ORIGINAL ARTICLE

Impact of the establishment of a trauma center on blunt traumatic spleen injury treatment: Comparison between pre-traumatic center and trauma center periods

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ABSTRACT

BACKGROUND: The spleen is a commonly injured intra-abdominal organ from blunt trauma. In cases of traumatic blunt spleen injury, immediate treatment is often required. This study aimed to investigate the prognostic impact of the establishment of a trauma center on the treatment of patients with blunt trauma injury to the spleen.

METHODS: We retrospectively reviewed 235 patients who visited our center from 2012 to 2019 for blunt trauma injury to the spleen. The study period was divided into two groups: January 2012 to September 2015 was the pre-center period (PCP), and September 2015 to December 2019 was the trauma center period (TCP). In each period, there were three treatment groups: Surgical group, embolization group, and conservative treatment group. The primary outcome was mortality, and the secondary outcomes were patient characteristics, such as injury severity score and abbreviated injury scale score, time from admission to intervention (both surgery and angiography embolization), and rate of spleen-preserving surgery.

RESULTS: In the conservative treatment group, the Hb and hct values were relatively low in the TCP than in the PCP (p=0.007, p=0.008, respectively). The intensive care unit admission rate was relatively high in the TCP (72.9% vs. 90.6%, p=0.031). The ISS was relatively low in the TCP (18 vs. 17, p=0.001). In the surgical group, the time taken to transfer patients to the operating room after admission was greatly reduced in the TCP (151 min vs. 107 min, p=0.028). In the embolization group, the patient's age and SBP were lower in the PCP than in the TCP (p=0.003, p=0.049, respectively); three patients had undergone embolization with CPR in the PCP, and no patient underwent CPR in the TCP. There were three deaths in PCP and none in the TCP (p=0.05).

CONCLUSION: The establishment of a trauma center has led to improvements in the treatment quality and prognosis of patients with blunt trauma injury to the spleen receiving either of the three treatments.

Keywords: Abdominal injuries; spleen; trauma centers.

INTRODUCTION

The spleen is one of the intra-abdominal organs commonly injured following blunt trauma. When injury occurs, bleeding of the spleen can be fatal. In these situations, immediate treatment is often required. Non-surgical and surgical treatments are available, and there are many opinions on the importance of trauma centers for these treatments.[1,2]

In South Korea, the Ministry of Health and Welfare has initiated procedures to establish a nationwide trauma center and deploy an appropriate number of regional trauma centers,[3] given the absence of such regional institutions and trauma treatment hospitals and specialists. In light of this, and with government support, our institution was nominated to function as a regional trauma center. We received financial support for center establishment and recruited medical spe-

Cite this article as: Jang H, Jo YG, Park Y, Jeong E, Lee N, Kim JC. Impact of the establishment of a trauma center on blunt traumatic spleen injury treatment: Comparison between pre-traumatic center and trauma center periods. Ulus Travma Acil Cerrahi Derg 2022;28:1570-1582.

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Ulus Travma Acil Cerrahi Derg 2022;28(11):1570-1582 DOI: 10.14744/tjtes.2021.03262 Submitted: 09.08.2021 Revised: 12.08.2021 Accepted: 25.09.2021

cialists and purchased the necessary physical medical equipment for trauma treatment. Our regional trauma center was officially launched in September 2015.

At present, our hospital has 1800 beds and is located in an area with a population of about 3 million. From 2013 to 2019, an average of 44,280 patients visited the emergency room annually, and the average annual number of severe trauma patients (injury severity score [ISS] >15) was more than 500 (1.1%). Since 2018, more than 600 severe trauma patients have been visiting the hospital every year, and the number is increasing.[4]

Before the trauma center was established, trauma care was performed and treatment was administered by various general surgery teams; also, the treatment decisions were made by the doctors on duty and not specialists. Once the trauma center was established, a trauma team comprising several specialists, including specialists in trauma surgery, orthopedic surgery, neurosurgery, and emergency medicine, was set up. The trauma bay was equipped with emergency and trauma intensive care units (ICUs) and trauma nurses and specialized systems. Therefore, we divided the study period into the trauma center period (TCP) and pre-center period (PCP). We analyzed the data on blunt traumatic spleen injury in both periods to evaluate the extent of clinical improvement with the early treatment of acute traumatic spleen injury after our trauma center was established. In this study, three types of treatments were provided for blunt traumatic spleen injury: Surgical treatment, conservative treatment, and embolization. Our analysis focused on changes in the treatment and patient variables in both periods and whether adequate treatment was provided to patients in both periods.

MATERIALS AND METHODS

Study Design and Clinical Data Collection

We analyzed patients with blunt trauma spleen injury who visited our center from 2012 to 2019 through a retrospective medical chart review. Since the regional trauma center was established in September 2015, the period from January 2012 to September 2015 was classified as the PCP, and the period from September 2015 to December 2019 was the TCP. The patients were divided into three treatment groups: Surgical group, embolization group, and conservative treatment group. Abdominal and splenic injuries were graded by the trauma team using the Organ Injury Scale of the American Association for the Surgery of Trauma.[5] The surgical group underwent splenectomy, splenorrhaphy, combined surgery for other organs, or damage control surgery. The embolization group underwent embolization using interventional radiology. Patients who underwent only angiography and not embolization were included in conservative treatment group. As this study aimed to evaluate the difference in early treatment of acute traumatic spleen injury in a trauma center setting, the patients who had delayed pseudoaneurysms and those treated later by angioembolization or surgery were excluded from the study.

The following clinical data were collected retrospectively: Age; sex; time from injury to admission; laboratory findings (including hemoglobin,[6] hematocrit [hct], and initial vital

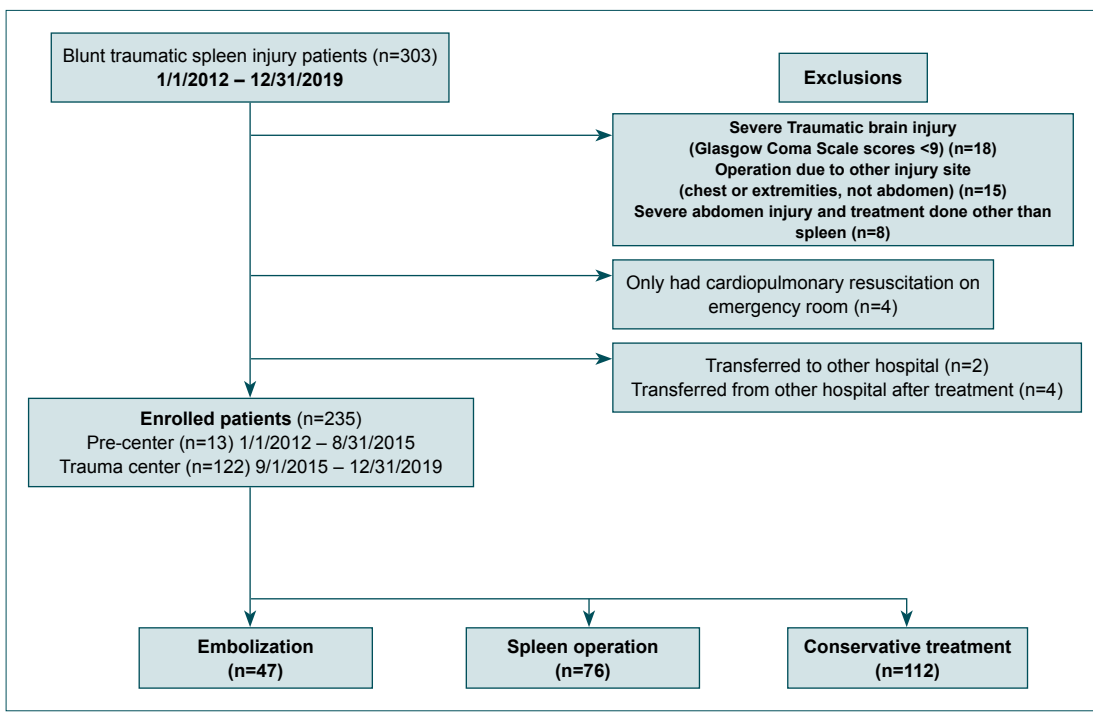

Figure 1. Study inclusion flowchart.

signs); glasgow coma scale (GCS) score; ISS; abbreviated injury scale (AIS) score; use of inotropes (norepinephrine, dopamine, vasopressin); ratio of PRC:FFP:PC transfusion in 24 h; hospital stay; time from injury to angiography/surgery; morbidity; and mortality.

This study was approved by the the Chonnam National University Hospital Institutional Review Board (CNUH-2020-363) and informed consent was waived due to its retrospective nature.

Patient Selection

In all, 20,863 patients were admitted during the study period, and 303 patients presented with spleen injury. Of the 303, the following were excluded: 18 patients with severe traumatic brain injury (GCS scores <9) because the treatment of this injury site could lead to biased outcomes, 15 patients who had endured injuries to other major sites (chest or extremities, not abdomen), 4 patients who were transferred after being treated in other hospitals, 14 patients who showed pseudoaneurysms on follow-up computed tomography during conservative treatment and underwent delayed angioembolization, 1 patient who underwent delayed surgical treatment during conservative treatment, 2 patients who experienced bleeding after surgical treatment and angioembolization (before and after each center), 2 patients who had insufficient medical data (transferred to another hospital during treatment), 8 patients who underwent surgery or intervention for other abdominal injuries, and 4 patients who received CPR. Hence, 235 patients were finally included for the analysis (Fig. 1).

Outcomes

Our primary hypothesis was that the mortality rate of the treated patients had improved from the PCP to the TCP. To evaluate the effect of the trauma center on treatment selection, that is, conservative treatment, embolization, or surgery, as a secondary outcome, patient characteristics, such as AIS and ISS, time from admission to intervention (surgery and angioembolization), and rate of spleen-preserving surgery, in the PCP and TCP were compared. The study was approved by the institutional review board of our institution.

Statistical Analysis

R software, version 4.0.2 (R Foundation for statistical computing, Vienna, Austria) and Stata/SE 16.1 (StataCorp, College Station, Texas, USA) were used for statistical analysis. Fisher's exact test was used to compare categorical data. For comparison of the mean values between two groups, the t-test and Wilcoxon rank-sum (Mann–Whitney U) test were performed. Kruskal–Wallis rank test was used to compare the mean values of the three groups, and Dunn's test with Bonferroni method was used for post-test evaluation. Crossover analysis was carried out with Pearson's Chi-squared test. Fisher's exact test was performed by dividing the analysis method through a normality test. For cross-analysis, if the expected frequency was <5, a nonparametric test was conducted. A $p<0.05$ was considered statistically significant.

RESULTS

Of the 235 patients, 122 were treated in the TCP and 113 were treated in the PCP (Table 1). The Hb and hct levels had decreased slightly, the initial SBP of the patients was rather high, and the IS score was low in the TCP when compared with those in the PCP. There were no significant differences in the rates of intervention methods used or damage control surgery between the periods. Hospital stay was longer in the TCP than in the PCP, and the rate of ICU admission increased significantly in the TCP. There were no significant differences in morbidity and mortality (Table 1). In the PCP and TCP periods, the difference in Hb, hct, BE, use of inotropes, CPR, SBP, type and number of transfusions, abdominal AIS, spleen AIS, and mortality between the three treatment groups was statistically significant.

The difference in the characteristics of patients in each treatment group was also clear; it can be seen that the difference in age was statistically significant. The mean age of the embolization group and conservative treatment group was lower than that of the surgical group. The morbidity was significantly different between the three groups. The PCP, RTS, ISS, length of hospital stay, and ICU status and duration were statistically significantly different between the three treatment groups only in the TCP (Table 2). For the conservative treatment group, the mean time from injury to admission was 119 min in the PCP and 180 min in the TCP but, the difference was not statistically significant.

The mean Hb and hct values were 13.2 and 12.0 in the PCP and 38.7 and 35.4 in the TCP, respectively, showing statistically significant differences. In addition, the ISS was relatively low in the TCP, at a significant level. In the conservative treatment group, all except five patients were admitted to the ICU in the TCP (Table 3). In the surgical group, there was no significant difference between the two period groups in terms of most of the variables.

However, in the surgery group, the ratio of PRC:FFP:PC transfusion within 24 h was 8.5:3.0:0 in the PCP and 7.5:4.0:4.5 in the TCP, showing that the transfusion rate had improved. In addition, the number of patients undergoing spleen-sparing surgery increased from 1 (2.8%) to 4 (10%). However, these values did not show any statistically significant difference.

The mean time taken to transfer patients to the operating room after admission was 151 min in the PCP and 107 min in the TCP, showing a statistically significant difference ($p=0.028$). The patients who underwent spleen-related operations were admitted to the ICU after surgery, showing a statistically significant difference (Table 4).

Table 1. Baseline characteristics and injury severity in the pre-center and trauma center periods

Center	Pre-center (n=113)	Trauma center (n=122)	p
Age	40.0 [21.0;56.1]	49.0 [23.0;62.1]	0.062
Sex, n (%)			0.508
Female	21 (18.6)	28 (23.0)	
Male	92 (81.4)	94 (77.0)	
Injury to admission time(min)	119.0 [60.0;240.0]	180.0 [119.0;299.0]	0.001
Revised trauma score	7.8 [6.9;7.8]	7.8 [7.1;7.8]	0.086
Hemoglobin	12.2 [10.1;13.6]	11.4 [9.4;12.9]	0.016
Hematocrit	36.2 [29.6;39.8]	33.6 [28.5;37.5]	0.018
Base excess	-3.8 [-6.8;-1.0]	-3.1 [-6.4;-0.4]	0.249
Inotropes, n (%)			0.172
No	93 (82.3)	109 (89.3)	
Yes	20 (17.7)	13 (10.7)	
Cardiopulmonary resuscitation, n (%)			0.638
No	108 (95.6)	119 (97.5)	
Yes	5 (4.4)	3 (2.5)	
Systolic blood pressure	100.0 [80.0;110.0]	110.0 [90.0;120.0]	0.046
Transfusion, n (%)			0.756
No	43 (38.1)	43 (35.2)	
Yes	70 (61.9)	79 (64.8)	
Abdomen AIS, n (%)			0.472
2	27 (23.9)	32 (26.2)	
3	45 (39.8)	54 (44.3)	
4	34 (30.1)	33 (27.0)	
5	7 (6.2)	3 (2.5)	
Spleen abbreviated injury scale, n (%)			0.341
2	41 (36.3)	48 (39.3)	
3	37 (32.7)	46 (37.7)	
4	29 (25.7)	26 (21.3)	
5	6 (5.3)	2 (1.6)	
Injury severity score, median	22.0 [17.0;27.0]	18.0 [13.0;22.0]	0.011
Intervention, n (%)			0.251
Embolization	18 (15.9)	29 (23.8)	
Spleen operation	36 (31.9)	40 (32.8)	
Conservative	59 (52.2)	53 (43.4)	
Damage control surgery, n (%)			0.322
No	106 (93.8)	109 (89.3)	
Yes	7 (6.2)	13 (10.7)	
Hospital stay (days)	17.0 [10.0;28.0]	21.0 [14.0;34.0]	0.017
Intensive care unit admission, n (%)			<0.001
No	24 (21.2)	5 (4.1)	
Yes	89 (78.8)	117 (95.9)	
Intensive care unit stay (days)	3.0 [2.0;5.0]	3.0 [2.0;5.0]	0.101
Morbidity, n (%)			0.469
No	88 (77.9)	89 (73.0)	
Yes	25 (22.1)	33 (27.0)	
Mortality, n (%)			1.000
No	106 (93.8)	115 (94.3)	
Yes	7 (6.2)	7 (5.7)	

Categorical variables are expressed as numbers (%), and continuous variables are presented as medians (first and third quartiles).

Table 2. Comparison of interventions (embolization, spleen operation, conservative treatment) between pre-center and trauma center periods

Center	Pre-center				Trauma center			
Intervention	**Embolization (n=18)**	**Operation (n=36)**	**Conservative (n=59)**	**p**	**Embolization (n=29)**	**Operation (n=40)**	**Conservative (n=53)**	**p**
Age	26.1 [17.0;44.0]	46.6 [30.5;64.6]	32.1 [21.5;54.1]	0.023	51.1 [40.0;62.1]	48.5 [30.1;67.0]	47.0 [14.1;58.0]	0.108
Sex, n (%)				0.870				0.877
Female	4 (22.2)	7 (19.4)	10 (16.9)		7 (24.1)	10 (25.0)	11 (20.8)	
Male	14 (77.8)	29 (80.6)	49 (83.1)		22 (75.9)	30 (75.0)	42 (79.2)	
Injury to admission time (min)	119.0 [60.0;240.0]	119.0 [60.0;180.0]	119.0 [60.0;240.0]	0.703	240.0 [175.0;411.0]	133.0 [119.0;256.5]	180.0 [119.0;299.0]	0.139
RTS	7.8 [6.9; 7.8]	7.1 [6.4; 7.8]	7.8 [7.5; 7.8]	0.144	7.8 [7.8; 7.8]	7.8 [6.4; 7.8]	7.8 [7.8; 7.8]	0.021
Hemoglobin	11.4 [9.5;13.0]	10.8 [8.5;12.6]	13.2 [11.1;14.2]	0.001	11.1 [9.3;12.9]	9.9 [8.6;11.8]	12.0 [11.0;13.1]	0.003
Hematocrit	33.2 [27.7;36.8]	32.3 [25.5;36.8]	38.7 [32.8;41.1]	<0.001	33.3 [27.6;37.6]	30.5 [25.4;34.5]	35.4 [32.3;38.1]	0.002
Base excess	-4.0 [-6.7; 0.2]	-6.2 [-9.4;-2.1]	-3.5 [-4.9;-0.6]	0.018	-2.8 [-4.8; 0.3]	-6.6 [-10.1;-3.3]	-1.5 [-4.0; 0.8]	<0.001
Inotropes, n (%)				0.041				0.002
No	15 (83.3)	25 (69.4)	53 (89.8)		28 (96.6)	30 (75.0)	51 (96.2)	
Yes	3 (16.7)	11 (30.6)	6 (10.2)		1 (3.4)	10 (25.0)	2 (3.8)	
CPR, n (%)				0.010				0.043
No	15 (83.3)	34 (94.4)	59 (100.0)		29 (100.0)	37 (92.5)	53 (100.0)	
Yes	3 (16.7)	2 (5.6)	0 (0.0)		0 (0.0)	3 (7.5)	0 (0.0)	
sBP	98.3±23.1	84.7±22.2	106.8±21.9	0.009	110.0 [100.0;120.0]	97.5 [65.0;110.0]	110.0 [100.0;120.0]	0.002
Transfusion, n (%)				<0.001				<0.001
No	6 (33.3)	2 (5.6)	35 (59.3)		9 (31.0)	0 (0.0)	34 (64.2)	
Yes	12 (66.7)	34 (94.4)	24 (40.7)		20 (69.0)	40 (100.0)	19 (35.8)	
Tr24 PRC	2.0 [0.0;4.0]	8.5 [4.0;13.0]	0.0 [0.0;2.0]	<0.001	1.0 [0.0;2.0]	7.5 [2.5;13.5]	0.0 [0.0;1.0]	<0.001
Tr24 FFP	0.0 [0.0; 2.0]	3.0 [1.0;10.0]	0.0 [0.0;0.5]	<0.001	1.0 [0.0;2.0]	4.0 [1.5;11.0]	0.0 [0.0;0.0]	<0.001
Tr24 PC	0.0 [0.0; 0.0]	0.0 [0.0;10.0]	0.0 [0.0;0.0]	<0.001	0.0 [0.0;0.0]	4.5 [0.0;10.0]	0.0 [0.0;0.0]	<0.001
Abdomen AIS, n (%)				<0.001				<0.001
2	1 (5.6)	1 (2.8)	25 (42.4)		2 (6.9)	5 (12.5)	25 (47.2)	
3	6 (33.3)	12 (33.3)	27 (45.8)		17 (58.6)	15 (37.5)	22 (41.5)	
4	9 (50.0)	18 (50.0)	7 (11.9)		10 (34.5)	18 (45.0)	5 (9.4)	
5	2 (11.1)	5 (13.9)	0 (0.0)		0 (0.0)	2 (5.0)	1 (1.9)	

Table 2. Comparison of interventions (embolization, spleen operation, conservative treatment) between pre-center and trauma center periods *(continue)*

Center	Pre-center				Trauma center			
Intervention	**Embolization (n=18)**	**Operation (n=36)**	**Conservative (n=59)**	**p**	**Embolization (n=29)**	**Operation (n=40)**	**Conservativ (n=53)**	**p**
Spleen AIS, n (%)				<0.001				<0.001
2	1 (5.6)	5 (13.9)	35 (59.3)		2 (6.9)	12 (30.0)	34 (64.2)	
3	9 (50.0)	10 (27.8)	18 (30.5)		17 (58.6)	13 (32.5)	16 (30.2)	
4	7 (38.9)	16 (44.4)	6 (10.2)		10 (34.5)	13 (32.5)	3 (5.7)	
5	1 (5.6)	5 (13.9)	0 (0.0)		0 (0.0)	2 (5.0)	0 (0.0)	
ISS, median	20.0 [16.0;27.0]	25.0 [16.5;29.0]	18.0 [17.0;27.0]	0.235	18.0 [17.0;22.0]	22.0 [18.0;30.5]	17.0 [9.0;22.0]	<0.001
Hospital stay (days)	12.0 [11.0;21.0]	23.5 [12.0;37.5]	16.0 [9.0;24.5]	0.077	23.0 [21.0;32.0]	24.5 [13.0;46.0]	17.0 [13.0;25.0]	0.035
ICU admission, n (%)				0.250				0.034
No	2 (11.1)	6 (16.7)	16 (27.1)		0 (0.0)	0 (0.0)	5 (9.4)	
Yes	16 (88.9)	30 (83.3)	43 (72.9)		29 (100.0)	40 (100.0)	48 (90.6)	
ICU stay (days)	3.0 [2.0;4.0]	3.5 [2.0;12.0]	3.0 [0.0;5.0]	0.166	3.0 [3.0;5.0]	4.5 [3.0;7.5]	3.0 [2.0; 4.0]	0.002
Morbidity, n (%)				0.002				0.080
No	14 (77.8)	21 (58.3)	53 (89.8)		23 (79.3)	24 (60.0)	42 (79.2)	
Yes	4 (22.2)	15 (41.7)	6 (10.2)		6 (20.7)	16 (40.0)	11 (20.8)	
Mortality, n (%)				0.012				<0.001
No	15 (83.3)	32 (88.9)	59 (100.0)		29 (100.0)	33 (82.5)	53 (100.0)	
Yes	3 (16.7)	4 (11.1)	0 (0.0)		0 (0.0)	7 (17.5)	0 (0.0)	

RTS: Revised trauma score; CPR: Cardiopulmonary resuscitation; sBP: Systolic blood pressure; Tr24: Transfusion in 24hours; PRC: Packed red cells; FFP: Fresh frozen plasma; PC: Platelet concentrates, AIS: Abbreviated injury scale; ISS: Injury severity score; ICU: Intensive care unit. Categorical variables are expressed as numbers (%), and continuous variables are presented as medians (first and third quartiles)

Table 3. Comparison of conservative treatment in the pre-center and trauma center periods

Center	Pre-center (n=59)	Trauma center (n=53)	p
Age	32.1 [21.5;54.1]	47.0 [14.1;58.0]	0.907
Sex, n (%)		0.785	
Female	10 (16.9)	11 (20.8)	
Male	49 (83.1)	42 (79.2)	
Injury to admission time (min)	119.0 [60.0;240.0]	180.0 [119.0;299.0]	0.065
RTS	7.8 [7.5;7.8]	7.8 [7.8;7.8]	0.472
Hemoglobin	13.2 [11.1;14.2]	12.0 [11.0;13.1]	0.007
Hematocrit	38.7 [32.8;41.1]	35.4 [32.3;38.1]	0.008
Base excess	-3.5 [-4.9;-0.6]	-1.5 [-4.0;0.8]	0.065
Inotropes, n (%)		0.345	
No	53 (89.8)	51 (96.2)	
Yes	6 (10.2)	2 (3.8)	
CPR, n (%)			
No	59 (100.0)	53 (100.0)	
sBP	110.0 [100.0;120.0]	110.0 [100.0;120.0]	0.305
Transfusion, n (%)		0.741	
No	35 (59.3)	34 (64.2)	
Yes	24 (40.7)	19 (35.8)	
Tr24 PRC	0.0 [0.0; 2.0]	0.0 [0.0;1.0]	0.552
Abdomen AIS, n (%)		0.676	
2	25 (42.4)	25 (47.2)	
3	27 (45.8)	22 (41.5)	
4	7 (11.9)	5 (9.4)	
5	0 (0.0)	1 (1.9)	
Spleen AIS, n (%)		0.666	
2	35 (59.3)	34 (64.2)	
3	18 (30.5)	16 (30.2)	
4	6 (10.2)	3 (5.7)	
ISS, median	18.0 [17.0;27.0]	17.0 [9.0;22.0]	0.001
Hospital stay (days)	16.0 [9.0;24.5]	17.0 [13.0;25.0]	0.195
ICU admission, n (%)		0.031	
No	16 (27.1)	5 (9.4)	
Yes	43 (72.9)	48 (90.6)	
ICU stay (days)	3.0 [0.0;5.0]	3.0 [2.0;4.0]	0.762
Morbidity, n (%)		0.195	
No	53 (89.8)	42 (79.2)	
Yes	6 (10.2)	11 (20.8)	
Mortality, n (%)			
No	59 (100.0)	53 (100.0)	

RTS: Revised trauma score; CPR: Cardiopulmonary resuscitation; sBP: Systolic blood pressure; Tr24: Transfusion in 24hours; PRC: Packed red cells; FFP: Fresh frozen plasma; PC: Platelet concentrates, AIS: Abbreviated injury scale; ISS: Injury severity score; ICU: Intensive care unit. Categorical variables are expressed as numbers (%), and continuous variables are presented as medians (first and third quartiles).

There was a major difference in mean age between the PCP (26 years) and the TCP (51 years) embolization groups. There was also a difference in the RTS between the two groups. The SBP was rather low in PCP, where three patients had undergone embolization with CPR; however, no patient had undergone CPR in the TCP.

Table 4. Comparison of the groups that underwent spleen operation in the pre-center and trauma center periods

Center	Pre-center (n=36)	Trauma center (n=40)	p
Age	46.6 [30.5;64.6]	48.5 [30.1;67.0]	0.599
Sex, n (%)		0.761	
Female	7 (19.4)	10 (25.0)	
Male	29 (80.6)	30 (75.0)	
Injury to admission time(min)	119.0 [60.0;180.0]	133.0 [119.0;256.5]	0.117
RTS	7.1 [6.4; 7.8]	7.8 [6.4;7.8]	0.690
Hemoglobin	10.8 [8.5;12.6]	9.9 [8.6;11.8]	0.444
Hematocrit	32.3 [25.5;36.8]	30.5 [25.4;34.5]	0.438
Base excess	-6.2 [-9.4;-2.1]	-6.6 [-10.1;-3.3]	0.662
Inotropes, n (%)		0.776	
No	25 (69.4)	30 (75.0)	
Yes	11 (30.6)	10 (25.0)	
CPR, n (%)		1.000	
No	34 (94.4)	37 (92.5)	
Yes	2 (5.6)	3 (7.5)	
sBP	80.0 [70.0;100.0]	97.5 [65.0;110.0]	0.332
Transfusion, n (%)		0.428	
No	2 (5.6)	0 (0.0)	
Yes	34 (94.4)	40 (100.0)	
Tr24 PRC	8.5 [4.0;13.0]	7.5 [2.5;13.5]	0.581
Tr24 FFP	3.0 [1.0;10.0]	4.0 [1.5;11.0]	0.608
Tr24 PC	0.0 [0.0;10.0]	4.5 [0.0;10.0]	0.371
Abdomen AIS, n (%)		0.252	
2	1 (2.8)	5 (12.5)	
3	12 (33.3)	15 (37.5)	
4	18 (50.0)	18 (45.0)	
5	5 (13.9)	2 (5.0)	
Spleen AIS, n (%)		0.197	
2	5 (13.9)	12 (30.0)	
3	10 (27.8)	13 (32.5)	
4	16 (44.4)	13 (32.5)	
5	5 (13.9)	2 (5.0)	
ISS, median	25.0 [16.5;29.0]	22.0 [18.0;30.5]	0.786
Admission to operation time (min)	151.0 [93.0;187.0]	107.0 [77.0;145.5]	0.028
Spleen sparing, n (%)		0.421	
Preserving*	1 (2.8)	4 (10.0)	
Splenectomy	35 (97.2)	36 (90.0)	
Damage control surgery, n (%)		0.303	
No	29 (80.6)	27 (67.5)	
Yes	7 (19.4)	13 (32.5)	
Hospital stay (days)	23.5 [12.0;37.5]	24.5 [13.0;46.0]	0.492
ICU admission, n (%)		0.024	
No	6 (16.7)	0 (0.0)	
Yes	30 (83.3)	40 (100.0)	
ICU stay (days)	3.5 [2.0;12.0]	4.5 [3.0; 7.5]	0.507
Morbidity, n (%)		1.000	
No	21 (58.3)	24 (60.0)	
Yes	15 (41.7)	16 (40.0)	
Mortality, n (%)		0.643	
No	32 (88.9)	33 (82.5)	
Yes	4 (11.1)	7 (17.5)	

RTS: Revised trauma score; CPR: Cardiopulmonary resuscitation; sBP: Systolic blood pressure; Tr24: Transfusion in 24hours; PRC: Packed red cells; FFP: Fresh frozen plasma; PC: Platelet concentrates, AIS: Abbreviated injury scale; ISS: Injury severity score; ICU: Intensive care unit. Categorical variables are expressed as numbers (%), and continuous variables are presented as medians (first and third quartiles).

Table 5. Comparison of the groups that underwent embolization in the pre-center and trauma center periods

Center	Pre-center (n=18)	Trauma center (n=29)	p
Age	26.1 [17.0;44.0]	51.1 [40.0;62.1]	0.003
Sex, n (%)			1.000
Female	4 (22.2)	7 (24.1)	
Male	14 (77.8)	22 (75.9)	
Injury to admission time(min)	119.0 [60.0;240.0]	240.0 [175.0;411.0]	0.063
RTS	7.8 [6.9;7.8]	7.8 [7.8;7.8]	0.015
Hemoglobin	11.4 [9.5;13.0]	11.1 [9.3;12.9]	0.939
Hematocrit	33.2 [27.7;36.8]	33.3 [27.6;37.6]	0.896
Base excess	-4.0 [-6.7;-0.2]	-2.8 [-4.8;0.3]	0.260
Inotropes, n (%)			0.150
No	15 (83.3)	28 (96.6)	
Yes	3 (16.7)	1 (3.4)	
CPR, n (%)			0.050
No	15 (83.3)	29 (100.0)	
Yes	3 (16.7)	0 (0.0)	
sBP	100.0 [80.0;110.0]	110.0 [100.0;120.0]	0.049
Transfusion, n (%)			1.000
No	6 (33.3)	9 (31.0)	
Yes	12 (66.7)	20 (69.0)	
Tr24 PRC	2.0 [0.0;4.0]	1.0 [0.0;2.0]	0.261
Abdomen AIS, n (%)			0.138
2	1 (5.6)	2 (6.9)	
3	6 (33.3)	17 (58.6)	
4	9 (50.0)	10 (34.5)	
5	2 (11.1)	0 (0.0)	
Spleen AIS, n (%)			0.733
2	1 (5.6)	2 (6.9)	
3	9 (50.0)	17 (58.6)	
4	7 (38.9)	10 (34.5)	
5	1 (5.6)	0 (0.0)	
ISS, median	20.0 [16.0;27.0]	18.0 [17.0;22.0]	0.397
Admission to angioembolization time (min)	166.5 [108.0;213.0]	172.0 [103.0;229.0]	0.948
Hospital stay (days)	12.0 [11.0;21.0]	23.0 [21.0;32.0]	0.004
ICU admission, n (%)			0.142
No	2 (11.1)	0 (0.0)	
Yes	16 (88.9)	29 (100.0)	
ICU stay (days)	3.0 [2.0;4.0]	3.0 [3.0;5.0]	0.047
Morbidity, n (%)			1.000
No	14 (77.8)	23 (79.3)	
Yes	4 (22.2)	6 (20.7)	
Mortality, n (%)			0.050
No	15 (83.3)	29 (100.0)	
Yes	3 (16.7)	0 (0.0)	

RTS: Revised trauma score; CPR: Cardiopulmonary resuscitation; sBP: Systolic blood pressure; Tr24: Transfusion in 24hours; PRC: Packed red cells; FFP: Fresh frozen plasma; PC: Platelet concentrates, AIS: Abbreviated injury scale; ISS: Injury severity score; ICU: Intensive care unit. Categorical variables are expressed as numbers (%), and continuous variables are presented as medians (first and third quartiles).

Table 6. Details of cases in the embolization group (pre-center period) in which the outcome was mortality

Sex/age	Injury to admission time (min)	RTS	hgb	hgb2	hct	BE	Inotro-pes	sBP	Transfusion (PRC/FFP/PC)	Abdomen AIS	Spleen AIS	ISS	Admission to angioembolization time (min)	Hospital stay (days)	ICU admission
*M/8	119	6.9	8.2	10.6	22.7	-7.4	Yes	110	4/0/0	5	4	29	108	1	No
**M/80	119	7.11	5	3.7	14.5	-4.5	Yes	80	3/4/0	3	3	22	92	2	Yes
**F/18	9	4.5	12.8	5.4	36.8	-8.4	No	70	10/0/0	4	3	50	209	1	Yes

*CPR started after 3 hours of admission, **CPR started after angioembolization. CPR: Cardiopulmonary resuscitation; RTS: Revised trauma score: hgb: Hemoglobin; hgb2: Follow up hemoglobin; hct: Hematocrit; BE: Base excess; sBP: Systolic blood pressure, transfusion packs; PRC: Packed red cells; FFP: Fresh frozen plasma; PC: Platelet concentrates; AIS: Abbreviated injury scale; ISS: Injury severity score; ICU: Intensive care unit.

Regarding mortality, three deaths occurred in the PCP and none in the TCP, indicating a statistically significant difference (Table 5). In the embolization group, all three deaths occurred in the PCP, and the characteristics of each are described in Table 6. Two of them died after undergoing CPR after angioembolization treatment, and the required ratio of PRC:FFP:PC transfusion was not reached. In the case of one patient, treatment was performed at the ward without ICU admission after the treatment, and in the case of the other patient, the initial Hb level was very low, but angioembolization was achieved. Regarding the third patient, the initial Hb level was within the normal range (12.8), but the follow-up Hb (Hb2) after 1 h was 5.4, and inotropes were not used properly; thus, the time until embolization was relatively long.

DISCUSSION

The establishment of the trauma center was a project led by the Korean government starting in 2012, and such centers have been established under the support of the government on a large scale. The purpose of establishing the trauma center was to reduce the mortality rate of patients with severe traumatic injury, especially in South Korea, where the proportion of preventable deaths due to severe traumatic injury is particularly high.[3,7] Before the establishment of the trauma center, the mortality rate from severe trauma in South Korea exceeded 30%, which is nearly 3 times that in other developed countries.[7] The establishment of the trauma center included the setting up of a specialized ICU for trauma, hiring dedicated trauma medical staff, and equipping wards and operating rooms with equipment for diagnosis and treatment, all under the government's support.[3]

The establishment of these trauma centers can help reduce the trauma-related mortality of patients, and the benefits of the established trauma centers in South Korea are gradually being seen.

In recent study, an improvement in the mortality rate of severely injured patients after the establishment of the trauma center in South Korea was noted, and the mortality rate was found to be similar to that in the United States.[8] In studies related to the establishment of trauma centers, the improvements in the outcomes of severely injured patients according to the trauma centers or trauma systems have been examined.[9–12]

However, besides the general improvement in mortality, very few studies have examined whether treatment is appropriately performed for specific diseases and if clinical factors change with changes in trauma centers.[13] Therefore, we analyzed the difference in the treatment of traumatic blunt spleen injury before and after the establishment of a trauma center. In addition, we analyzed other differences as well. First of all, the overall time from injury to admission had increased from the PCP to the TCP because of an increase in patient acceptance through increased coverage of patients in a wide area after

the establishment of a regional trauma center and an increase in transfer requests from other hospitals.

Further, the duration of ICU stay had increased significantly because beds could be secured at trauma centers. It was not easy to distinguish between the overall patient groups in the TCP and PCP. On comparing the patient groups according to the treatment method, it was apparent that each showed distinct differences in specific factors. Table 2 outlines the significant differences between the groups in the TCP and PCP.

As can be seen from the results, there was a difference in the age distribution for the embolization and conservative treatment group, relative the surgery group, before the establishment of the center, indicating that angioembolization as a treatment option is more often chosen in children.[14] However, a total of eight people aged 20 years underwent embolization in the PCP, and two of them died; four patients aged under 20 years underwent embolization in the TCP. This result can be attributed to the positive views on embolization regardless of patient age in the TCP. In addition, in TCP, the differences in the ISS score and duration of ICU stay were clear among the three treatment groups (Tables 3–5).

There was a difference between the PCP and TCP in the selection of patients for conservative treatment; the Hb and hct levels were slightly lower in the TCP than in the PCP, and there was also a difference in spleen AIS and the ICU admission rate. In all, nine patients underwent conservative treatment without embolization after angiography: One in the PCP and eight in the TCP. The decision to provide simple conservative treatment in the TCP was not based only on lab findings such as Hb and hct and initial CT images but also active angiography. The importance of early diagnosis using angiography is shown in studies where extravasation at the time of admission was found to be highly associated with the possibility of treatment, such as delayed splenectomy.[15,16]

On comparing the surgical groups in the TCP and PCP, no significant difference was observed, but the time taken to transfer patients to the operation room after admission was reduced by 44 min from 151 min to 107 min, indicating a statistically significant difference. The significant reduction in the transfer time to the emergency room can be seen as a strongly positive effect of the trauma center. These results appear relatively short when compared to the 145 (min) between arrival at the ED and the first therapeutic procedure reported by other centers.[17] In the TCP, all patients were subjected to post-operation care through ICU admission. Although the difference was not statistically significant, the PRC:FFP:PC ratio within 24 h changed from 8.5:3.0:0 in the PCP to 7.5:4.0:4.5 in the TCP, closer to the 1:1:1 ratio according to the massive transfusion protocol. In the case of transfusion of three units or more within the first 24 h, the rate of transfusion may affect the patient's mortality.[6] Of note, the rate of spleen-sparing surgery was higher in the TCP than in the PCP.

There was a large difference in the average age of the patients in the two periods: 26 in the PCP and 51 in the TCP. The recent guidelines on splenic trauma state that children and adults should be treated differently and that for most pediatric patients, non-surgical treatment is preferred.[18] In addition to the patient's hemodynamic status and physiology, age seems to have been an important factor in the PCP. In the TCP, compared with the PCP, embolization treatment was selected more frequently to protect the spleen as much as possible, irrespective of the age of the patient. Splenic artery embolization treatments have also been advocated by recent studies. Embolization has become an important option for non-surgical management of bleeding, and the treatment failure rate in the non-surgical management group is also decreasing.[19] In addition, according to the recent WSES treatment guidelines, non-surgical treatment is recommended for patients with blunt trauma spleen injuries in a hemodynamically stable state without other internal injuries requiring surgery, regardless of injury grade.[18] In addition, according to a multicenter analysis by Banerjee et al.,[20] splenic artery embolization is presently performed more frequently in Level I trauma centers, resulting in more spleen salvages and fewer non-surgical management failures now than in the past.

In the PCP, three patients who underwent CPR were treated with angioembolization, but they died. The SBPs of patients who underwent embolization in the TCP appeared to be higher than those of patients in the PCP; thus, suitable treatment was administered taking into consideration the hemodynamic status in the TCP.

There are several studies on trauma center establishment and survival benefit and improvements in patient outcomes.[11] However, our study focused on not only the beneficial aspects of trauma center establishment but also appropriate treatment strategies for suitable patients. Thus, our study identified what aspects had improved since the establishment of the center and what aspects need to be improved. Further, our study can direct future studies on quality control of various trauma treatment strategies.

Limitations

This study has limitations as it is a retrospective study and there is a possibility of selection bias. Furthermore, the treatment of blunt trauma spleen injury cannot simply be determined by grade, and there are many points to consider when opting for either surgery or conservative treatment. Even in the case of low-grade splenic injuries, there are cases where surgical treatment is necessary depending on the patient's hemodynamic and physiologic status. In addition to the spleen injury grade, the structural anatomy of the patient's spleen as well as the combined injury grade, taking into account other parts that are affected, can also influence the treatment option chosen. For this reason, the WSES trauma classification, in which hemodynamic status was added to the American

Association for the Surgery of Trauma injury scoring scale, was applied in practice.[17] Therefore, in this study, the TCP and PCP were compared using actual AIS scores so that the limitations of the AIS scoring are also evident. Many factors contribute to variations in treatment, the most important being the grade of injury. In addition, in the process of designating a trauma center as a national project, there is a chance that bias may occur because the system has not been changed since the establishment of the trauma center; however, there is a certain period of preparation to ensure the requisite changes are made. The major limitation in the case of angioembolization is that the treatment method and timing can be changed by the interventionist and the individual making the treatment plan. The wide area covered by the trauma center may have also affected the results; however, the time from injury to admission was not significantly shortened due to the increase in transportation time and the usage of long-distance power sources. Thus, it is not known to what extent these factors affected the patient's treatment results.

In addition, given the characteristics of regional hospitals, the patient groups in the PCP and TCP were not significantly different. Since the mechanism of traumatic injury was limited to blunt injury and the use of firearms is prohibited in South Korea, the results of this study may be different from those in general trauma centers seen in other countries. Therefore, future studies could focus on other diseases and injury mechanisms or involve multiple centers to determine changes required in transportation or hospital systems. Although our study focused on the establishment of the trauma center itself, the transformation of the hospital system itself, improvement of triage, transfer, etc., which are important elements of a trauma system, were not well examined.[21] Thus, the limitations related to being a regional trauma center can be addressed and overcome in future studies.

Conclusion

Since the establishment of the trauma center, there has been an improvement in the selection of the treatment method for blunt trauma spleen injury. Patient prognosis after treatment was also analyzed. Our results show that the establishment of a trauma center led to improvements in treatment quality and patient prognosis; however, there was also scope for further improvement.

Ethics Committee Approval: This study was approved by the the Chonnam National University Hospital Institutional Review Board (Date: 07.12.2020, Decision No: CNUH-2020-363).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: H.J., Y.G.J.; Design: E.J.; Supervision: J.C.K.; Materials: Y.P.; Data: N.L.; Analysis: H.J.; Literature search: Y.G.J.; Writing: H.J., Y.G.J.; Critical revision: Y.G.J.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Travma merkezleri kurulmasının künt travmatik dalak yaralanması tedavisi üzerine etkisi: Travma merkezleri öncesi ve sonrası dönemlerin karşılaştırılması

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AMAÇ: Dalak, künt travma nedeniyle yaygın olarak yaralanan bir batın içi organdır. Künt dalak yaralanması vakalarında sıklıkla acil tedavi gerekir. Bu çalışma, künt dalak yaralanması olan hastaların tedavisinde travma merkezleri kurulmasının prognostik etkisini araştırmayı amaçlamıştır.

GEREÇ VE YÖNTEM: 2012–2019 yılları arasında dalakta künt yaralanma nedeniyle merkezimizi ziyaret eden 235 hastayı geriye dönük olarak inceledik. Çalışma süresi iki gruba ayrıldı: Ocak 2012–Eylül 2015 arası travma merkezi öncesi dönem (TÖD) ve Eylül 2015–Aralık 2019 arası travma merkezi dönemi (TMD). Her bir dönemde, üç tedavi grubu mevcuttu: Cerrahi grup, embolizasyon grubu ve konservatif tedavi grubu. Birincil sonuç mortalite idi; ikincil sonuçlar ise, yaralanma şiddeti skoru (ISS) ve kısaltılmış yaralanma ölçeği puanı gibi hasta özellikleri, başvurudan müdahaleye kadar geçen süre (hem cerrahi hem de anjiyografi embolizasyonu) ve dalak koruyucu cerrahi oranı idi.

BULGULAR: Konservatif tedavi grubunda TMD'de Hb ve Hct değerleri, TÖD'ye göre nispeten düşüktü (sırasıyla, p=0.007, p=0.008). TMD'de yoğun bakıma yatış oranı nispeten yüksekti (%72.9'a karşı %90.6, p=0.031). TMD'de yaralanma şiddeti skoru (ISS) nispeten düşüktü (18'e karşı 17, p=0.001). Cerrahi grubunda, hasta kabulünden sonra ameliyathaneye transfer için geçen süre TMP'de büyük ölçüde azalmıştır (151 dakikaya karşı 107 dakika, p=0.028). Embolizasyon grubunda hastanın yaşı ve SBP, TÖD'de TMD'ye göre daha düşüktü (sırasıyla p=0.003, p=0.049); TÖD'de üç hastaya CPR ile embolizasyon uygulanmış, TMD'de ise hiçbir hastaya CPR uygulanmamıştı. TÖD'de üç ölüm mevcuttu; TMD'de hiç ölüm gerçekleşmemişti (p=0.05).

TARTIŞMA: Bir travma merkezinin kurulması, künt dalak yaralanması olan ve üç tedaviden birini alan hastaların tedavi kalitesinde ve prognozunda iyileşmelere yol açmıştır.

Anahtar sözcükler: Batın yaralanmaları; dalak; travma merkezleri.

Ulus Travma Acil Cerrahi Derg 2022;28(11):1570-1582 doi: 10.14744/tjtes.2021.03262