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Epidemiology and outcomes of patients with penetrating trauma in Incheon Metropolitan City, Korea based on National Emergency Department Information System data: a retrsopective cohort study

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Purpose: Patients with penetrating injuries are at a high risk of mortality, and many of them require emergency surgery. Proper triage and transfer of the patient to the emergency department (ED), where immediate definitive treatment is available, is key to improving survival. This study aimed to evaluate the epidemiology and outcomes of patients with penetrating torso injuries in Incheon Metropolitan City.

Methods: Data from trauma patients between 2014 and 2018 (5 years) were extracted from the National Emergency Department Information System. In this study, patients with penetrating injuries to the torso (chest and abdomen) were selected, while those with superficial injuries were excluded.

Results: Of 66,285 patients with penetrating trauma, 752 with injuries to the torso were enrolled in this study. In the study population, 345 patients (45.9%) were admitted to the ward or intensive care unit (ICU), 20 (2.7%) were transferred to other hospitals, and 10 (1.3%) died in the ED. Among the admitted patients, 173 (50.1%) underwent nonoperative management and 172 (49.9%) underwent operative management. There were no deaths in the nonoperative management group, but 10 patients (5.8%) died after operative management. The transferred patients showed a significantly longer time from injury to ED arrival, percentage of ICU admissions, and mortality. There were also significant differences in the percentage of operative management, ICU admissions, ED stay time, and mortality between hospitals.

Conclusions: Proper triage guidelines need to be implemented so that patients with torso penetrating trauma in Incheon can be transferred directly to the regional trauma center for definitive treatment.

Keywords: Abdominal injuries; Thoracic injuries; Penetrating wounds; Trauma centers

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INTRODUCTION

Background

Trauma is the most common cause of death among young people in Korea, and the preventable death rate ranges from 32.6% to 50.4% [1–3]. Therefore, the Korean government and medical societies agreed to develop a trauma system, including the establishment of regional trauma centers (RTCs) in 2012. In 2014, the first RTC opened, with plans to establish 17 RTCs in Korea by 2021. However, several aspects of the regional trauma system, including governance, low-level trauma centers, and authorized guidelines for injured patient care, have yet to be established.

The management of penetrating torso injuries is challenging because it requires rapid and accurate assessment and surgical intervention. The rapid prehospital transportation of patients with penetrating injuries to the appropriate facility (i.e., a trauma center) is crucial [4,5]. Rapid transportation and management by experienced trauma surgeons at trauma centers have been shown to improve the survival of patients with major penetrating injuries [6,7]. A study also showed that patients from rural areas had a higher prehospital mortality risk than those from urban areas [8]. Worse outcomes were related to the response time, distance of transport, and limitations in specialized care in rural areas.

Obejctives

This study aimed to describe the demographics and outcomes of patients with penetrating torso injuries in Incheon Metropolitan City after 2014, when the first RTC opened in Incheon.

METHODS

Ethics statement

This study was approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GCIRB2020-375). The requirement for informed consent from patients was waived due to the retrospective nature of the study.

Study design and setting

This retrospective cohort study used data obtained from the National Emergency Department Information System (NEDIS), which is a database operated by the Ministry of Health and Welfare that collects data from all patients visiting 434 emergency departments (EDs) in Korea. The data included patients' demographics, clinical characteristics, and diagnosis codes at admission. This study did not receive any funding from external sources.

We extracted the data of all trauma patients who visited EDs in Incheon Metropolitan City from NEDIS between January 2014 and December 2018. Patients with trauma were identified using International Classification of Diseases (ICD) codes. Superficial injuries, drowning, or intoxication cases were not included in the dataset. In this study, we included patients with penetrating injuries to the torso (chest and abdomen) based on ICD codes (Fig. 1).

Population and trauma care system of Incheon Metropolitan City

Three million people live in Incheon Metropolitan City, which is surrounded by Seoul and Gyeonggi Province. This region has a population of approximately 20 million. There is one hospital—hereinafter referred to hospital B—in Incheon that has both a regional emergency center (REC) and an RTC. In addition, one REC without an RTC, nine local emergency centers (LECs), and nine local emergency institutions exist in the city. Before the RTC opened in 2014, trauma patients were triaged based on the shortest transport time and distance, such that severely injured patients could be brought to the nearest REC or LEC. After the RTC opened, the standard guidelines for 119 (i.e., emergency) paramedics recommended that severely injured patients be transported to the RTC or an REC; however, this has not been well orchestrated by the trauma governance system.

Statistical analysis

The basic demographic variables, types of ED, mechanism of injury, ED presentation route, and other clinical information were analyzed. Age was categorized into the following groups: 0–19, 20–29, 30–39, 40–49, 50–59, 60–69, and ≥70 years. The presentation routes were categorized as either direct or transferred.

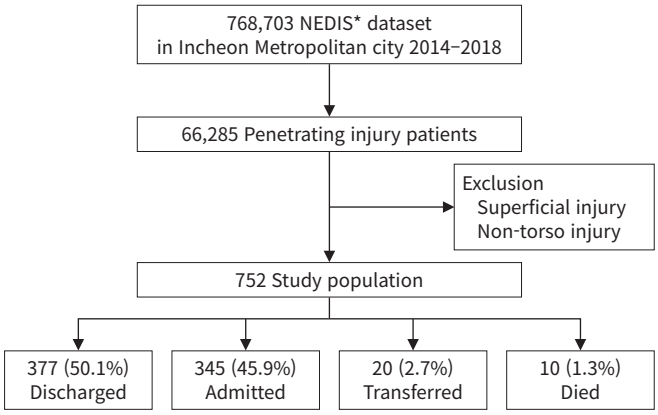

Fig. 1. Flowchart of the study enrollment. NEDIS, National Emergency Department Information System.

Medical information included vital signs, mental status at the time of ED arrival, patient's disposition after ED management, diagnosis on admission, and outcome at the time of discharge. The time variables included estimated injury time, ED arrival time, and discharge time from the ED or admission. Using the time variables, we calculated the time from injury to ED arrival, the ED stay time, and the time from injury to ED disposition.

All data were analyzed using IBM SPSS ver. 22 (IBM Corp., Armonk, NY, USA). Numerical data are presented as mean ± standard deviation or median (interquartile range), and categorical data are presented as percentages. The chi-square test was used to compare proportions for categorical variables, and the Student t-test or Mann-Whitney U-test was used to compare means or medians for continuous variables, as appropriate. Statistical significance was defined as $P < 0.05$.

RESULTS

Of the 768,703 trauma patients who visited EDs in Incheon during the 5-year study period, 752 patients with penetrating torso injuries were included in this study (Fig. 1). Among them, 377 (50.1%) were discharged from the ED, 345 (45.9%) were admitted, 20 (2.7%) were transferred to another hospital, and 10 (1.3%) died in the ED. The most common age group was 40 to 49 years (22.5% of total patients, 24.3% of admitted patients), and more than 70% of the patients were male (Table 1). Approximately half

Table 1. The basic demographic and clinical characteristics of the study population

Variable	Total (n=752)	Admitted (n=345)	Non-admitted (n=407)	P-value
Age (yr)				<0.001[a]
0–19	92 (12.2)	21 (6.1)	71 (17.4)	
20–29	115 (15.3)	55 (15.9)	60 (14.7)	
30–39	133 (17.7)	63 (18.3)	70 (17.2)	
40–49	169 (22.5)	84 (24.3)	85 (20.9)	
50–59	143 (19.0)	63 (18.3)	80 (19.7)	
60–69	62 (8.2)	30 (8.7)	32 (7.9)	
≥70	38 (5.1)	29 (8.4)	9 (2.2)	
Male sex	537 (71.4)	255 (73.9)	282 (69.3)	0.162
Classification of emergency center				<0.001[a]
Regional emergency center	321 (42.7)	185 (53.6)	136 (33.4)	
Local emergency center	413 (54.9)	151 (43.8)	262 (64.4)	
Direct transportation	687 (91.4)	293 (84.9)	394 (96.8)	<0.001[a]
KTAS[b] score				<0.001[a]
1	9 (1.2)	2 (0.6)	7 (1.7)	
2	161 (21.4)	119 (34.5)	42 (10.3)	
3	104 (13.8)	59 (17.1)	45 (11.1)	
4	159 (21.1)	23 (6.7)	136 (33.4)	
5	22 (2.9)	1 (0.3)	21 (5.2)	
Systolic blood pressure (mmHg)	118.2±43.8	124.7±34.5	112.6±49.7	<0.001[a]
Pulse rate (beats/min)	82.2±27.5	89.4±22.4	76.1±29.9	0.020[a]
Respiratory rate (breaths/min)	18.7±6.2	20.0±4.1	17.7±7.4	<0.001[a]
ED disposition		NA	NA	NA
Discharge	377 (50.1)			
Transfer out	20 (2.7)			
Admission to ward or ICU	345 (45.9)			
Death in ED	10 (1.3)			
Time from injury to ED (min)	48 (30–60)	54 (30–65)	39 (27–60)	0.004[a]
ED stay time (min)	79 (36–138)	108 (68–167)	52 (24–104)	<0.001[a]
Time from injury to ED disposition (min)	143 (85–248)	175 (120–274)	115 (65–208)	<0.001[a]

Values are presented as number (%), mean±standard deviation, or median (interquartile range).
KTAS, Korean Triage and Acuity Scale; ED, emegency department; NA, not applicable; ICU, intensive care unit.
[a]Statistically significant differences between groups. [b]Available from 2016.

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of the patients (42.7%) were transported to RECs, and 90% of patients presented directly to the ED. The admission group showed a significantly lower percentage of patients who presented directly to the ED and had higher Korean Triage and Acuity Scale (KTAS) scores than the nonadmission group. The ED stay time was significantly longer in the admission group.

We compared the clinical characteristics between patients who received nonoperative management (NOM) and operative management (OM) (Table 2). More patients in the OM group than in the NOM group were managed in RECs (62.8% vs. 44.5%, P=0.001). The OM group showed significantly lower systolic blood pressure and a higher rate of admission to the intensive care unit (ICU). None of the patients died after NOM, whereas 10 patients (5.8%) who received OM died. The transferred patients showed a significantly longer time from injury to ED (43 minutes vs. 101 minutes), higher ICU admission rate (21.3% vs. 43.7%), and higher mortality (2.2% vs. 7.7%) (Table 3).

The number of patients admitted was significantly different among EDs in Incheon (Table 4). Hospital B (both the RTC and REC) had the highest patient volume, managing 46.1% of the total patients and 58.2% of the OM patients. The ICU admission rates varied from 15.8% to 71.7% among hospitals, and hospital

Table 2. Comparison of NOM and OM groups (n=345)

Variable	NOM group (n=173)	OM group (n=172)	P-value
Classification of emergency center			0.001[a]
Regional emergency center	77 (44.5)	108 (62.8)	
Local emergency center	93 (53.8)	58 (33.7)	
Direct transportation	145 (83.8)	148 (86.0)	0.334
Systolic blood pressure (mmHg)	129.9±30.0	119.5±37.8	0.005[a]
Pulse rate (beats/min)	87.5±21.4	91.3±23.3	0.117
Respiratory rate (breaths/min)	19.6±4.0	20.1±4.1	0.218
Time from injury to ED (min)	57 (30–79)	51 (30–60)	0.750
ED stay time (min)	173 (88–199)	87 (52–143)	0.440
Time from injury to ED disposition (min)	211 (140–325)	150 (98–224)	0.110
Admission to ICU	53 (30.6)	122 (70.9)	<0.001[a]
Discharged to home	153 (88.4)	147 (85.5)	0.028[a]
Died in hospital	0	10 (5.8)	

Values are presented as number (%), mean±standard deviation, or median (interquartile range).
NOM, nonoperative management; OM, operative management; ED, emergency department; ICU, intensive care unit.
[a]Statistically significant differences between the groups.

Table 3. Comparison of patients group by route of emergency department admission (n=752)

Variable	Direct (n=687)	Transferred (n=65)	P-value
Classification of emergency center			0.001[a]
Regional emergency center	279 (40.6)	42 (64.6)	
Local emergency center	408 (59.4)	23 (35.4)	
Systolic blood pressure (mmHg)	117.9±43.9	120.9±42.6	0.605
Pulse rate (beats/min)	81.6±27.7	88.7±24.5	0.300
Respiratory rate (breaths/min)	18.5±6.2	20.4±5.5	0.100
Time from injury to ED (min)	43 (30–60)	101 (60–240)	<0.001[a]
ED stay time (min)	76 (34–137)	92 (55–149)	0.555
Time from injury to ED disposition (min)	138 (82–235)	218 (159–450)	0.001[a]
Admission to ICU	146 (21.3)	29 (44.6)	<0.001[a]
Mortality	15 (2.2)	5 (7.7)	0.027[a]

Values are presented as number (%), mean±standard deviation, or median (interquartile range).
ED, emergency department; ICU, intensive care unit.
[a]Statistically significant differences between the groups.

Table 4. Comparison of patient volume and clinical characteristics among emergency centers in Incheon Metropolitan City (n=332)

Variable	Emergency center						
	A	B	C	D	E	F	G
Classification of emergency center	REC	RTC+REC	LEC	LEC	LEC	LEC	LEC
No. of patients	50 (14.5)	159 (46.1)	18 (5.2)	19 (5.5)	18 (5.2)	31 (9)	37 (10.7)
Nonoperative management	31 (62.0)	60 (37.7)	12 (66.7)	14 (73.7)	15 (83.3)	15 (48.4)	15 (40.5)
Operative management	19 (38.0)	99 (62.3)	6 (33.3)	5 (26.3)	3 (16.7)	16 (51.6)	22 (59.5)
Transferred from other hospitals	3 (6.0)	35 (22.0)	1 (5.6)	0 (0.0)	2 (11.1)	3 (9.7)	8 (21.6)
ICU admission	13 (26.0)	114 (71.7)	5 (27.8)	3 (15.8)	3 (16.7)	17 (54.8)	17 (45.9)
ED stay time (min)							
Admitted patients	172	98	151	70	61	286	212
Patients directly transferred to the operating room	141	65	123	89	48	142	158
Death	0	7 (4.4)	0	0	0	2 (6.5)	1 (2.7)

Values are presented as number (%) or median.
REC, regional emergency center; RTC, regional trauma center; LEC, local emergency center; ICU, intensive care unit; ED, emergency department.

B had the largest number of patients admitted to the ICU during the 5-year study period. The shortest ED stay for all admitted patients was 61 minutes, and the longest stay was 286 minutes. In addition, there was a significant variation in the ED stay time of patients who were directly transferred to the operating room (from 48 minutes to 157.5 minutes) (Fig. 2).

DISCUSSION

In this study, penetrating torso injuries accounted for 1.1% and 0.1% of all penetrating injuries and all injuries, respectively. Although a direct comparison is difficult due to differences in the clinical characteristics of the study population, this study showed a relatively low incidence of penetrating torso injuries in Incheon over the last 5 years, similar to other industrialized countries [9–11]. Moreover, the incidence and mortality rates of penetrating torso injuries requiring hospitalization were relatively low [12–14]. Unlike in the United States and South Africa, firearms are prohibited in Korea, which may, in part, contribute to the low incidence of penetrating injuries [15,16].

Most patients were directly transported to the ED for treatment, and the median time from injury to ED arrival was 48 minutes. However, 8.6% of the patients did not receive definitive management in the ED where they initially arrived. Moreover, patients who required hospitalization had a lower rate of direct transportation and longer stays in the ED. This is supported by the opinion that the roles of the RTC and other emergency medical centers are not clearly distinguished, meaning the emergency triage system is not efficient at the prehospital level in Korea [17]. As a result, patients with severe trauma were not concentrated in the RTC.

The transferred patients had a longer time from injury to the final ED arrival than the other patients. Furthermore, they showed a higher rate of ICU admission and mortality, suggesting that a delayed arrival to the final ED due to transfer could be a risk factor for poor outcomes. Therefore, we need to focus on these transferred cases to improve the outcomes after penetrating injuries.

Fu et al. [7] reported that trauma centers with a high volume of penetrating trauma patients were associated with good outcomes. In Incheon, only hospital B has an RTC in addition to an REC. This hospital has managed a substantial number of patients in the last 5 years. Our findings showed that the rates of OM and ICU admission were higher in hospital B than in the other REC. Despite this, the ED stay time in hospital B was shorter than that in other hospitals. Of note, patients who were directly transferred to the operating room had a significantly shorter stay in the emergency room in hospital B than in other hospitals. Hoyt et al. [18] reported that direct transport to the operating room for resuscitation was associated with better outcomes in patients with penetrating torso injuries. Meizoso et al. [19] argued that protocols to shorten the ED stay for patients requiring surgery are essential. To improve the clinical outcomes of penetrating torso injuries, it is necessary to establish a trauma governance system that allows direct transfer Limitations treatment.

Limitations

This study had some limitations. First, as with other retrospective studies with large databases, this study has the potential for selection bias. Second, the NEDIS data lack granular clinical informa-

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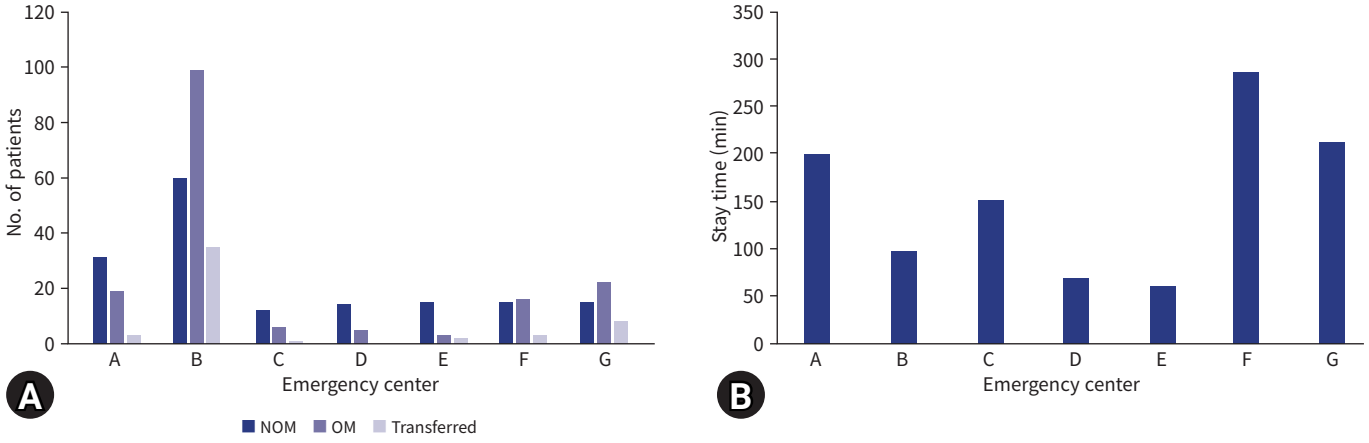

Fig. 2. Comparison between emergency centers in Incheon. (A) Comparison of the number of patients admitted among emergency centers. (B) Emergency department stay time at each emergency center. NOM, nonoperative management; OM, operative management; Transferred, transferred from other hospitals.

tion, such as hemodynamic changes and transfusion requirements. Third, a comparative analysis of data from other regions with similar characteristics would have made it possible to better understand the characteristics of patients with penetrating injuries in Incheon. Despite these limitations, this study is the first to analyze specific injury mechanisms in the metropolitan area of Korea and will be helpful in establishing trauma governance in Incheon.

Conclusions

The number of patients with penetrating torso injuries in Incheon Metropolitan City was small enough to be managed at a single definitive treatment facility. Transferring patients to other hospitals is associated with delayed arrival to the final ED, which can cause poor outcomes. To address these factors, appropriate triage guidelines are needed to allow direct transfer to the RTC for patients with penetrating torso trauma in Incheon.

ARTICLE INFORMATION

Author contributions

Conceptualization: BY, JL; Data curation: SBJ, SHL; Formal analysis: YK, JC, JG, YP, YM; Methodology: KKC, MAL, GJL; Visualization: BY, SBJ, SHL, JL; Writing–original draft: YK, JC, JG, YP, KKC, MAL, GJL; Writing–review & editing: all authors. All authors read and approved the final manuscript.

Conflicts of interest

Gil Jae Lee is the Editor-in-Chief, Min A Lee is the associate editor, and Seung Hwan Lee and Kang Kook Choi are Editoial Board members of the *Journal of Trauma and Injury* but were not involved in the peer reviewer selection, evaluation, or decision process of this article. The authors have no other conflicts of interest to declare.

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Data availability

Data of this study are available from the corresponding author upon reasonable request.

Additional information

This study was presented at the 9th Pan-Pacific Trauma Congress in June 2022 in Gyeongju, Korea.

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