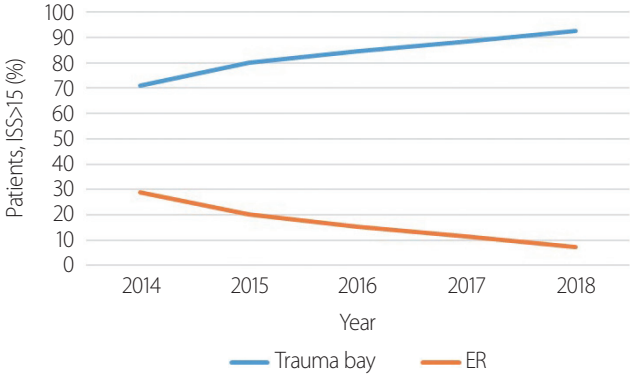


**Fig. 3.** Initial triage. The percentage of severe trauma patients (ISS >15) who were managed in the emergency room instead of trauma bay is decreasing throughout the 5-year period. ISS: injury severity score, ER: emergency room.

**Table 3.** Time audits for trauma team activation cases

| Year | ER stay | Laparotomy | Thoracotomy | Craniectomy |
|---|---|---|---|---|
| 2014–2018 | 177.3±57.1 | 127.8±68 | 111.6±75.1 | 201.2±61.5 |
| 2014 | 229.7±83.2 | 158±68 | 99.7±66.4 | 208.3±58.1 |
| 2015 | 196.9±76.9 | 133.4±65.7 | 97.7±61.3 | 209±55.2 |
| 2016 | 265.4±89.2 | 121.6±70.5 | 104.6±78.6 | 215.7±62.8 |
| 2017 | 133.7±43.6 | 105.5±62.7 | 125.1±76.8 | 178.6±58.9 |
| 2018 | 140.8±48.1 | 128.1±66.1 | 137.2±86.8 | 197.1±66.8 |
| *p*-value | <0.001 | 0.007 | 0.413 | 0.003 |

Data reported in minutes, mean±standard deviation.
ER: emergency room.


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**Table 4.** W and Z scores (using trauma and injury severity score) of the total patient population by year

| | N | W score | Z score |
|---|---|---|---|
| 2014 | 3,065 | 0.77 | 2.87 |
| 2015 | 3,180 | 0.83 | 3.68 |
| 2016 | 2,869 | 1.68 | 6.5 |
| 2017 | 3,154 | 2.06 | 8.17 |
| 2018 | 2,940 | 1.06 | 3.69 |

trauma bay decreased from 230 minutes in the first year, 2014, to 140 minutes in 2018. The mean time to entering the OR for laparotomy and craniotomy reduced slightly; however, the mean time for thoracotomy remained stable through the years (Table 3). The trauma center W and Z scores for each year for the total study population were better than those observed in the major trauma outcome study (MTOS). The W and Z scores were the highest in 2017; however, they decreased in 2018 (Table 4).

## DISCUSSION

In this study, we found that the trauma volume of our regional trauma center was appropriate, comparable to that in level I trauma centers in the US. The American College of Surgeons Committee on Trauma criteria for level I trauma center verification include an annual number of at least 1,200 patients, of which at least 240 must have an ISS >15 [8]. Before the establishment of the regional trauma center, there were about 250 patients with severe trauma (ISS >15) annually in GMC Trauma Center. Previous studies have shown that the establishment of a designated trauma center and the centralization of the management of severely injured patients can result in better outcomes [5,9]. Therefore, an increased patient volume after trauma center establishment could help in fulfilling the purpose of the plan. In addition, an increasing rate of direct transportation of severely injured patients via emergency medical services (EMS) was observed in this study. In one study from Korea, the proportion of transfers from other hospitals was found to be only 46% [10]. This improvement is also a main principle of trauma center designation and could contribute to better outcomes [11,12].

There were several noteworthy demographic findings in our study. First, the age distribution data suggested that the patients in our study population were older. Advanced age is a widely acknowledged risk factor for adverse outcomes after trauma, and the management of older trauma patients can be challenging for trauma surgeons [13-15]. The mean age of our study population increased each year. Most patients were in the age group of 55–59 years for men and 75–79 years for women. Identifying the risk factors of adverse outcomes for older patients and implementing appropriate multidisciplinary geriatric-specific protocols is necessary. Second, most patients with trauma injuries, especially those in the severe trauma group (96.5%), experienced blunt trauma. In the group of patients with severe trauma, only 1.8% experienced penetration injuries (e.g., stabbing). There were no gunshot injuries in the 5 years considered in this study. The lack of these injuries creates difficulties in training individuals for the management and surgical care of patients with penetrating trauma; therefore, there is a need to develop appropriate trauma training programs or courses. Third, more than 80% of the study participants had an ISS below 15. This is higher than that observed in level I trauma centers in the US. This percentage can contribute to a lower trauma center performance level [5]. As such, more appropriate triaging in the field, the training of the EMS personnel, and a regional trauma system should be developed.

The emergency room (ER) stay time and the time it takes to get the patients to the OR are related to outcomes and used as audit filters for trauma centers [16]. The ER stay time in our center decreased year by year, and it was shorter than that reported in previous domestic studies [17,18]. However, it was still longer than our goal of 90 minutes, and further efforts will be required to improve this. An audit revealed that the time required for evacuating an intracranial hematoma and for laparotomy is 4 hours and 1 hour, respectively [16]. The time required for a craniotomy decreased after hiring dedicated neurosurgeons in the trauma center; this time was consistent with the current recommendations. The time required to perform a laparotomy also decreased from 2014 to 2017; however, it increased in 2018. This procedure lasted

longer than recommended because we analyzed all trauma laparotomies, including those for minor abdominal trauma. The time to perform thoracotomy was increasing constantly although there was no statistical significance. In time audit, we could find the worsening in 2018. It is difficult to prove, but there could be some possible reasons. Firstly, the increased usage of the whole body CT scan and resuscitative endovascular balloon occlusion of aorta could delay time to OR. Secondly, there were new trauma surgeons in 2017 and it could make a time delay. With these audit filters, we could make several modifications and develop protocols to shorten these time intervals. Now, it is possible to bypass the trauma bay and head directly to the OR in extreme and urgent cases.

The MTOS and TRISS methodology can be utilized for objective measurement of trauma center performance, with stratification based on the severity of patients' injuries [19]. The objectives of the MTOS were to develop national standards for trauma care in emergency and trauma centers so that hospitals or systems could compare their outcomes with standards based on the management of injuries of similar severities. The outcomes, examined based on TRISS, improved until 2017 and then declined in 2018. We could not find an appropriate explanation for this trend; however, we are analyzing data profoundly to further investigate this. Nevertheless, several authors have suggested the potential limitations of TRISS, and these results should thus be interpreted cautiously [19].

The KTDB, from which we collected data, was established in 2013. It is the first trauma data bank in Korea, and there are 17 trauma registration systems currently operating in different countries [10,20]. It is a very valuable resource and can be used to improve trauma and emergency care systems. However, there are several limitations to the KTDB. First, there are only 17 regional trauma centers that input data to the KTDB. Other emergency centers that treat patients with severe trauma do not send data to the KTDB; thus, it is difficult to use these data to develop a national trauma system. Second, although the KTDB has more than 250 variables, laboratory results, specific surgical treatment, and follow up after discharge are not included. Third, while there is a data dictionary, the definitions were not clear until recently and the knowledge of the data coordinators was not sufficient. As such, detailed data dictionaries, more intensive education, and quality improvement are required to obtain reliable data.

In conclusion, the patient volume of the regional trauma center in Incheon was appropriate according to general recommendations. However, we need to develop more quality indicators and quality improvement programs to become a well-developed trauma center in the future. In addition, a true national trauma data bank should be developed to implement a more inclusive trauma system in Korea.

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