

A Comparison of the Effectiveness of Before and After the Regional Trauma Center's Establishment

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Purpose: The purpose of this study was to analyze the effectiveness of regional trauma center's management.

Methods: Data collected between January 2013 and December 2015 from a regional trauma center registry was retrospectively reviewed. The patients who had injury severity score (ISS) greater than 15 and over the age of 18 were included. We compared annual general characteristics, the injury mechanism, the pathway of transportation, the injury severity score, the length of stay in emergency department (ED) and hospital, the in-hospital mortality.

Results: The annual numbers of enrolled patients were 337, 334 and 278, respectively. No significant differences were found in the annual patient's median ages, injury mechanism, ISS and in-hospital mortality. The annual proportions of coming from other hospital and the median length of stay in hospital were increased after establishment of regional trauma center. The annual median lengths of stay in ED were decreased remarkably.

Conclusion: Through the establishment of regional trauma center, the length of stay in ED can be reduced but not in-hospital mortality. More multidisciplinary cooperation and well-organized study is needed to reduce mortality of major trauma patients and maximize effect of regional trauma center. [J Trauma Inj 2016; 29: 68-75]

Key Words: Regional trauma center, Injury severity score, Length of stay, Mortality rate

I. Introduction

According to classification of causes of death in National Statistical Office (NSO) in 2014, trauma is ranked the 3rd place in overall causes of death followed by death caused by neoplasm and problems of circulatory system. Particularly, trauma is the number 1 cause of death from teenagers to those in their thirties.(1) According to the domestic research released in 2006, direct and indirect economic losses due to domestic trauma are approximately 39,800,370,000 dollars, which accounts for roughly 4% of South Korea's GDP (Gross Domestic Product):

in particularly, trauma can heavily result in social and financial losses in young working age population along with long-term rehabilitation and decline in labor-productivity.(2)

In case of these trauma patients, it frequently occurs that it is hard to get an accurate diagnosis in good time before visiting a hospital and receive proper treatments. Moreover, both treatments from patient transportation and in-hospital care are all important to decide an injured patient's prognosis. Therefore, in recent years, the need of management system for trauma patients has emerged because this new management approach to trauma patients

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is relatively more efficient and systematic than conventional emergency medical system. Thus, in 2008, initiating specialized trauma centers for severe trauma patients as a starting point, supporting business with foundation of severe trauma centers has been proceeded to establish systematic system for trauma in earnest.(3,4)

The preventable trauma death rate is an indicator to measure the proportion of deaths considered to be preventable if proper treatments are provided. Especially, it is confirmed that its rate in Korea is higher than foreign nations; according to Kim et al.,(5) in 2006, the preventable trauma death rate in Korea was 39.6%, which is higher than 15.0% of Montana State in the USA in 2003.(6) Therefore, Korean government has established a specific goal to reduce the preventable trauma death rate less than 20% by the year 2020.(7)

Our hospital was selected as an object of the specialized trauma center project for severe trauma patients in 2012. Then, the hospital has been preparing to operate a regional trauma center. In particular, in 2013, a severe trauma team was composed of thoracic surgery and general surgery specialists in the hospital and the hospital has been actively operating a state-designated regional trauma center until now.

The yearly data of visited patients for 3 years from 2013 to 2015 were analyzed in this study. The study aims at comparing effects before and after opening the regional trauma center through analysis of physiological characteristics, treatment results, duration time at an emergency room, mortality rate, and etc. in severe trauma patients.

II. Materials and Methods

This study selected those patients visited the emergency center for 3 years (from January 1st, 2013 to December 31st, 2015) and retrospectively analyzed their data. Inclusion criteria of subjects in the study are as follows: 1) trauma patients who are 18 years old or over; 2) the patients obtained at least 15 scores in Injury Severity Score (ISS), based on Abbreviated Injury Scale (AIS); and 3) the patients visited an emergency center, designated as a regional trauma

center at the university medical center, where approximately 80,000 patients have visited annually.

The following patients were excluded from the study: 1) dead-on-arrival patients; 2) dead patients during receiving treatments in the ED; 3) patients were voluntarily discharged or transferred to another hospital from the ED; 4) iatrogenic damaged patients; 5) burned patients; 6) patients hanged themselves.

ISS was confirmed by a professional coordinator in the trauma center and a top resident in the emergency medicine. This study focused on comparing data before and after 2014 years when the hospital firstly opened and operated its regional trauma center; patients' basic features per year, a cause of injury, a route of admission, and ISS were measured. As a result of the measurements, the following things were compared and analyzed in the order listed: firstly, duration time at ED and secondly, mortality rate.

SPSS version 18.0 (SPSS Inc., Chicago, USA) was used for statistical analysis; Chi-square test was taken for categorical variables and ANOVA test was taken for continuous variables. Moreover, logistic multiple regressions were used for analyzing the factors related to death. The significance level is 0.05 (p -value).

III. Results

The total number of subjects in this study was 949 patients (337 in 2013, 334 in 2014, and 278 in 2015) (Fig. 1). The medians of average age of three groups were 55 (Interquartile Range (IQR) 43-66) years old, 53 (IQR 41-64) years old, and 54 (IQR 42-65) years old, ($p=0.317$). In all three groups, the ratio of male patients was higher than that of female patients. (77.7%, 75.1%, 74.1%, $p=0.547$) In relation to causes of injury, traffic accident was all ranked as the first cause of injury in three groups. Other causes of injury were listed in the order: falls/slip; an injury by an object; and a stab/an injury by a machine.

In the three groups, percentages of patients who directly came to the ED of the hospital after being injured through an ambulance and an emergency helicopter were 56.9%, 40.7%, and 49.2%, respectively. On the other hand, percentages of patients,

transferred from another hospital were 43.0%, 59.2%, and 50.7%, respectively ($p < 0.001$); compared

to 2013, after opening the trauma center in 2014, the number of the patients, transferred from another

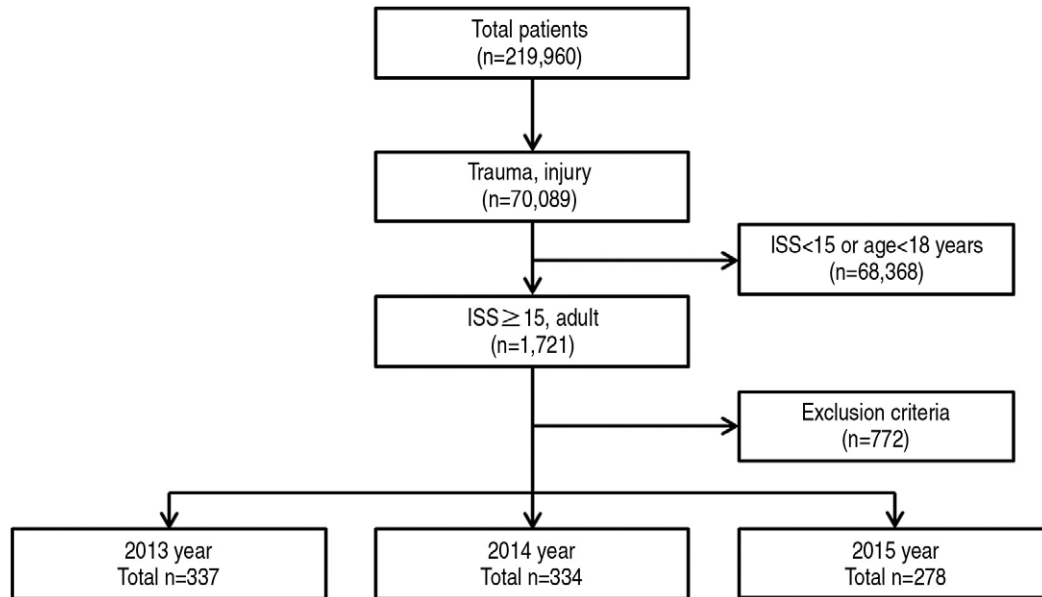


Fig. 1. Study flow diagram of annual adult major trauma patients.

Table 1. Clinical and demographic characteristics of all included patients

	Total N=949 n (%)	Years			p-value
		2013	2014	2015	
Age (yrs)*	54 (42-65)	55 (43-66)	53 (41-64)	54 (42-65)	0.317
Sex					0.547
Male	719 (75.7)	262 (77.7)	251 (75.1)	206 (74.1)	
Female	230 (24.2)	75 (22.2)	83 (24.8)	72 (25.9)	
Injury mechanism					0.046
TA [†]	475 (50.0)	149 (44.2)	164 (49.1)	162 (58.27)	
Falls/Slip	324 (34.1)	126 (37.3)	120 (35.9)	78 (28.0)	
Collision	49 (5.1)	17 (5.0)	18 (5.3)	14 (5.0)	
Stab/Machine	27 (2.8)	10 (2.9)	11 (3.2)	6 (2.1)	
Unknown	74 (4.8)	35 (10.3)	21 (6.2)	18 (6.4)	
Pathway of transportation					<0.001
Direct coming to hospital	465 (49.0)	192 (56.9)	136 (40.7)	137 (49.2)	
Transfer from other hospitals	484 (51.0)	145 (43.0)	198 (59.2)	141 (50.7)	
ISS*	22 (17-27)	22 (17-26)	22 (17-26)	22 (17-29)	0.062
Main abbreviated injury scale					<0.001
Head/Neck ≥ 3	552 (58.1)	242 (71.8)	183 (54.7)	127 (45.6)	
Chest ≥ 3	174 (18.3)	42 (12.4)	69 (20.6)	63 (22.6)	
Abdomen ≥ 3	185 (19.4)	41 (12.7)	61 (18.2)	83 (29.8)	
Extremity ≥ 3	38 (4.0)	12 (3.5)	21 (6.2)	5 (1.8)	
Length of stay in hospital (days)*	25 (14-48)	24 (12-45)	23 (13-45)	28.5 (17-54)	0.003

* These data were represented as median (25 percentile-75 percentile).

[†] TA: traffic accident

er hospital had been increased. However, in 2015, the number of the patients, directly visited to the hospital has been relatively increased.

The medians of ISS of patients by year were 22 ($p=0.062$) and there was no statistical significance, injured legion with the highest AIS by body parts in all three groups was head and neck legion (71.5%, 54.7%, 45.6%, $p<0.001$). The median of total length of hospital stay was 25 days; the medians of length of hospital stay by year were 24 (IQR 12–45) days, 23 (IQR 13–45) days and 28.5 (IQR 17–54) days, respectively, ($p=0.003$); the length of hospital stay in 2015 was increased compared to previous years (Table 1).

Regarding length of stay in ED, annual median values of the patients were 289 (IQR 191–424) min., 203 (IQR 151–294) min., and 182 (IQR 125–251) min. ($p<0.001$); the time has been shorten per each year; especially, after classifying into a neurosurgery department, a trauma surgery department, and other departments, length of stay in ED was compared annually. It also showed significant results (Fig. 2).

Percentages of whole patients' administration per year in the neurosurgery department had the highest percentage in 2013 and 2014 compared to other departments. However, in 2015, percentage of patients, entered into the trauma surgery department was higher than that in the neurosurgery department (63.5% vs 23.4%, 48.2% vs 36.2%, 39.5% vs 50.3%, $p<0.001$). These results seem to be related with increasing percentage of the patients, hospitalized into the trauma surgery department because after opening the trauma surgery department, if a

patient has a minor neurosurgical injury, the patient was admitted to the trauma surgery department instead of the neurosurgery one. Percentages of patients, admitted to the ED through a surgery room or an angiography room were 27.8%, 26.9%, and 33.8% per year ($p=0.139$) (Table 2).

Results after administration show that discharging cases after recovery were 43.9%, 58.0%, and 46.2% per year ($p<0.001$). Thus, discharging percentage was increased after opening the trauma center in 2014 and then decreased again. On the other hand, percentages of transferring to another hospital were 39.4%, 27.5%, and 48.9% per year ($p<0.001$), which shows the percentages were

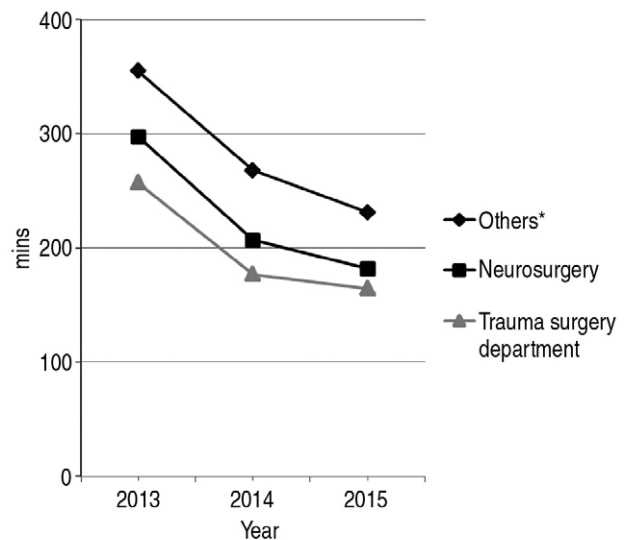


Fig. 2. Annual median length of stay in emergency department by admitted department are getting shorter. *Others included orthopedics, spine center, emergency medicine, etc.

Table 2. Disposition of ED* treatment

	Total N=949 n (%)	Years			p-value
		2013	2014	2015	
Admitted department					<0.001
NS †	485 (51.1)	214 (63.5)	161 (48.2)	110 (39.5)	
TD ‡	340 (35.8)	79 (23.4)	121 (36.2)	140 (50.3)	
Others§	124 (13.0)	44 (13.0)	52 (15.5)	28 (10.0)	
Operation/intervention					0.139
Done	278 (29.2)	94 (27.8)	90 (26.9)	94 (33.8)	

* ED: emergency department

† NS: neurosurgery

‡ TD: trauma surgery department

§ Others included orthopedics, spine center, emergency medicine, etc.

decreased after opening the trauma center and then increased again. Furthermore, mortality rates of hospitalized patients were 16.6%, 14.3%, and 16.1% per year ($p < 0.001$). Thus, compared to 2013, mortality-

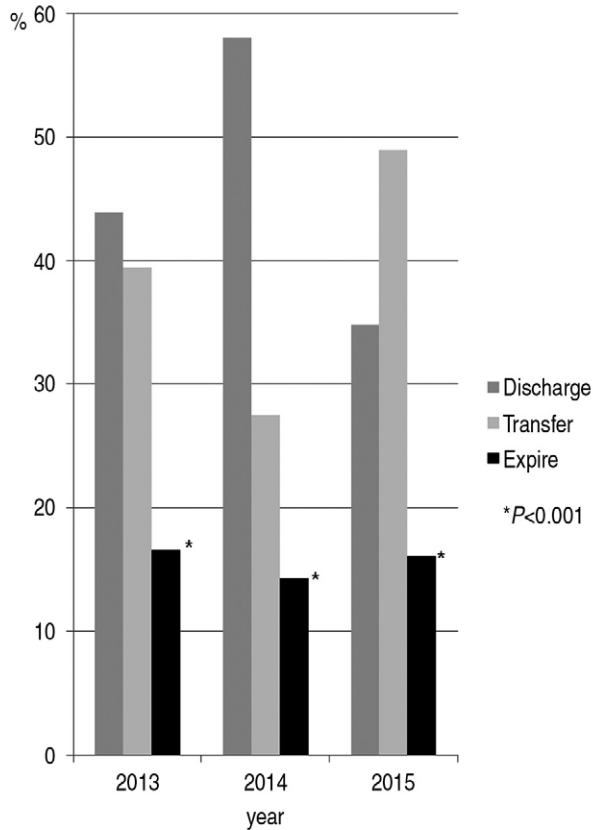


Fig. 3. By an annual disposition of admitted patients, there were no significant differences in in-hospital mortality.

ty rate was decreased by 2.3% in 2014 when right after opening the trauma center. However, when mortality rate in 2015 was compared with that in 2013, there was no big difference (Fig. 3).

The multiple regression of mortality rate by year and each department showed that odds ratios (ORs) of death rate in the patients in 2014 and 2015 compared to 2013 were 0.77 (95% Confidence Interval (CI): 0.491-1.209, $p=0.257$), 0.81 (95% CI: 0.511-1.288, $p=0.377$), respectively. The ORs of the patients through the neurosurgery department were 1.18 (95% CI: 0.696-2.008, $p=0.535$), 0.93 (95% CI: 0.506-1.724, $p=0.827$), which means that there was no difference between years. The ORs of the patents excluding those through the neurosurgery department were 0.34 (95% CI: 0.134-0.882, $p=0.026$) in 2014 and 0.84 (95% CI: 0.380-1.880, $p=0.682$) in 2015; of them, the ORs of the patients in the trauma surgery department were 0.34 (95% CI: 0.122-0.962, $p=0.042$) and 0.77 (95% CI: 0.315-1.881, $p=0.566$); it is confirmed that the death rate of patients of the trauma surgery department was decreased right after opening the trauma center in 2014 (Table 3).

IV. Discussion

In the U.S., since the mid-1900s, when the first trauma center was established, the nation has continuously made an effort for management of severe trauma patients. Under leading by American College

Table 3. Multiple logistic regression by mortality following admitted department (2013, Reference)

Group	Year	OR* (95% Confidence interval)	p-value
Total patients	2014	0.77 (0.491-1.209)	0.257
	2015	0.81 (0.511-1.288)	0.377
NS [†] patients	2014	1.18 (0.696-2.008)	0.535
	2015	0.93 (0.506-1.724)	0.827
Non NS [†] patients	2014	0.34 (0.134-0.882)	0.026
	2015	0.84 (0.380-1.880)	0.682
TD [‡] patients	2014	0.34 (0.122-0.962)	0.042
	2015	0.77 (0.315-1.881)	0.566

* OR: odds ratio

† NS: neurosurgery

‡ TD: trauma surgery department

of Surgeons Committee on Trauma (ACSCOT), regular inspection has been sustainably performing to investigate functions of trauma centers all over the U.S.(8) Comparing to that, in South Korea, establishment and operation of national trauma centers have not been in the early stage yet.

Researchers of this study investigated whether there are changes in duration length of stay in ED, length of hospital stay, and mortality rate before and after opening the regional trauma center. It is actually confirmed that although the length of stay in ED has been decreased annually after opening the trauma center, the length of hospital stay and the mortality rate haven't been shown any big change. This result of the study is similar to outcomes of several internal and external studies. Robert et al.(9) said that despite of early vitalization of trauma teams, there was no difference in severely injured patients' mortality rate after 6 weeks. Lee et al.(10) also reported that in relation to treatments for multiple injury patients, operation of emergency trauma teams could enhance the treatments and immediacy of hospitalization, but it didn't help to improve final survival rate itself in the short term.

However, when multiple regression analysis was performed to investigate association of mortality rate per each department and each year, the following results were derived; 1) compared to 2013 before starting the trauma center, mortality rate decreased in 2014 right after opening the trauma center; 2) in particular, when we narrowed down patients in the trauma surgery department, mortality rate's OR decreased in mortality rate; and 3) there was no difference between before and after opening the trauma center in mortality rate of other seriously injured patients at other departments. (neuro-surgery department, orthopedics department, and etc.) Like these results, the reason to show different mortality rates among severe trauma patients with the same ISS values is that patients in the neuro-surgery department occupy a big portion of the severe trauma patients; and their mortality rates are relatively higher than other patients.(11-13)

On the other hand, the factors of decline in mortality rate of patients at the trauma surgery department after opening the trauma center are that com-

pared to neurosurgery and orthopedics departments, exclusive specialist system in the trauma surgery department has been more actively operating since initiating a demonstration project for the trauma center and that early medical decisions were feasible through rapid and cooperative treatments among medical specialists in the trauma surgery department. Moreover, more effective and rapid treatments could be delivered in the trauma surgery department as opening of regional trauma centers contributed to establish facilities such as an intensive care unit and a surgery room or a ward, specialized in trauma.(14)

In case of multiple injury patients, their length of stay in ED can be delayed in many cases due to a lot of complicated treatment processes and diagnoses.(15-16) The following results are reported in detail; extended length of stay in ED can negatively affect to offer quality medical treatments and prognosis of patients; especially, severe trauma patients that received tracheal intubation were more affected complications of pneumonia if their length of stay in ED becomes longer.(17-18) Many studies have reported that proper operation of severe trauma teams can reduce length of stay in ED.(10) Moreover, it can significantly impact on improving overall survival rate of patients.(19-20) In this respect, results of this study can be positive outcomes not only for medical staffs but also for patients as the patients' length of stay in ED has been annually decreased after starting the regional trauma center.

However, when we simply focus on reducing patients' length of stay in ED, it can result in decreasing quality of treatments or errors in diagnostic processes. As there is always a possibility of mistaken diagnosis and adverse reactions, we should pay special attention to that. Especially, regarding patients with traumatic injury in the head, there are studies, shown that there was no special influence between patients' length of stay in ED and their prognosis.(21-22) Therefore, in addition to proper treatment length of stay in ED, further studies for other criteria to improve patients' overall survival rate are needed.

The preventable trauma death rate, mentioned above can be reduced when all mortality rates in

pre-hospital and in-hospital stages are improved. Therefore, provision of active education for emergency medical technicians working inside of an ambulance and promotion of trauma centers should be carried out to support effective transportation, which is known as an influential factor on patients' mortality rate in the pre-hospital care stage.^(5,23) In particular, the percentage of patients, referred from another hospital had been increased after opening the trauma center, and then the percentage has been gradually increasing, whereas the percentage of patients, directly visited the trauma center has been increasing gain. These results can be considered that the education and promotion have gained their effectiveness to some degree.

This study confirmed that in 2015, percentage of transferring patients and overall length of hospital stay increased compared to last 2 years. Regarding this point, additional analysis of data may need to see whether patients' complications such as infection or acute respiratory distress syndrome have been relatively increased or not in comparison with data of previous year. This is because these complications can cause to extend length of hospital stay in trauma patients.⁽²⁴⁻²⁶⁾ Moreover, in the future, roles of severe trauma teams need to be discussed through establishment of specific and clear discharging criteria.

As establishment of system and recognition of the importance of trauma centers have been recently progressed in Korea, still, there is a lack of research on clinical guidelines and definitive roles of trauma centers. Therefore, national efforts should be continued to maximize efficiency of establishing trauma centers, which is currently on-going protect and to reduce preventable mortality rate from trauma through continuous inspection about treatment results of patients, execution of overall statistical research and analysis for regional trauma centers all around the nation.

There are a few limitations in the study; first of all, it is a retrospective study so it limits to correct objective data; secondly, the subjects of the study were severe trauma patients, visited one single hospital so it may have a limitation to represent all patients with serious trauma; thirdly, the patients

were only classified by ISS values without their physiological indexes. Therefore, it may have a limitation to comprehend patients' severity; and lastly, the patients' causes of death were not clearly investigated.

V. Conclusion

Introduction of domestic trauma centers has been performed in recent years in Korea. After operation of regional trauma centers, patients' length of stay in ED has been continuously decreasing along with decline in whole patients' mortality rate in the early state of the operation. Therefore, there is a need to actively perform further studies in the long term to achieve improvement, and effective establishment of trauma system and regional trauma centers.

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