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Assessment of the disaster medical response system through an investigation of a 43-vehicle mass collision on Jung-ang expressway

Hee Young Lee, Jeong IL Lee, Oh Hyun Kim, Kang Hyun Lee, Hyeong Tae Kim, Hyun Youk*

Wonju College of Medicine, Yonsei University, Department of Emergency Medicine, Republic of Korea

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ABSTRACT

Purpose: It was considered the challenges of the actual response and the potential for improvement, including the activities of the disaster response system, national emergency medical center, and the regional base hospital for the treatment of multiple traffic accident victims. The purpose of this study was to analyze the accident management system through real investigating the multiple collision over 10 vehicles with mass casualty events as a disaster situation.

Methods: This study was retrospective study to analyze the disaster event with multiple collision traffic accident on the expressway in Korea. We visited five medical centers for eight days since the accident occurred and interviewed the injured patients in this accident to examine the health status and medical records. After that, we visited the sixteen car-repair shops in four cities for real investigate about damaged vehicles. According to the arrangement of the accident situation for the accident vehicles through real-world investigation, we reproduced all parts of the accident scene, which were real-world investigated, by the accident situation sketch program. The collected data were summarized by Collision Deformation Classification (CDC) codes, and the medical records of the occupants were assessed using the Injury Severity Score (ISS).

Results: The cause of the accident was snow freezing of the road. The information about 72 injured patients on 31 damaged vehicles was collected by phone, visit, and actual accident investigation. Of the 72 patients who were examined, 4 were severely injured and 68 were mildly injured. The accident occurred in the order of Sedan 13 (41.9%), SUV 11 (35.5%), Truck 4 (12.9%), Van 2 (6.5%) and Bus 1 (3.2%). The median value of the age [lower quartile and upper quartile] was 43 [34.5–52] years old and the patients included 25 drivers, 11 passengers, 7 back seat passengers, and 29 bus passengers.

Conclusion: The primary cause of this mass collision accident was road surface freezing, but the more serious secondary cause was a driver's inability to avoid the accident scene after the first collision. The severely injured occupants were occurred on the roads outside and inside the vehicle. In the event of a disaster, various teams from the police team, firefighting team, DMAT, EMS, road management team are gathered, and communication and command system between each team is important in order to identify and solve the disaster situation. To do this, it is important to develop manuals and prepare for training through repeated simulations.

1. Introduction

Disasters are occurring all over the world. Also, the prevalence, mortality, and economic costs related to disasters are increasing (Task Force on Quality Control of Disaster Management, 2003). Mass collision accident is increasing in frequency with the development of rapid industrialization and large-scale transportation. Also, it occurs in a wide variety of types and sizes, which is from accidents caused by transportation to industrial accidents such as leakage of toxic chemicals, a collapse of buildings, and fire (Pucher et al., 2014; Shah et al., 2015). It is important to establish the monitoring, surveillance and early warning system at the national level in order to minimize losses in responding to such mass collision accidents (World Health Organization, 2007).

According to a research report by the World Health Organization (WHO), traffic accidents caused by weather are 1.5 million cases per year, 673,000 cases of human injury, and 7400 cases of fatal damage. In order to solve these problems, the United States, Europe, and Japan are carrying out various researches to identify and improve the causes of accidents by pursuing multiple collision accidents (Lee and Fazio, 2005; Biswas et al., 2006; World Health Organization, 2015).

* Corresponding author at: Department of Emergency Medicine, Wonju Severance Christian Hospital, Yonsei University, 20, Ilsan-ro, Wonju, Gangwon, 26426, Republic of Korea.
E-mail address: yhmentor@gmail.com (H. Youk).

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Korea has 232,035 traffic accidents each year, with 350,400 injured and 4621 deaths. On a daily average basis, 635 traffic accidents occur and 960 people are injured. In 2008, Korea was included in countries with the highest number of traffic accidents per 10,000 cars in OECD countries, and it did not change significantly in 2015 (Korea Road Traffic Authority, 2015).

According to a recent incident report, multiple collisions of vehicles related to the weather are occurring constantly in Korea. Despite many casualties, research and disaster preparedness guidelines are still lacking (Park, 2014; Wang, 2014).

The purpose of this study was to analyze the accident management system through real investigating the multiple collision over 10 vehicles with mass casualty events as a disaster situation.

2. Methods

2.1. Study design

This study was retrospective study to analyze the disaster event with multiple collision traffic accident at January 16, 2015 on the Jungang expressway in Korea. Immediately after the accident, the Disaster Medical Assistance Team (DMAT) was dispatched to the on-site of the disaster. it was identified the status of transferring the patients, emergency call system, the route of transferring patients to the hospital, and the traction route of the damaged vehicles through collecting by DMAT advance team. We visited five medical centers for eight days since the accident occurred and interviewed the injured patients in this accident to examine the health status and medical records. After that, we visited the sixteen car-repair shops in four cities for real investigate about damaged vehicles. According to the arrangement of the accident situation for the accident vehicles through real-world investigation, we reproduced all parts of the accident scene, which were real-world investigated, by the accident situation sketch program (Easy Street Draw 6, A-T Solutions, USA). The study was conducted after getting approval by the research ethics committee of Yonsei University (YWMR-14-5-074).

2.2. Disaster Medical Assistance Team (DMAT) in Korea

There are 20 disaster base hospitals in Korea as of 2015, and they are gradually expanding. In each disaster base hospital, there are a disaster medical officer and has 3 DMAT teams consists of doctor, nurse, and EMT (Emergency Medical Technician). It can be requested from the Emergency Medical Situation Room of the Central Emergency Medical Center and can be also requested from local government or fire department. The DMAT's indications of dispatch are as follows.

1 Situations/incidents where more than 10 casualties have already occurred and additional casualties are suspected
2 Confirmation of the sinking of a passenger ship in operation, a crash of a passenger aircraft, a derailment of a passenger train, a fall of a large van, or rollover
3 Confirmation of multiple traffic accidents in vehicles over 10 cars
4 Identification of population exposure by chemistry and radiation

If there is a DMAT request, the regional DMAT will be sent first, and if additional manpower is needed, another regional DMAT will be added and the central DMAT will be joined.

2.3. Patient information

We collected the accident information from National Emergency Medical Center (NEMC) primarily and visited the medical centers to interview the people who were related to accident (119 paramedics, trainee drivers and patients) secondly. The medical staff obtained the consent from the patient or his/her family and asked the detailed accident information. The injury severity of patient was presented by the Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS).

AIS has already proved its usefulness in classifying traumas and predicting prognosis in trauma patients and is same in motor vehicle crash patients. Based on analyzing the whole medical record in an electronic clinical information system 2 coordinators coded and the other coordinator rechecked independently following 05/08 update of AIS manual (Association for the Advancement of Automotive Medicine, 2008). For classifying each body region, AIS08 consists of head, face, neck, thorax, abdomen, spine, upper extremity, lower extremity, external, and other. To properly classify lesions in the ISS, spinal injuries have been subdivided into cervical, thoracic, and lumbar spinal injuries. Thus, a total of 11 body parts (head, face, neck, chest, abdomen, upper extremity, lower extremity, external, cervical spine, thoracic spine, and lumbar spine) were analyzed separately instead of AIS08 classification. And then AIS were regrouped by the AIS body region; head and neck area; facial area; chest area; internal organs in the abdominal and hip area; upper and lower extremities and hips; and external factors, such as burn, frostbite, and explosion. The highest AIS number is called the maximum AIS (MAIS). The ISS indicates injury scores calculated by summing up the squares of AIS values for the three body parts with high degrees of injuries. It is expressed from 1 to 75 points, where patients with scores of 15 points or higher scores considered to be serious cases.

2.4. Accident car information

Accident vehicle photos of the front, rear, left side, right side were basically obtained and photos of major collision areas and internal damage areas, evidence of whether the safety belt was fastened, and evidence whether the airbag was inflated were additionally obtained. Because it affected the severity of the patient depending on whether or not the safety belt was fastened, it was considered by the patient's statement or actual accident investigation. When the patient stated that he/she had fastened a safety belt or when there was a sign of scratching or loosening of the safety belt when investigating an accident vehicle, it was recorded as fastened the safety belt. Conversely, when the windshield had a trace of damage by the head (Bull's eye fracture) or the patient/the rescuer stated insufficiently, it was recorded as not fastened the safety belt. In addition, to identify more accurate situations, the researcher visited the competent police station to ask the investigator in charge whether the accident was reported and request information on accident situations only for reported cases. Based on the data collected as such, accident vehicle damage information was identified in the form of Collision Deformation Classification code (hereinafter, CDC code). The CDC code is a vehicle damage code devised by the US Society of Automotive Engineers (SAE) that indicates vehicle damage areas, damage shapes, and the degree of damage. The CDC code consists of seven digits, which is characterized the location and extent of damage in an abbreviated format. Also, it can be presented about the collision type and severity for sedan, truck, and van (Society of Automotive Engineers International, 2017). The relationship between the damage to the occupants and the deformation of the vehicle was excluded from this study as a limited data.

3. Results

3.1. Accident report

On January 16, 2015, a 43-vehicle mass collision accident occurred at the 345 km marker of the Busan-bound direction of the Jungang Expressway at around 10 A.M. First, a passenger car slid and collided with the median, followed by an SUV colliding with the guardrail while avoiding the passenger car, which blocked the view of the road and led to a total of 43 collisions (Fig. 1).

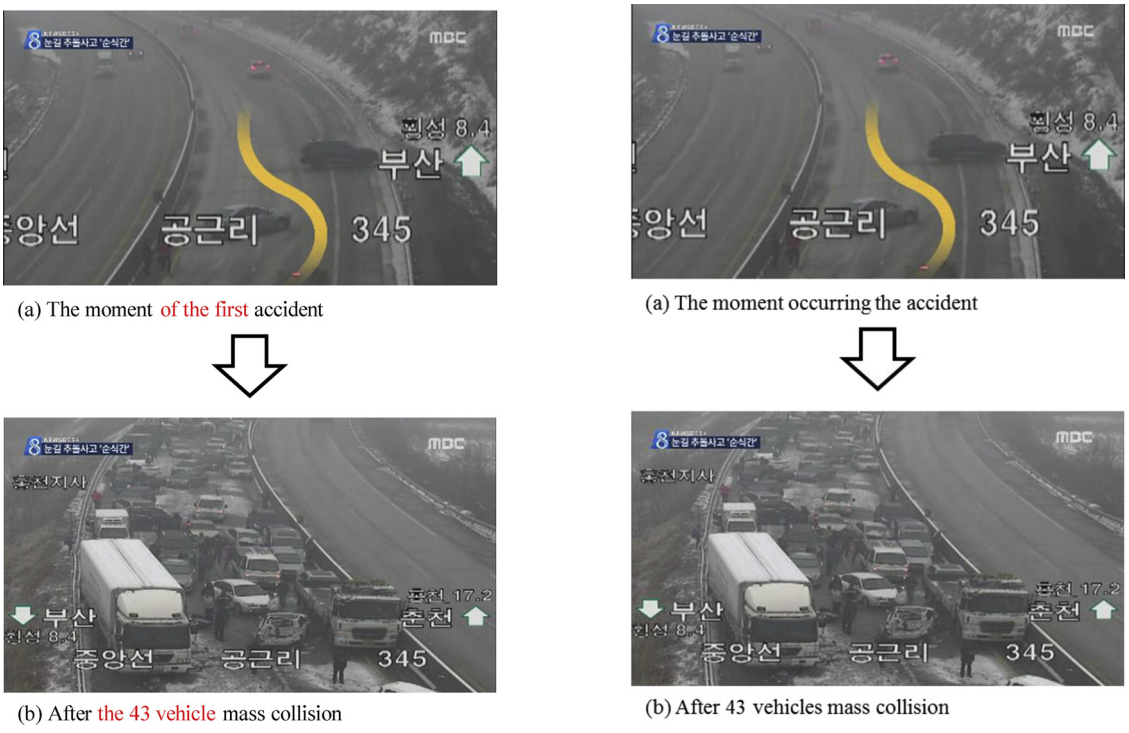

Fig. 1. Closed-circuit television (CCTV) recordings related to the mass collision.

3.2. Emergency Medical Service (EMS) response to the disaster

As shown in Table 1, the accident was first reported at 10:15 AM by a 119 emergency call. It was described to the NEMC as a 20-collision accident. At 11:10 AM, the Gangwon Aviation Medical Team notified that it could not operate in the low visibility (sight distance of 1600 m and snowfall), and at 11:15 AM it requested dispatch from the NEMC to Wonju Severance Christian Hospital. At 11:21 AM, the DMAT advance team (one doctor, two paramedics, and one nurse) departed to the scene of the accident. At 11:45 AM, the advance team arrived at the scene of the accident, followed by a second team (additional personnel). At 12:28 PM, patient information was transferred to four hospitals (Wonju, Hoengseong, etc.) via telephone (Table 2). After counting the final patient, DMAT was returned and the situation was terminated at 12:42 PM.

3.2.1. Safety

As soon as the accident occurred, the expressway manager, the police, and the 119 paramedics started managing the safety with the assessment of the accident and the location where the patients were. The drivers of traction vehicles helped to clear the scene by moving the vehicles and the police kept the scene safe while identifying the cause of the accident.

Most drivers involved in the accident, concerned about the potential for the additional collisions immediately after the collision, exited their cars, and evacuated to mountains outside the expressway. The on-site management of the accidents in premeditating for the constantly falling snow and cold was not prepared. Patients were assessed at the accident site only by 119 paramedics and then transferred to the hospital. Movement with uncontrolled number of accident cars and traveling route and so on was initiated and partial onsite control of the field conductor was done and management was not done accurately.

3.2.2. Incident command and communication

Generally, in case of mass casualty events, the field command center which controls all activities in the field is set up and consists of systematic reporting and control system under command. However, prior to the installation of on-site command post, the towing of the accident vehicle was started first, and the classification and transfer of 119 paramedics began without precise command system. Little cooperation was communicated, although there were 119 rescue teams, 119 emergency paramedics, DMAT advance team, police, highway patrols, drivers of towing vehicles and insurance research personnel at the work site.

3.2.3. Triage

The on-site severity and patient classification were conducted by 119 paramedics, patients preferentially classified in the middle ring

Table 1
Propagation and deployment of DMAT.

Time	Response
10:15	The first report of 20 vehicles mass collision accident to 119 dispatch center (local 119)
11:10	EMS-exclusive helicopter (Dr. Heli) not allowed to operate due to low visibility (sight distance 1600 m and snowfall) by the Gangwon Aviation Medical Team
11:15	National Emergency Medical Center (NEMC) requested to send DMAT from Wonju Severance Christian Hospital to the scene.
11:21	DMAT advanced team deployed
11:45	DMAT arrived on the scene, soon after the DMAT latecomer was deployed.
12:28	The NEMC shared information on patient transfer to each hospital
12:42	The DMAT returned and the NEMC reported that situation had ended.

* EMS: Emergency Medical Service, * DMAT: Disaster Medical Assistance Team.

Table 2
Classification of receiving hospitals and treatment of patients through DMAT.

Receiving Hospital	Distance (km)	Total No. of Patients	Results of Hospital Triage		
			Emergent	Non-emergent	Dead upon Arrival
Won-ju Severance Christian Hospital	27.1	4	2	2	–
Won-ju Medical Center	34.0	3	–	3	–
Sung-ji Hospital	27.5	15	–	15	–
Hoeng-sung Samsung Hospital	8.5	3	–	3	–
Nam-yang-ju Hanyang General Hospital	115.1	29	–	29	–
Total		54	2	52	–

were immediately brought to the nearest hospital. The information of the patients transferred to the hospital through paramedics was immediately known by the NEMC. However, it was difficult to grasp exact information on mass collisions such as the number of patients, transportation information, vehicle information, and vehicle movement route due to people who left without an accident statement in the field.

3.2.4. Treatment

Patient treatment occurred at the site was done by 119 paramedics. On site clinic, because the installation time was delayed and all patients who needed treatment on site were transferred to short distance hospitals, it was not done. Most occupants and injured people were required to wait in below freezing temperatures, before transport to nearby hospitals was arranged, due to a lack of adequately warm shelters set up by the emergency services. Many injured people were required to wait in their damaged vehicles.

3.2.5. Transport

The 119 paramedics found the patients from multiple areas at the accident site; they classified the severity of the patients' injuries and prioritized the transfer of patients who required hospital transport. Patients were transported by 119 public ambulance and private ambulance. Also, the remaining patients who required medical care were taken aboard tow vehicle or a vehicle which could drive in accident site. The uninjured persons who were related to the mass collision but not need hospital care escaped from the accident site with another vehicle that was not related to the mass collision after their vehicles were cleared. However, several patients have occurred in the field, and information on the route of casualties has not been obtained precisely.

3.2.6. Tracking

Information regarding the total number of accident vehicles in the field, the number of injured individuals, the movement routes, the vehicle tow routes, etc. was not obtained exactly. Because, in this case, the tow vehicle driver moved the accident vehicles outside the accident site first before upon the arrival of the police. From a medical point of view, 119 paramedics immediately transferred the patient to the hospital as appropriate. However, patient and vehicle information related to the mass collision was not well managed and all situations were closed and there was no further patient tracking.

3.2.7. Behavioral health response

The local emergency medical system did not offer psychiatric treatment or continued posttraumatic stress management other than to the accident patients who received medical treatment at the accident site.

3.3. Actual accident investigation process and result

After the mass collision accident, starting at 1:00 PM, the information on the storage place of the vehicles associated with the accident was obtained from the towing company, the 119 paramedics, the police, the car repair center, and the occupants of the accident vehicle. Of the 43 collision vehicles, 31 vehicles were real-world investigated except for 12 vehicles that were not towed due to minor damage. Sedan 13 (41.9%), SUV 11 (35.5%), Truck 4 (12.9%), Van 2 (6.5%) and one bus (3.2%). The patients were transferred to five hospitals and investigated through direct visits and telephone calls. However, it was different from the accident information obtained through the actual accident investigation and the patient information obtained from the National Central Emergency Medical Center. Accident vehicles were towed to 18 car repair centers in 7 local cities. We visited 15 centers in four cities, including 6 in Wonju, 1 in Hoengseong, 6 in Hongcheon, and 2 in Chuncheon, in order to collect incident data (Fig. 2).

3.4. Map of the accident scene

Of the 31 cars investigated in the actual accident, 23 vehicles showed large multiple collisions in three groups (Fig. 3–6). In addition, eight cars were investigated for accidents related to the accident, although the information was not linked to the three groups created earlier. Information on the vehicle and passengers is shown in Table 3.

3.5. Final transfer patient outcome

Unlike the NEMC report, we detected 72 injured patients on 31 damaged vehicles by phone, visit, and actual accident investigation. Of the 72 patients who were examined, 4 were severely injured and 68 were mildly injured. The median value of the age [lower quartile and upper quartile] was 43 [34.5–52] years old and the patients included 25 drivers, 11 passengers, 7 back seat passengers, and 29 bus passengers.

But, NEMC reported 54 patients transferred to five hospitals by 119 public ambulance, private ambulances, and personal vehicles. Accident information was described for 39 patients except for 15 patients who returned home immediately after receiving medical care at the emergency room (Table 3). Patients were classified according to sex, age, seating position, safety belt use, front and side airbag deployment, vehicle type, group which the vehicle occupants belonged to, CDC code, injury severity score, and admission status. The patients included 22 men and 17 women. Most of the patients (38, 97.4%) were fastening safety belt and 9 cases (23.1%) included the frontal airbag deployment. The types of cars included sedans (21), SUVs (10), light trucks (1), vans (4), and heavy trucks (3), and the mean ISS was 2 [1–3]. Patients with minor injuries generally returned home after personal care.

The injuries of patients were generally less severe compared to the degree of damage to the vehicles and the number of cars involved in the accident. It was likely because most of the individuals left their vehicles and fled the roadway immediately after the initial accident, so they might not be affected by the additional collisions. However, a woman left the damaged vehicle shortly after the accident and crashed into a truck oncoming from behind. As a result, she was transferred to a severe trauma patient, including traumatic brain injury. Her ISS was 17, and she had a severe facial bone fracture, multiple rib fractures, traumatic pneumothorax, multiple pelvic bone fractures and lower leg fractures. Most accident victims had to expose to the cold until they were transported. According to the accident parties who came to the hospital,

Fig. 2. Real-world investigated cities to collect incident data.

there was no appropriate response immediately after the accident; the injured people had been exposed to the cold weather for quite some time and had to escape to a less damaged vehicle and wait for the transfer after the risk of further collisions disappeared.

4. Discussion

The accident occurred on the occurrence of a vehicle slipping accident caused by the freezing of the expressway, the initial response of the accident was immature, and additional collision occurred continuously. After a collision with the initial slip, if the vehicle is moved quickly toward the outside of the highway, the continuous collision is

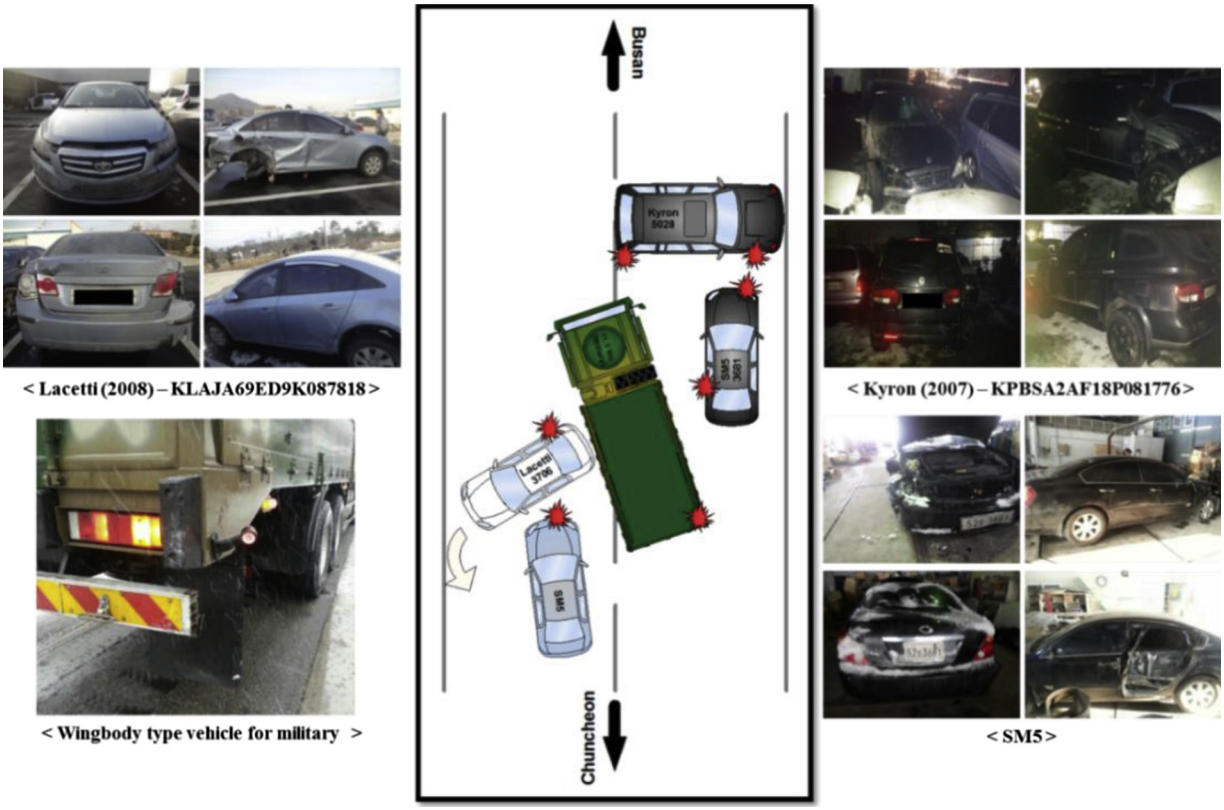

Fig. 3. Accident description of Group 1 in the mass collision.

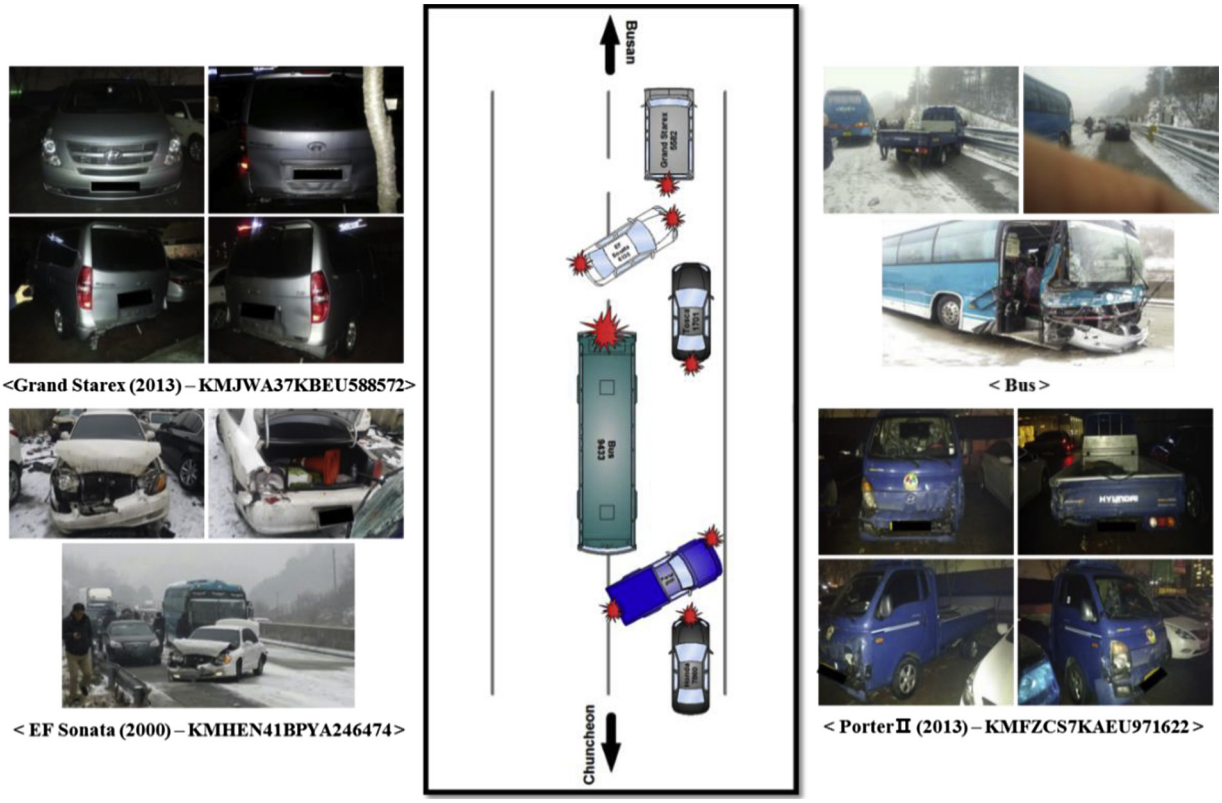

Fig. 4. Accident description of Group 2 in the mass collision.

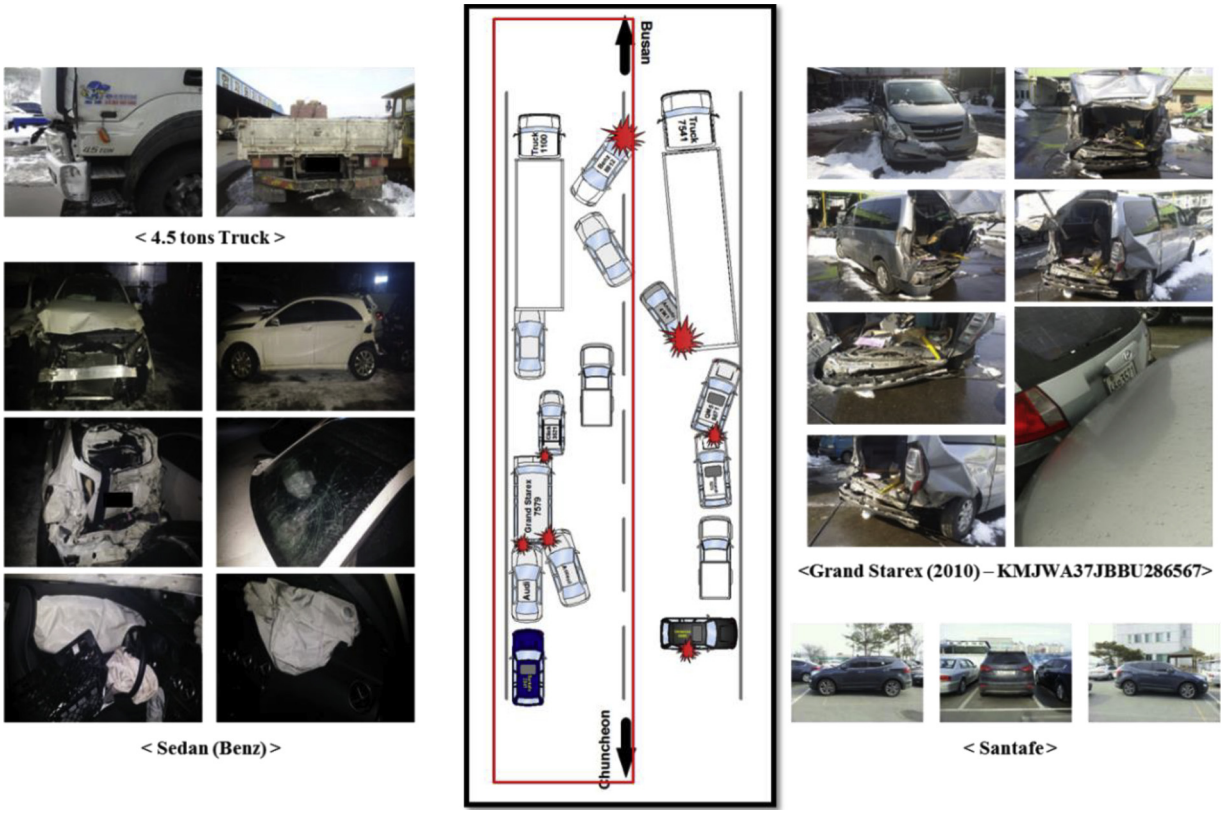

Fig. 5. Accident description of left-side of Group 3 in the mass collision.

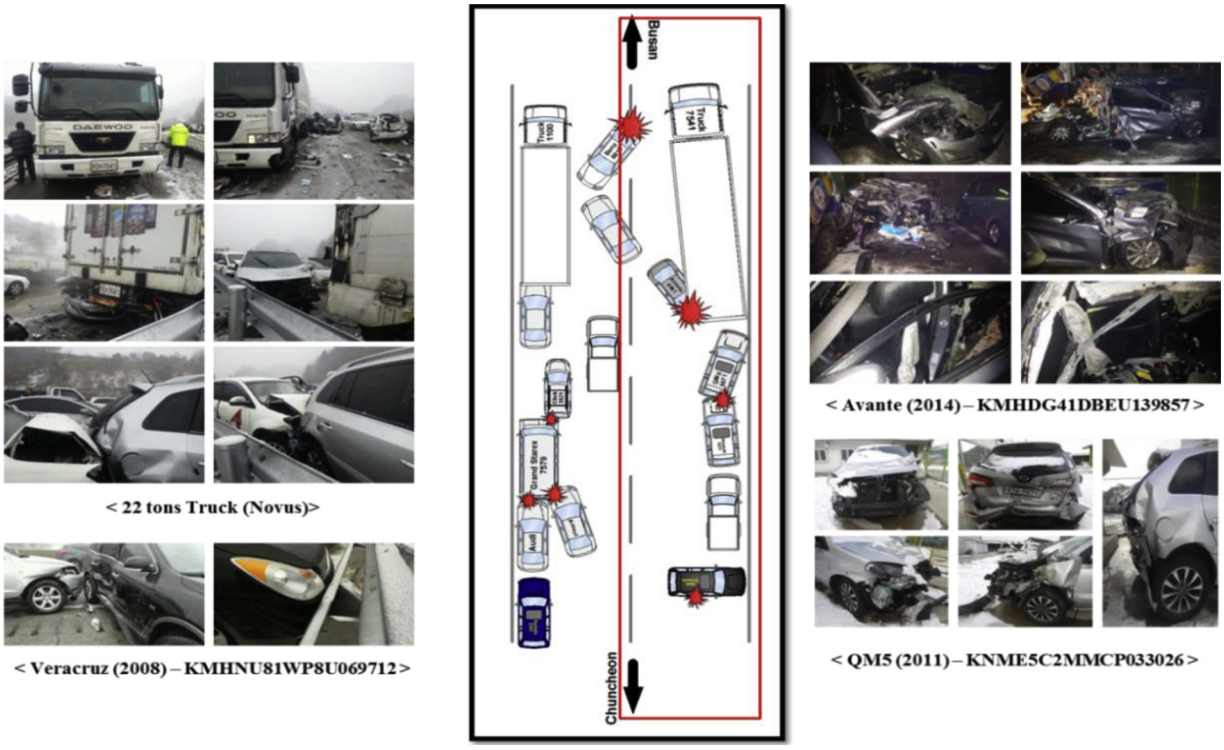

Fig. 6. Accident description of right-side of Group 3 in the mass collision.

less frequent. In a study by Nagatani et al., lane change caused accidents to decrease with early continuous collisions at highway, multiple collision accident (Nagatani and Yonekura, 2014).

Most injured patients quickly left the accident vehicle after the first collision and moved farther out of the way and further from the accident site. This reduces the risk of repetitive damage due to additional collisions. In this study, however, a woman emerged rapidly and became a severe trauma patient, including traumatic brain injury, due to a crash into a truck oncoming from behind.

Multiple collision accidents, unlike single impact crash, had a higher risk of severe injuries with complex collision mechanisms (Bahouth and Digges, 2005). Also, an injury might be increased due to multiple collisions rather than a single collision. In order to investigate the collision accident between two vehicles in general, only two vehicles could be investigated in order to investigate the collision mechanism and the injury mechanism. However, multiple collision accidents could be understood by examining and analyzing as many vehicles as possible before and after complicated collision. In case of this mass collision accident, the DMAT departed immediately after the dispatch request, but it was only 30 min after the accident that it was possible to reach the scene and after many vehicles had already been moved. This made it difficult to grasp the precise location of the vehicle after the accident and to fully understand the mechanism of the mass collision. If a complex collision mechanism could be understood in multiple collision accidents, it would be possible to develop an initial response manual to prevent further damage.

For studies such as Bradford, manuals should be developed for accident prevention and safety on expressways, and in order to prevent recurrence, it is necessary to know the cause (what, how, why) related to the accident continuously We pursued tracking and said that they had to proceed with several methods (American Association of State Highway and Transportation Officials, 2010; Brimley et al., 2012; Sun et al., 2014). After accepting the declaration, the dualized dispatch system of 119 EMS team, disaster medical team of Central Emergency Medical Center was utilized. However, due to the lack of cooperation and communication between the field activists (police, drivers of the towing vehicles, 119 teams, police, disaster team), there was confusion in patient site management and casualties information management. Studies by John and others suggested that communication between the role of ICS and multiple related organizations operating in the field is necessarily important for effective management at the time of disasters and many casualties (Hick et al., 2008).

And on the scene, despite many casualties, the patient trembled in the cold at the scene due to lack of emergency medical personnel and facilities utilized in the area. Cha et al. (2016) suggested that trained personnel and equipment should be equipped in the local system in order to operate the safety system to prepare for the occurrence of many casualties such as disaster. In the field, there was a problem that the counting of the accident handling process, the total number of patients, the number of transferred patients, the transfer means, the transfer hospital, and the patient's condition were different from the actual research. As shown in the results of this study, the information about the accident scale and the number of patients identified by the NEMC and the one about the number of patients obtained through actual investigation immediately after the accident were different. This could be explained by how quickly the on-scene command system is established, the site is directed, and the information to be grasped depends on the evaluation by the field activity experts and the classification of the patient's severity. It is known that situation control and information gathering occurred at the time of an accident and the command of all the activities are controlled at the site command center (Hong et al., 2014; Zengin et al., 2015). Gomez et al. (2011) suggested that the role of ICS in the field should be prompt and accurate in the event of a disaster to prevent confusion and operate as a systematic management system.

It is necessary to determine who will take command in the field, how to cooperate with the relevant organizations, and how to effectively communicate for on-site control and management, as revealed by the problems experienced in the present accident. The problem that arises from mass collisions on local expressways is the lack of personnel, equipment, and response manuals required by the local emergency medical service 119 to be prepared for these situations, as well as the

Table 3
Details of the vehicle's damage and the occupant's condition from the actual investigation.

Sex	Age	Seating Position	Safety Belt	Front Airbag	Side Airbag	Vehicle Type	Group	CDC Code	ISS	Progress
F	32	1	1	2	3	2	1	02RFEW2	3	Discharge
F	28	1	1	1	3	1	4	12FYEW3	1	Discharge
F	14	2	1	1	3	1	4	12FYEW3	1	“
F	1	3	1(CRS)	3	3	1	4	12FYEW3	–	“
M	31	5	1	3	3	1	4	12FYEW3	1	“
M	4	4	1	3	3	1	4	12FYEW3	–	“
F	31	4	1	3	3	2	3	12FDEW2	2	Transfer
F	52	2	1	1	1	1	3	06BDAW9 / 12FDHW8	17	GW
F	52	1	1	1	1	1	3	06BDAW9 / 12FDHW8	1	GW
F	57	3	1	3	3	1	3	06BDAW9 / 12FDHW8	2	GW
F	46	4	1	3	3	1	3	06BDAW9 / 12FDHW8	1	GW
M	58	1	1	1	3	2	4	–	14	ICU
M	42	1	1	2	3	4	2	06BDEW1	3	GW
F	45	1	1	2	3	1	2	12FDEW2 / 06BDEW1	–	“
M	50	2	1	3	3	1	2	12FDEW2 / 06BDEW1	–	“
M	56	1	1	2	3	3	2	12FDEW2 / 06BDEW1		“
M	55	1	1	1	3	1	2	–	2	GW
F	54	2	1	1	3	1	2	–	1	“
F	43	1	1	2	3	2	3	06BRES1 / 09LFEW1	1	“
F	43	2	1	3	3	2	3	06BRES1 / 09LFEW1	3	GW
F	43	4	1	3	3	2	3	06BRES1 / 09LFEW1	1	“
M	49	1	1	1	3	4	3	12FREW1 / 06BZEW3	2	GW
M	40	2	1	3	3	4	3	12FREW1 / 06BZEW3	–	“
M	52	3	1	3	3	4	3	12FREW1 / 06BZEW3	–	“
M	38	1	1	3	3	2	3	–	–	“
M	44	2	1	1	1	1	3	12FDEW2 / 06BDAW7	1	“
M	68	1	2	3	3	1	4	12FDEW2	10	GW
F	64	2	1	3	3	1	4	12FDEW2	1	Discharge
M	40	1	1	2	3	1	4	06BDEW5	2	GW
M	27	1	1	2	3	2	3	03RPEW2	2	GW
M	44	1	1	2	3	1	1	12FLEW2 / 08BPAW1	x	Discharge
F	52	1	1	2	3	1	4	12FREW2	3	GW
M	36	1	1	–	–	2	3	12FYEW3 / 06BDEW3	–	Discharge
M	38	1	1	3	3	6	3	06BDLW1	–	Discharge
F	44	1	1	–	–	1	4	07BLEE5 / 01FREE1	–	Discharge
M	47	1	1	–	–	2	4	12FREE1 / 09LYEW3	–	Discharge
M	36	2	1	–	–	6	1	02RBME1	–	Discharge
M	29	1	1	–	–	6	1	02RBME1	–	Discharge
M	33	1	1	1	3	1	1	04RZEW2	—	Discharge

* Sex: F-Female, M-Male * Seating Position: 1-Driver, 2-Front-seat passenger, 3-2nd-row left-seat passenger, 4-2nd-row right-seat passenger, 5-2nd-row middle-seat passenger * Safety belt: 1-Yes, 2-No * CRS: Child Restraint System.
* Front Airbag: 1-Yes, 2-No, 3-Unknown * Side Airbag: 1-Yes, 2-No, 3-Unknown.
* Vehicle type: 1-Sedan, 2-SUV, 3-Light truck, 4-Van, 5-Bus, 6-Heavy truck * Group: 1-Vehicle occupants belonging to Figure 3, 2-Vehicle occupants belonging to Figure 4, 3-Vehicle occupants belonging to Figure 5 and Figure 6, 4-Others.
* ISS: Injury Severity Score * ICU-Intensive Care Unit, GW-General Ward.

lack of a unified response system that consults with the police, the highway control station, and the tow vehicle drivers. In order to reduce the incidence of additional accidents, preventive measures are needed. In the event of mass collision accidents on the expressway, it is necessary to continuously develop and educate individuals on the initial response and methods for impact mitigation in case of collision, the rapid approach in narrow road conditions. Based on the results of this study, further studies on vehicle collisions human injuries are necessary through additional data collection.

5. Limitation

The purpose of this study was to analyze the accident management system through real investigating the multiple collision. But, we could not complete the investigation of all damaged vehicles and all injured patients. So, we could not analyze the complex mechanism of multiple impact collisions and accident management system in Korea.

6. Conclusion

Patient analysis showed that 3 patients had higher ISS score only in the passenger car, and the severity of the patients was higher in the first collision group during the first and second collision. After the first impact, the injured patient is better to leave the damaged vehicle for avoiding the additional collision in multiple impact collision. But in some situation, the leaving the damaged vehicle to induce severe pedestrian injury by another car.

In the event of a disaster, various teams from the police team, firefighting team, DMAT, EMS, road management team are gathered, and communication and command system between each team is important in order to identify and solve the disaster situation. To do this, it is important to develop manuals and prepare for training through repeated simulations.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.aap.2018.11.004.

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