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Analysis of Aspiration Risk Factors in Severe Trauma Patients: Based on Findings of Aspiration Lung Disease in Chest Computed Tomography

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Purpose: The present study will identify risk factors for aspiration in severe trauma patients by comparing patients who showed a sign of aspiration lung disease on chest computed tomography (CT) and those who did not.
Methods: We conducted a retrospective review of the Korean Trauma Data Bank between January 2014 and December 2019 in a single regional trauma center. The inclusion criteria were patients aged ≥18 years with chest CT, and who had an Injury Severity Score ≥16. Patients with Abbreviated Injury Scale (AIS)-chest score ≥1 and lack of medical records were excluded. General characteristics and patient status were analyzed.
Results: 425 patients were included in the final analysis. There were 48 patients showing aspiration on CT (11.2%) and 377 patients showing no aspiration (88.7%). Aspiration group showed more endotracheal intubation in the ER (p=0.000) and a significantly higher proportion of severe Glasgow Coma Scale (GCS) (p=0.000) patients than the non-aspiration group. In AIS as well, the median AIS head score was higher in the aspiration group (p=0.046). Median oxygen saturation was significantly lower in the aspiration group (p=0.002). In a logistic regression analysis, relative to the GCS mild group, the moderate group showed an odds ratio (OR) for aspiration of 2.976 (CI, 1.024–8.647), and the severe group showed an OR of 5.073 (CI, 2.442–10.539).
Conclusions: Poor mental state and head injury increase the risk of aspiration. To confirm for aspiration, it would be useful to perform chest CT for severe trauma patients with a head injury.

Keywords: Pneumonia, aspiration; Tomography, X-ray computed; Multiple trauma; Risk

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INTRODUCTION

Aspiration occurs commonly in severe trauma patients, and risk factors are known to include loss of consciousness, facial injury, and elevated intra-abdominal pressure [1,2]. Although it is not possible to ascertain the exact incidence of aspiration in severe trauma, depending on the research methods, the incidence is reported to be 6–54% [3-6]. Aspiration is known to cause lung disease from mild bronchiolitis to aspiration pneumonia and aspiration pneumonitis [7,8], and the development of these lung diseases increases the rate of progression acute respiratory distress syndrome (ARDS) [9,10]. Therefore, prevention and awareness of aspiration is an important issue in the management of severe trauma patients.

Previous studies on aspiration in severe trauma patients have investigated the presence of foreign bodies in the oropharynx, or in the larynx during endotracheal intubation [9,10]. These methods are limited by the fact that oropharyngeal foreign bodies cannot be considered clear evidence of aspiration, and that laryngeal foreign bodies cannot be checked without attempting intubation. It is expected that the diagnostic accuracy of testing for aspiration could be improved by using chest computed tomography (CT). However, there have been few previous studies on severe trauma patients showing findings of aspiration on chest CT. Hence, the purpose of the present study was to identify risk factors for aspiration in severe trauma patients by comparing patients who showed signs of aspiration lung disease on chest CT and those who did not. In addition, clinical differences were compared between the two patient groups, including the rate of endotracheal intubation in the emergency room (ER), the intensive care unit (ICU) admission rate, and the in-hospital mortality rate.

METHODS

Subjects and study period

The Korean Trauma Data Bank (KTDB) is a system for collecting data about trauma care from regional trauma centers and specialized trauma training institutions, which started with 5 regional trauma centers in 2013, and includes a total of 17 locations now in 2020. Based on the National Emergency Department Information System (NEDIS), a designated coordinator in each hospital collects data on dead, transferred, and hospitalized patients who visited the ER for trauma, and this data is also managed by a board-certified physician at a trauma center.

Patients who were transferred to the trauma center in accordance with the field triage decision scheme underwent chest CT, all following the judgment of the trauma physician. Among these patients, those with alert mental status and without the signs and symptoms of chest or abdominal trauma and are focused assessment with sonography for trauma (FAST) all negative did not undergo chest CT [11].

The present study focused on patients registered in the KTDB who had visited a single regional trauma center between January 1st 2014 and December 31st 2019. The inclusion criteria were patients aged ≥18 years who had undergone chest CT, and who had an Injury Severity Score (ISS) ≥16. The exclusion criteria were patients with an Abbreviated Injury Scale (AIS)-chest score ≥1, patients who had been transferred from the ER to another hospital while alive, patients who did not have a recorded Glasgow Coma Scale (GCS) score, patients whose data could not be inspected due to mis-recording of the chart number, patients with duplicate chart numbers, and patients for whom access to the patient records was restricted due to a suicide attempt. In addition, patients were excluded if they had a chest injury making it difficult to differentiate traumatic lung injury, such as pulmonary contusion, and aspiration lung disease on CT.

Study design and methods

Patients with suspected aspiration in the estimation of a certified radiologist, based on findings of bilateral perihilar, ill-defined, alveolar consolidations, multifocal patchy infiltrates, posterior dominant distribution of lung opacities, and segmental or lobar consolidation on chest CT, were classified in the aspiration group; patients without the above findings were classified in the non-aspiration group.

As general characteristics, the patients' sex, age, mechanism of accident, time of accident, past medical history, status at discharge from the ER, and intubation in the ER were compared between the aspiration and the non-aspiration group. Mechanism of accident was categorized as motor vehicle traffic accident (TA), pedestrian TA, motorcycle TA, fall down/slip down or unknown, and time of accident was categorized as 00:00–08:00, 08:00–16:00, or 16:00–24:00. Status at discharge from the ER was categorized as ward, ICU or death in the ER.

The patient status at ER arrival was compared between the aspiration group and the non-aspiration group. Patient status at ER arrival included vital signs, initial GCS, ISS, and AIS. For vital signs, the initial systolic and diastolic blood pressure (SBP and DBP, respectively), heart rate, respiratory rate, body temperature, and oxygen saturation were included. In patients who regained spontaneous circulation after cardiopulmonary resuscitation (CPR), the first vital signs after restoring circulation were used. The initial GCS was categorized as mild (14–15), moderate (9–13), or severe (3–8), and for patients whose GCS was only recorded after intubation, the verbal response was scored as 1 point. ISS was categorized as severe (16–24) or critical (>25).

Analysis and statistics

After categorization, the data was analyzed statistically using SPSS statics version 24.0 (SPSS Inc., Chicago, IL, USA). For discrete variables, univariate analysis was performed using the chi-square test, and for continuous variables with a non-normal distribution, the Mann-Whitney *U* test was used. A logistic regression analysis was performed to investigate the risk factors associated with aspiration. Results with a *p*-value <0.05 were considered to be statistically significant.

RESULTS

There were 3,159 patients registered in the KTDB between January 1st 2014 and December 31st 2019. Of these, 1,333 patients without chest CT scans were excluded, and 1,326 patients with AIS-chest ≥1 were excluded. A further 75 patients were excluded due to mis-recorded or duplicate chart numbers, transfer from the ER to another hospital, being under 18 years of age, or due to trauma affecting the interpretation of CT scans, and the remaining 425 patients were included in the final analysis. Of these 425 patients, there were 48 patients showing aspiration on chest CT (11.2%) and 377 patients showing no aspiration (88.7%) (Fig. 1).

When general characteristics were compared between the aspiration group and the non-aspiration group, endotracheal intubation was performed in the ER for 239 patients in total, with 42 patients from the aspiration group (87.5%) and 197 patients from the non-aspiration group (52.3%), which was a significantly higher rate of intuba-

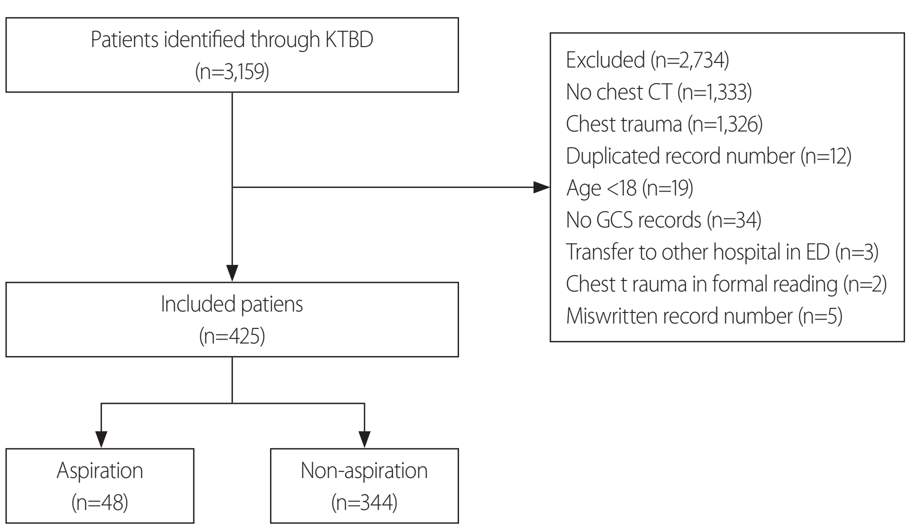

Fig. 1. Enrollment and grouping. KTDB: Korea Trauma Data Bank, CT: computed tomography, GCS: Glasgow Coma Scale, ED: emergency department.

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tion in the aspiration group (p=0.000). The mean age was 53.5 years (median value, 40.0–64.7 years) in the aspiration group and 54.0 years (median value, 40.0–67.0 years) in the non-aspiration group, which was not a statistically significant difference (p=0.613). Likewise, there were no significant differences in sex, mechanism of accident, time of accident or past medical history, or status at discharge from the ER (Table 1).

When patient status upon arrival at the ER was compared between the two groups, in terms of mental status, the aspiration group showed 11 mild patients (22.9%), 6 moderate patients (12.5%), and 31 severe patients

Table 1. Baseline characteristics and demographics feature of patients

Characteristics	Total	Aspiration	Non-aspiration	*p*-value
Total	425 (100)	48 (100)	377 (100)	
Gender				0.073
Male	318 (74.8)	41 (85.4)	277 (73.5)	
Female	107 (25.2)	7 (14.6)	100 (26.5)	
Age (years)	54.0 (40.0–67.0)	53.5 (40.0–64.7)	54.0 (40.0–67.0)	0.613
Mechanism of accident				0.843
Motor vehicle TA	48 (11.3)	5 (10.4)	43 (11.4)	
Pedestrian TA	109 (25.6)	13 (27.1)	96 (25.5)	
Motorcycle TA	74 (17.4)	11 (22.9)	63 (16.7)	
Fall down, slip down	158 (37.2)	16 (33.3)	142 (37.7)	
Unknown	36 (8.5)	3 (6.3)	33 (8.8)	
Time of accident (24 hours)				0.328
00:00–08:00	131 (30.8)	17 (35.4)	114 (30.2)	
08:00–16:00	166 (39.1)	14 (29.2)	152 (40.3)	
16:00–24:00	128 (30.1)	17 (35.4)	111 (29.4)	
Past medical history				
Acute coronary syndrome	9 (11.3)	0 (0)	9 (2.4)	0.606
Cardiovascular disease	11 (2.6)	1 (2.1)	10 (2.7)	1.000
COPD	2 (0.5)	0 (0)	2 (0.5)	1.000
HTN	99 (23.3)	8 (16.7)	91 (24.2)	0.245
DM	59 (13.9)	5 (10.4)	54 (14.4)	0.457
Liver disease	15 (3.5)	3 (6.3)	12 (3.2)	0.235
Bleeding disorder	1 (0.2)	1 (2.1)	0 (0)	0.113
Admission to				0.103
Ward	28 (6.6)	0 (0)	28 (7.4)	
ICU	395 (92.9)	48 (100)	347 (92.0)	
ER death	2 (0.5)	0 (0)	2 (0.5)	
Intubation in ER				0.000
Yes	239 (56.2)	42 (87.5)	197 (52.3)	
No	186 (43.8)	6 (12.5)	180 (47.7)	

Values are presented as number (%) or median (interquartile range).
TA: traffic accident, COPD: chronic obstructive pulmonary disease, HTN: hypertension, DM: diabetes mellitus), ICU intensive care unit, ER: emergency room.

(64.6%), while the non-aspiration group showed 217 mild patients (57.6%), 37 moderate patients (9.8%), and 123 severe patients (32.6%), meaning that there was a significantly higher proportion of severe patients in the aspiration group (p=0.000). In AIS as well, the median AIS head score was 4.0 (4.0–5.0) in the aspiration group and 4.0 (3.0–5.0) in the non-aspiration group, which was higher in the aspiration group (p=0.046), and the median AIS abdomen score was 0.0 (0.0–0.0) in the aspiration group and 0.0 (0.0–2.0) in the non-aspiration group, which was significantly lower in the aspiration group (p=0.027). Median oxygen saturation was significant lower in the aspiration group, at 96.0 (89.2–98.0), than in the non-aspiration group, at 98.0 (95.0–99.0) (p=0.002). The vital signs of blood pressure, heart rate, respiratory rate, and body tem-

Table 3. Logistic regression analysis on aspiration

Variables	Adjusted	
	Odds ratio	95% CI
Age	0.796	0.491–1.292
Sex	0.527	0.220–1.261
Time of accident		
08:00–16:00	Reference	Reference
16:00–24:00	1.375	0.638–2.962
00:00–08:00	1.669	0.758–3.672
Initial GCS		
Mild (13–15)	Reference	Reference
Moderate (9–12)	2.976	1.024–8.647
Severe (3–8)	5.073	2.442–10.539

Values are presented as number (%) or median (interquartile range).
CI: confidential interval, GCS: Glasgow Coma Scale.

Table 2. Patient status at ED arrival

Characteristics	Total	Aspiration	Non-aspiration	p-value
Total	425	48	377	
Vital sign in ER arrival				
SBP (mmHg)	136.0 (114.0–157.5)	131.5 (114.2–165.7)	136.0 (114.0–157.0)	0.740
DBP (mmHg)	81.0 (69.5–95.0)	79.5 (61.2–95.5)	81.0 (70.0–95.0)	0.164
Heart rate	85.0 (73.0–100.0)	88.0 (73.2–103.0)	84.0 (73.0–100.0)	0.479
Respiratory rate	20.0 (18.0–22.0)	20.0 (18.0–24.0)	20.0 (18.5–22.0)	0.490
Body temperature	36.4 (36.0–36.8)	36.0 (35.6–36.8)	36.4 (36.0–36.8)	0.109
O2 saturation	98.0 (94.0–99.0)	96.0 (89.2–98.0)	98.0 (95.0–99.0)	0.002
Initial GCS				0.000
Mild (13–15)	228 (53.6)	11 (22.9)	217 (57.6)	
Moderate (9–12)	43 (10.1)	6 (12.5)	37 (9.8)	
Severe (3–8)	154 (36.2)	31 (64.6)	123 (32.6)	
ISS of patients				0.441
Severe (16–24)	238 (56.0)	24 (50.0)	214 (56.8)	
Critical (>25)	187 (44.0)	24 (50.0)	163 (43.2)	
AIS of patients				
AIS (head)	4.0 (3.0–5.0)	4.0 (4.0–5.0)	4.0 (3.0–5.0)	0.046
AIS (facial)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.628
AIS (abdomen)	0.0 (0.0–2.0)	0.0 (0.0–0.0)	0.0 (0.0–2.0)	0.027
AIS (extremities)	0.0 (0.0–3.0)	0.0 (0.0–2.0)	0.0 (0.0–3.0)	0.279
AIS (external)	0.0 (0.0–1.0)	0.5 (0.0–1.0)	0.0 (0.0–1.0)	0.624

Values are presented as number (%) or median (interquartile range).
ED: emergency department, SBP: systolic blood pressure, DBP: diastolic blood pressure, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, AIS: Abbreviated Injury Scale.

perature, and the ISS showed not significant differences between the groups on arrival in the ER (Table 2).

In a logistic regression analysis including age, sex, time of accident, and GCS on admission to the ER, relative to the GCS mild (13–15) group, the moderate (9–12) group showed an odds ratio (OR) for aspiration of 2.976 (CI, 1.024–8.647), and the severe (3–8)group showed an OR of 5.073 (CI, 2.442–10.539). Consistent with the chi-square tests above, there were no statistically significant differences in aspiration rate according to age, sex, or time of accident (Table 3).

DISCUSSION

In a study by Benjamin et al. [9], when aspiration was judged by the presence or absence of an aspiration event, the incidence of aspiration among severe trauma patients was 25.4%. Aspiration pneumonitis develops within minutes when a patient aspirates ≥0.3 cc per 1 kg body weight of highly acidic gastric contents [12]. Aspiration lung diseases are characterized by bilateral, ill-defined, alveolar consolidations, multifocal patch infiltrates, posterior dominant distribution of lung opacities, and segmental or lobar consolidation on chest CT scans [13,14]. In the present study, based on chest CT scans taken soon after trauma, the incidence of aspiration among severe trauma patients was found to be 11.2%. The fact that the incidence was lower than the previous study is thought to be due to differences in how aspiration was identified, and identifying aspiration based on chest CT findings consistent with aspiration lung disease is expected to be the more diagnostically accurate method.

Altered mental status is related to aspiration, and more severely altered mental status is known to be associated with higher risk of aspiration [15,16]. Studies on severe trauma patients have also shown worse mental status in the aspiration group compared to the non-aspiration group [9,10]. Patients with impaired consciousness show decreased or loss of the gag and cough reflexes. These reflexes help to protect against aspiration, and so patients with impaired consciousness are more susceptible to aspiration [17,18]. The present study also showed lower GCS on admission to the ER among severe trauma patients, and multivariate logistic regression analysis showed that, compared to patients with mild (13–15) impairment of mental status, the OR for aspiration for moderate (9–12) patients was 2.976 (CI, 1.024–8.647) and for severe (3–8) patients was 5.073 (CI, 2.442–10.539), meaning that worse mental status was associated with higher risk of aspiration, which was consistent with previous studies.

Fawcett et al. [10] reported that, among severe trauma patients, the aspiration group show higher max head AIS scores than the non-aspiration group, and Benjamin et al. [9] also found that head AIS scores were higher in severe trauma patients with aspiration compared to those without aspiration. Traumatic head injury causes impairment or loss of consciousness [19]. Head injury in severe trauma also often causes vomiting, to the extent that vomiting is considered evidence of a potential intracranial injury, and this could also increase the risk of aspiration [20]. In the present study of severe trauma patients, there was a higher distribution of AIS-head scores in the aspiration group compared to the non-aspiration, which is consistent with previous research.

In two previous prospective studies, aspiration patients showed statistically higher ISS than non-aspiration patients (aspiration 26.0 vs. non-aspiration 17.0, p=0.027; aspiration 25.0±1.7 vs. non-aspiration 21.9±1.5, p-value=0.04) [8,9]. In the present study, there was no significant difference in ISS between the aspiration group and the non-aspiration group, with 24 severe patients (score 16–24, 50%) and 24 critical patients (score >24, 50%) in the aspiration group and 214 severe patients (score 16–24, 56.8%) and 163 critical patients (score >24, 43.2%) in the non-aspiration group (p=0.441). This is thought to be because patients who did not undergo chest CT were not included in the study. Given that head injury and impaired consciousness are risk factors for aspiration, as seen above, isolated brain injury patients may not have undergone chest CT scanning, resulting in selection bias affecting the results. Since recent studies recommend whole-body CT for severe trauma patients [21-24], it would also be beneficial to consider chest CT to check for aspiration in patients with isolated brain injury.

Aspiration pneumonia causes hypoxia and increased infiltration of the lung field [1]. In the present study, the median oxygen saturation was significantly lower in the aspiration group, at 96.0% (interquartile range [IQR], 89.2–98.0%), than in the non-aspiration group, at 98.0% (IQR, 95.0–99.0%) (p-value=0.002). The frequency of endotracheal intubation in the ER was also significantly higher in the aspiration group, at 42 patients (87.5%), than in the non-aspiration group, at 197 patients (52.3%) (p-value=0.000). This is thought to be related to the poorer mental state and hypoxia shown by the aspiration group in this study.

This study had several limitations. First, this was a retrospective study conducted at a single regional trauma center. The number of patients enrolled in the study was insufficient for a more thorough statistical comparison of relevant factors between the aspiration group and the non-aspiration group. Second, because it is difficult to differentiate between aspiration lung disease and traumatic lung injury from radiologic findings, patients with an AIS-chest score of ≥1 point were excluded from this study. Consequently, patients with traumatic lung injury accompanied by head injury were omitted, which could have affected the results by selection bias. Third, regarding the significantly lower oxygen saturation upon arrival at the ER, patients who had been transferred from another hospital or brought by the emergency services (119) are usually intubated or administered oxygen before arrival. Since there are no precise records of oxygen administration before arrival at the hospital, this makes it difficult to precisely analyze differences in oxygen saturation. Fourth, for patients whose initial GCS was not recorded but who had GCS recorded only after intubation, the verbal response was scored as 1 point to proceed with the analysis. This is because there are cases where intubation is performed immediately upon arrival at the ER since the patients subject to this study were severe trauma patients with ISS >15. Although patients who were intubated without the previous record of GCS should be excluded from the study since their GCS cannot be referred to, because the intubated patients before GCS recording tend to be intubated due to severely impaired consciousness, they were scored as 1 point. It is thought that this may have affected the accuracy of the statistical analysis.

CONCLUSION

In severe trauma patients, poor mental state and head injury increase the risk of aspiration. In order to test for aspiration, it would be useful to perform chest CT for severe trauma patients with head injury to check for accompanying aspiration lung disease. Therefore, in severe trauma patients with head injury or poor mental state, various measures should be considered to reduce the risk of aspiration, and this will need to be investigated further in studies with a larger sample size of patients.

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