Korean J Neurotrauma. 2023 Jun;19(2):227-233
https://doi.org/10.13004/kjnt.2023.19.e16
pISSN 2234-8999·eISSN 2288-2243

KJNT

Clinical Article

Check for updates

Comparison of Preventable Trauma Death Rates in Patients With Traumatic Brain Injury Before and After the Establishment of Regional Trauma Center: A Single Center Experience

Dae Han Choi [1], **Tae Seok Jeong** [1], **and Myung Jin Jang** [2]

[1]Department of Neurosurgery, Gil Medical Center, Gachon University College of Medicine, Incheon, Korea
[2]Regional Trauma Center, Gil Medical Center, Gachon University College of Medicine, Incheon, Korea

OPEN ACCESS

Received: Feb 21, 2023
Revised: Mar 15, 2023
Accepted: Mar 22, 2023
Published online: May 26, 2023

Address for correspondence:
Tae Seok Jeong
Department of Neurosurgery, Gachon University Gil Medical Center, Gachon University College of Medicine, 21 Namdong-daero 774beon-gil, Namdong-gu, Incheon 21565, Korea.
Email: jeongtaeseok@outlook.com

ORCID iDs
Dae Han Choi
https://orcid.org/0000-0001-5281-2770
Tae Seok Jeong
https://orcid.org/0000-0001-5877-0647

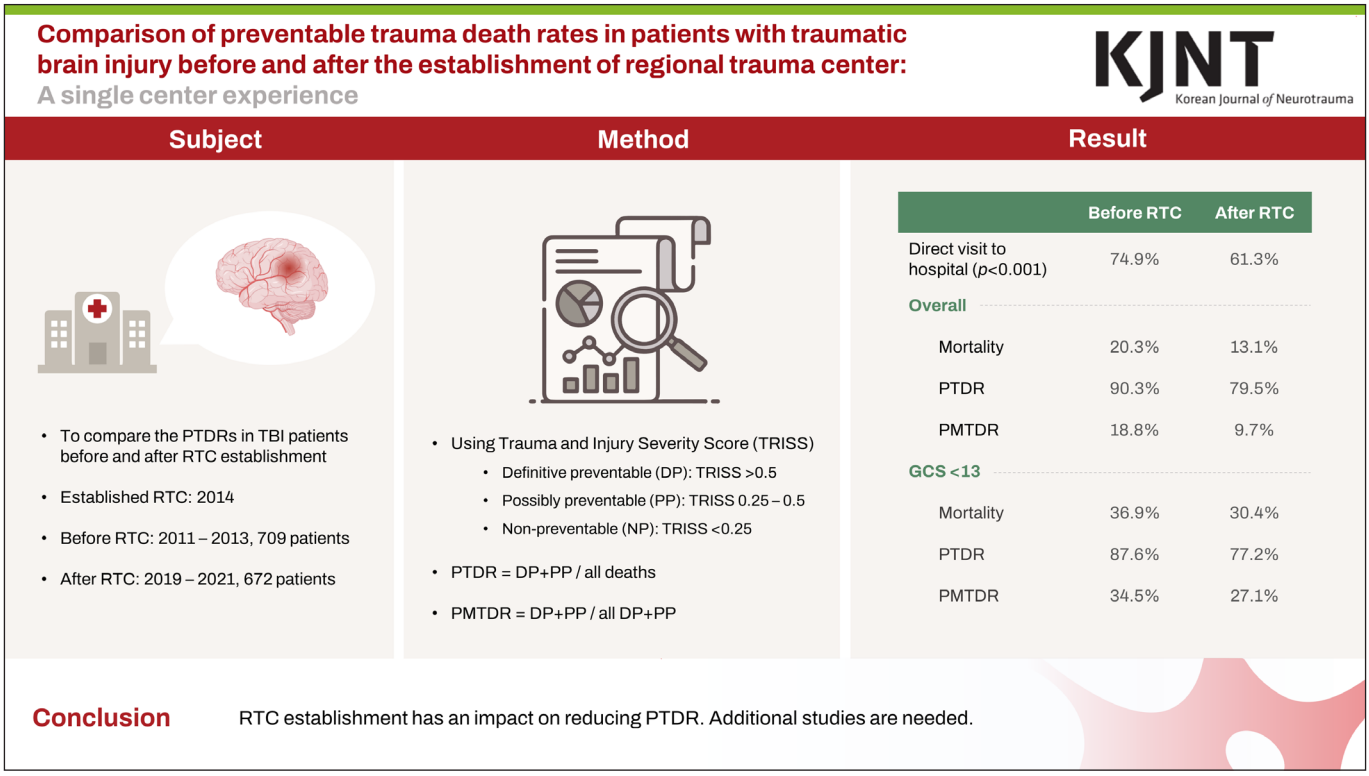
Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Objective: To compare preventable trauma death rates (PTDRs) in patients with traumatic brain injury before and after the establishment of a regional trauma center (RTC) at a single center.
Methods: Our institution established an RTC in 2014. A total of 709 patients were enrolled from January 2011 to December 2013 (before RTC) and 672 from January 2019 to December 2021 (after RTC). The revised trauma score, injury severity score, and trauma and injury severity score (TRISS) were evaluated. Definitive preventable (DP), possibly preventable (PP), and non-preventable deaths were defined as TRISS >0.5, TRISS 0.25–0.5, and TRISS <0.25, respectively. PTDR was the proportion of deaths from DP+PP out of all deaths, and the preventable major trauma death rate (PMTDR) was the proportion of deaths from DP+PP out of all DP+PP.
Results: The overall mortality rates before and after the establishment of RTC were 20.3 and 13.1%, respectively. PTDR was lower after the establishment of RTC than before (90.3% vs. 79.5%). The PMTDR was also lower after the establishment of RTC than before (18.8% vs. 9.7%). The ratio of direct hospital visits was higher in patients before the establishment of RTC than in those after (74.9% vs. 61.3%, p<0.001).
Conclusion: Establishing the RTC reduced PTDRs. Additional studies on factors associated with PTDR reduction are required.

Keywords: Injury severity score; Mortality; Trauma center; Traumatic brain injury; Treatment outcome

GRAPHICAL ABSTRACT



INTRODUCTION

The preventable trauma death rate (PTDR) refers to the proportion of deaths from traumatic injuries that could have been prevented through appropriate and timely intervention [13] and is a measure of the quality of patient care and the effectiveness of trauma systems in reducing deaths from traumatic injuries. PTDR is an important indicator of the performance of trauma systems and is used to identify areas for improvement.[8] Methods that are widely used to calculate PTDR include the trauma and injury severity score (TRISS), international classification of disease-based injury severity score (ICISS), and expert panel studies.[3]

Since 2012, the Ministry of Health and Welfare in Korea has promoted the designation and establishment of regional trauma centers (RTCs) to reduce PTDR.[18] As of 2022, 17 RTCs have been established and are operating nationwide. PTDR in Korea has been decreasing since the establishment of the national trauma system based on the implementation of RTCs.[8,12,16] We aimed to compare PTDRs in patients with traumatic brain injury (TBI) before and after the establishment of the RTC at a single center.

MATERIALS AND METHODS

This retrospective study was approved by the Clinical Research Ethics Review Committee of Gil Medical Center (GDIRB2023-042). Because this was a retrospective study, the Clinical Research Ethics Review Committee waived the need for informed consent.

https://doi.org/10.13004/kjnt.2023.19.e16

Patient selection

Because our institution established an RTC in 2014, the period before establishing the RTC for patient selection was from January 2011 to December 2013. In the early days of the establishment of the RTC, there were not enough neurotrauma specialists. Therefore, the period after the RTC was set from January 2019 to December 2021, when three neurotrauma specialists took charge of all patients with neurotrauma. Among all trauma patients who visited the RTC, the number of patients with injury severity score (ISS) >15 who were included in the Korean Classification of Disease Code of the Intracranial Injury, S060–S069, was 1,942. Exclusion criteria were death upon arrival at the emergency room, cardiopulmonary resuscitation before visiting the hospital, and uncheckable revised trauma score (RTS) items (**TABLE 1**). After excluding 561 patients who met the exclusion criteria, 1,381 patients were finally enrolled (709 before and 672 after the establishment of RTC).

Data analysis

Age, sex, injury mechanism, initial vital signs, initial Glasgow Coma Scale (GCS) score, and visit route were evaluated as baseline characteristics. Trauma scoring systems, including the RTS, ISS, and TRISS, were used to compare trauma severity using the following formula[2]:

$$RTS=(0.9368\times GCS)+(0.7326\times \text{Systolic Blood Pressure})+(0.2908\times \text{Respiratory Rate})$$

$$ISS=(\text{1st AIS Score})^2+(\text{2nd AIS Score})^2+(\text{3rd AIS Score})^2$$

(AIS: Abbreviated Injury Scale)

TRISS

$$\text{Probability of Survival}=1/(1+e^{-b})$$

$$b_{Blunt}=-0.4499-(0.0835\times ISS)+(0.8085\times RTS)-(1.7430\times \text{AgeIndex})$$

$$b_{Penetrating}=-2.5355-(0.0651\times ISS)+(0.9934\times RTS)-(1.1360\times \text{AgeIndex})$$

TRISS was used to classify trauma as definitive preventable (DP, TRISS >0.5), possibly preventable (PP, TRISS 0.25–0.5), and non-preventable (NP, TRISS <0.25) according to the probability of survival. The PTDR and preventable major trauma death rate (PMTDR) before and after the establishment of RTC were calculated using the TRISS.[16]

$$PTDR=\text{Number of Deaths from DP+PP}/\text{Number of All Deaths}$$

$$PMTDR=\text{Number of Deaths from DP+PP}/\text{Number of All DP+PP}$$

In addition, PTDR and PMTDR were compared in patients with moderate and severe TBI (GCS <13) because mild TBI had no significant effect on death.

TABLE 1. Inclusion and exclusion criteria

Criteria	Detail
Inclusion criteria	KCD code (S060–S069)
	KCD code (S060–S069)
Exclusion criteria	Death on arrival to the emergency room
	Cardiopulmonary resuscitation before visiting the hospital
	Uncheckable RTS items
	Severe trauma to both eyes
	Intubation before visiting the hospital
	Sedation from the use of sedatives before visiting the hospital
	No record of respiratory rate

ISS: injury severity score, KCD: Korean Classification of Disease, RTS: revised trauma score.

https://doi.org/10.13004/kjnt.2023.19.e16

Statistical analysis

Continuous variables were described using means and standard deviations, whereas categorical variables were expressed as frequencies. Continuous variables were compared using an independent *t*-test, whereas categorical variables were compared using Pearson's χ^2 test. All tests were performed using a statistical significance criterion of α=0.05. Statistical analyses were performed using SPSS for Windows (version 23.0; IBM Corp., Armonk, NY, USA).

RESULTS

Patient characteristics

There were no differences in age, sex, injury mechanisms, initial vital signs, or initial GCS scores before and after the establishment of RTC. However, the visit route differed significantly between the patients before and after the establishment of RTC. The proportion of direct hospital visits after trauma was higher in patients before the establishment of RTC than in those after (74.9 vs. 61.3%, p<0.001) (**TABLE 2**).

Trauma scoring systems

The RTS, ISS, and TRISS did not differ significantly before and after the establishment of RTC (**TABLE 3**).

PTDR

The overall mortality rates before and after the establishment of RTC were 20.3% and 13.1%, respectively. PTDR and PMTDR were lower after the establishment of RTC than before (90.3% vs. 79.5% and 18.8% vs. 9.7%, respectively) (**TABLE 4**). In patients with mild TBI (GCS score <13), PTDR and PMTDR were lower after the establishment of RTC than before (87.6% vs. 77.2% and 34.5% vs. 27.1%, respectively) (**TABLE 5**).

TABLE 2. Characteristics of patients before and after the RTC

Characteristics	Before RTC (n=709)	After RTC (n=672)	*p*-value
Age (yr)	57.1±20.5	56.7±20.7	0.735
Sex, female	181 (25.5)	164 (24.4)	0.630
Injury mechanisms			0.707
Blunt	703 (99.2)	665 (99.0)	
Penetrating	6 (0.8)	7 (1.0)	
Initial vital sign			
Systolic blood pressure	131.8±35.8	130.3±36.2	0.434
Respiratory rate	20.3±4.6	20.1±4.4	0.290
Initial GCS	11.3±4.3	11.7±4.2	0.068
Visit route			<0.001*
Direct	531 (74.9)	412 (61.3)	
Transfer	178 (25.1)	260 (38.7)	

Values are presented as mean ± standard deviation or number (%).
RTC: regional trauma center, GCS: Glasgow Coma Scale.
*p<0.05, statistically significant difference.

TABLE 3. Comparison of trauma scoring systems before and after the RTC

Score	Before RTC	After RTC	*p*-value
RTS	6.88±1.27	6.86±1.64	0.779
ISS	25.04±7.91	24.27±8.03	0.072
TRISS	0.80±0.22	0.82±0.24	0.082

Values are presented as mean ± standard deviation.
RTC: regional trauma center, ISS: injury severity score, RTS: revised trauma score, TRISS: trauma and injury severity score.

https://doi.org/10.13004/kjnt.2023.19.e16

TABLE 4. Comparison of PTDR before and after the RTC

Variables	Before RTC (n=709)		After RTC (n=672)	
Survival probability	Survival	Death	Survival	Death
Definitely preventable (>0.5)	526	94	626	46
Possibly preventable (0.25–0.5)	34	36	26	24
Non-preventable (<0.25)	5	14	17	18
PTDR (%)	90.3 (130/144)		79.5 (70/88)	
PMTDR (%)	18.8 (130/690)		9.7 (70/722)	

PTDR: preventable trauma death rate, RTC: regional trauma center, PMTDR: preventable major trauma death rate.

TABLE 5. Comparison of PTDR of patients below GCS 13 before and after the RTC

Variables	Before RTC (n=306)		After RTC (n=260)	
Survival probability	Survival	Death	Survival	Death
Definitely preventable (>0.5)	156	63	138	37
Possibly preventable (0.25–0.5)	32	36	26	24
Non-preventable (<0.25)	5	14	17	18
PTDR (%)	87.6 (99/113)		77.2 (61/79)	
PMTDR (%)	34.5 (99/287)		27.1 (61/225)	

PTDR: preventable trauma death rate, GCS: Glasgow Coma Scale, RTC: regional trauma center, PMTDR: preventable major trauma death rate.

DISCUSSION

In the present study, despite no differences in RTS, ISS, and TRISS before and after the establishment of RTC, PTDR decreased significantly after. Increased human resources and equipment, improved protocols for major trauma treatment, and the ability of trauma specialists in various fields to provide multidisciplinary treatment have had an impact on the decrease in PTDR after the establishment of the RTC.[7]

In the literature, PTDRs based on expert review panel judgements were 35%–45% in the absence of organized trauma systems, with a reduction of 15%–20% after implementation of the trauma systems and centers.[3] Similar results were obtained in surveys conducted in Korea, where PTDRs decreased to 40.5% in 1997,[9] 35.2% in 2010,[10] and 15.7% in 2019.[12] As mentioned above, the methods that are widely used to calculate PTDR include TRISS, ICISS, and expert panel studies.[3] PTDR by panel study is a widely used method; however, it has the disadvantage of being subjective in the early stages of the center's operation. Therefore, it may be unsuitable to determine whether the quality of the trauma center has improved.[3,16] There are studies showing large differences between PTDRs calculated using each method,[10,11,16] and PTDR calculated using TRISS tends to be higher than that calculated by panel studies.[10,16] In the present study, PTDR calculated using TRISS decreased after the RTC was established but had a high value of 79.5%. Park et al.[16] investigated the PTDR of 20 emergency medical centers from August 2006 to July 2007 and reported that the PTDR calculated using an expert panel study was 32.6%, whereas that using TRISS was 74.2%.

TRISS is the survival probability, which reflects the anatomical factors of injury (ISS), physiological factors (RTS), age-related comorbidity, and the mechanism of injury (blunt or penetrating). Although TRISS is widely used and the use of the TRISS formula removes subjectivity in the calculation of survival probability, it has limitations, mainly due to the inclusion of RTS and ISS.[14,15] RTS is calculated by assigning weight to the initial GCS, systolic blood pressure, and respiratory rate; however, it is difficult to measure accurately when endotracheal intubation is performed in a prehospital setting.[4] The ISS component does not consider more than one lesion in each body region in its calculations, which may

https://doi.org/10.13004/kjnt.2023.19.e16

underestimate severity.[5] Several proposals have been published to modify TRISS to address these issues.[4,5]

Although the proportion of patients transferred from other hospitals increased after the establishment of the RTC in our hospital, the PTDR decreased. In studies using data from the National Emergency Department Information System of Korea, the PTDR was higher when patients were transferred from other hospitals than when they visited the last hospital directly.[8,12,17] When comparing patients who were transferred to other hospitals to those who arrived directly at the trauma centers, unexpected deaths were more common and length of stay in the intensive care unit was longer.[1] Since improving care quality at the hospital level is important for patient prognosis,[6] selecting an initial hospital that can provide sufficient treatment to patients with severe trauma may further improve treatment outcomes.

Limitations

This study has some limitations. First, in this retrospective study, it may not have been clear whether the cause of death was trauma-related because the autopsy findings were unknown. Second, there is a possibility of selection bias because patients who experienced cardiac arrest before transfer to the hospital and those whose RTS could not be measured were excluded from the study. Because the PTDR in this study, calculated using TRISS, was higher than that in previous studies, it is necessary to calculate the PTDR using other methods, such as ICISS or an expert panel study. Further studies are needed to determine the improvements that have been made after the establishment of trauma centers and the factors related to the reduction in mortality.

CONCLUSION

Although this was a single-center retrospective study, the establishment of RTC had an impact on reducing PTDR. Further studies on factors associated with PTDR reduction are required.

REFERENCES

1. Brain Trauma Foundation, American Association of Neurological Surgeons, Congress of Neurological Surgeons, Joint Section on Neurotrauma and Critical Care, AANS/CNS, Bratton SL, Chestnut RM, et al. Guidelines for the management of severe traumatic brain injury. VIII. Intracranial pressure thresholds. **J Neurotrauma** 24 Suppl 1:S55-S58, 2007
PUBMED | CROSSREF
2. Champion HR, Copes WS, Sacco WJ, Lawnick MM, Keast SL, Bain LW Jr, et al. The Major Trauma Outcome Study: establishing national norms for trauma care. **J Trauma** 30:1356-1365, 1990
PUBMED | CROSSREF
3. Chiara O, Cimbanassi S, Pitidis A, Vesconi S. Preventable trauma deaths: from panel review to population based-studies. **World J Emerg Surg** 1:12, 2006
PUBMED | CROSSREF
4. Domingues CA, de Sousa RM, Nogueira LS, Poggetti RS, Fontes B, Muñoz D. The role of the new trauma and injury severity score (NTRISS) for survival prediction. **Rev Esc Enferm USP** 45:1353-1358, 2011
PUBMED | CROSSREF
5. Domingues CA, Coimbra R, Poggetti RS, Nogueira LS, de Sousa RM. New trauma and injury severity score (TRISS) adjustments for survival prediction. **World J Emerg Surg** 13:12, 2018
PUBMED | CROSSREF

https://doi.org/10.13004/kjnt.2023.19.e16

6. Huh Y, Kwon J, Moon J, Kang BH, Kim S, Yoo J, et al. An evaluation of the effect of performance improvement and patient safety program implemented in a new regional trauma center of Korea. **J Korean Med Sci** 36:e149, 2021
PUBMED | CROSSREF
7. Jeong TS, Choi DH, Kim WK. Comparison of outcomes at trauma centers versus non-trauma centers for severe traumatic brain injury. **J Korean Neurosurg Soc** 66:63-71, 2023
PUBMED | CROSSREF
8. Jung K, Kim I, Park SK, Cho H, Park CY, Yun JH, et al. Preventable trauma death rate after establishing a national trauma system in korea. **J Korean Med Sci** 34:e65, 2019
PUBMED | CROSSREF
9. Jung KY, Kim JS, Kim Y. Problems in trauma care and preventable deaths. **J Korean Soc Emerg Med** 12:45-56, 2001
10. Kim H, Jung KY, Kim SP, Kim SH, Noh H, Jang HY, et al. Changes in preventable death rates and traumatic care systems in Korea. **J Korean Soc Emerg Med** 23:189-197, 2012
11. Kim Y, Jung KY, Cho KH, Kim H, Ahn HC, Oh SH, et al. Preventable trauma deaths rates and management errors in emergency medical system in korea. **J Korean Soc Emerg Med** 17:385-394, 2006
12. Kwon J, Lee M, Moon J, Huh Y, Song S, Kim S, et al. National follow-up survey of preventable trauma death rate in Korea. **J Korean Med Sci** 37:e349, 2022
PUBMED | CROSSREF
13. MacKenzie EJ. Review of evidence regarding trauma system effectiveness resulting from panel studies. **J Trauma** 47:S34-S41, 1999
PUBMED | CROSSREF
14. Moore L, Lavoie A, Turgeon AF, Abdous B, Le Sage N, Emond M, et al. Improving trauma mortality prediction modeling for blunt trauma. **J Trauma** 68:698-705, 2010
PUBMED | CROSSREF
15. Offner PJ, Jurkovich GJ, Gurney J, Rivara FP. Revision of TRISS for intubated patients. **J Trauma** 32:32-35, 1992
PUBMED | CROSSREF
16. Park CY, Yu B, Kim HH, Hwang JJ, Lee J, Cho HM, et al. Park index for preventable major trauma death rate. **J Trauma Inj** 28:115-122, 2015
CROSSREF
17. Sampalis JS, Denis R, Fréchette P, Brown R, Fleiszer D, Mulder D. Direct transport to tertiary trauma centers versus transfer from lower level facilities: impact on mortality and morbidity among patients with major trauma. **J Trauma** 43:288-295, 1997
PUBMED | CROSSREF
18. Seo EW, Im J. A review of quality management and improvement of trauma fee schedule in regional trauma center. **Health Policy Manag** 31:399-408, 2021
CROSSREF