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Selected Topics: Prehospital Care

DISPATCH OF HELICOPTER EMERGENCY MEDICAL SERVICES VIA ADVANCED AUTOMATIC COLLISION NOTIFICATION

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☐ **Abstract—Background: Advanced automatic collision notification (AACN) is a system for predicting occupant injury from collision information. If the helicopter emergency medical services (HEMS) physician can be alerted by AACN, it may be possible to reduce the time to patient contact. Objective: The purpose of this study was to validate the feasibility of early HEMS dispatch via AACN. Methods: A full-scale validation study was conducted. A car equipped with AACN was made to collide with a wall. Immediately after the collision, the HEMS was alerted directly by the operation center, which received the information from AACN. Elapsed times were recorded and compared with those inferred from the normal, real-world HEMS emergency request process. Results: AACN information was sent to the operation center only 7 s after the collision; the HEMS was dispatched after 3 min. The helicopter landed at the temporary helipad 18 min later. Finally, medical intervention was started 21 min after the collision. Without AACN, it was estimated that the HEMS would be requested 14 min after the collision by fire department personnel. The start of treatment was estimated to be at 32 min, which was 11 min later than that associated with the use of AACN. Conclusions: The dispatch of the HEMS using the AACN can shorten the start time of treatment for patients in motor vehicle collisions. This study demonstrated that it is feasible to automatically alert and activate the HEMS via AACN.** © 2016 Elsevier Inc.

☐ **Keywords—trauma system; helicopter emergency medical services; automatic collision notification; intelligent transportation system**

INTRODUCTION

In most developed countries, emergency medical services (EMS) use of helicopters is common. Generally, these services are called "air ambulance" or "helicopter emergency medical services" (HEMS). In Japan, HEMS crew configuration includes onboard physicians who are dispatched to the scene to provide medical treatment expeditiously (1–3). Japan's approach of including physicians in the HEMS crew differs from that in the United States, but is similar to many European HEMS programs (4–7). Needless to say, medical interventions should be initiated as soon as possible in cases of severe trauma (8–10). To achieve this goal, various types of medical intervention should be initiated before arrival at the emergency department (ED).

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Automatic collision notification (ACN) is an intelligent transportation system (ITS) that provides the car's location using airbag sensors in the car, along with a global positioning system (GPS). Automakers have been developing this technology as advanced ACN (AACN). This system has been designed to enable early recognition of vehicle collisions and prediction of the degree of occupant injury based on collision information, such as impact direction, speed, delta-V (difference in velocity change), number of occupants, rollover, and other data (11,12).

If HEMS with an onboard physician can be alerted by the AACN, it may be possible to reduce the time for HEMS contact. This might lead to improved rates of survival for severe trauma patients. The purpose of this study, therefore, was to validate the feasibility of early HEMS dispatch via AACN.

METHODS

Japanese HEMS System

As a national project under the direction of the Ministry of Health, Labor and Welfare, the Japanese HEMS system was developed based on ADAC in Germany, REGA in Switzerland, and the London HEMS in the United Kingdom (4–7). Since 2001, the HEMS system has been established at 47 bases across Japan; however, nationwide coverage has not yet been achieved. In this system, a helicopter is specially configured for EMS, and helicopter personnel include an onboard physician and nurse. Helicopter personnel are alerted by a direct call from the dispatch center at the fire department (FD) or by an emergency medical technician (EMT) at the scene, and the helicopter is airborne within a few minutes after receiving the call. The helicopter lands at the scene or at a designated temporary heliport, such as a public park, athletic field, or schoolyard nearest the scene. The physician and flight nurse conduct airway management, fluid resuscitation, administration of drugs, and some surgical interventions at the scene or in an ambulance parked at the temporary heliport. Then, the patient is transported to the hospital by helicopter or ambulance. The Japanese HEMS system was founded by the central and local governments with a budget of approximately $1.6 million per year per base hospital. There are no accurate data regarding the percentage of responses that need physician-level care; however, 19.9% of all HEMS missions nationwide were dispatched to the scene of traffic accidents in 2013.

Car Crash Test

A full-scale car crash test was conducted with the use of HEMS and a test car equipped with an AACN system to develop a new approach for a HEMS alert system, according to the experimental flow shown in Figure 1. The study was planned and conducted in collaboration with the Specified Nonprofit Organization of Emergency Medical Network of Helicopter and Hospital (HEM-Net); Toyota Motor Corporation; the Japan Automobile Research Institute (JARI) to conduct the crash test; the Tsukuba FD located nearby JARI; and HELPNET, a private emergency call center. The trauma center of the author's facility is a base hospital for the HEMS base and receives approximately 1,200 requests annually.

The car (Toyota Crown Majesta) equipped with an AACN system was collided head-on against a wall at 50 km/h (32 miles/h) at the JARI crash test facility. Two dummies (HYBRID-III AM50 as a passenger with a seat belt and HYBRID-III AF05 as a driver without a seat belt) were seated in the vehicle. Immediately after the collision, the helicopter with an onboard physician and a nurse on standby at the HEMS base was alerted via the operation center of HELPNET based on the AACN information (Figure 2). The algorithm of AACN developed by Toyota Motor Corporation in collaboration with Wake Forest University was adopted to predict the injury severity of the occupants (13). The helicopter took off from the base hospital while Tsukuba FD personnel were dispatched to the scene and transported the patient (a dummy) to a temporary helipad that was prepared near the crash test facility at JARI. The helicopter landed after the FD ensured the safety of the site, and the medical staff started treatment in the ambulance before transporting the patient to the base hospital by helicopter (Figure 3A).

The actual times were recorded for each segment of the Tsukuba FD and the HEMS response. The estimated times (typical mean times in real life) were set at 5 min for notification of the FD and 7 min for the arrival of EMT personnel at the scene of the collision. These times were based on routine emergency cases in which the HEMS was requested via the FD without use of AACN (Figure 3B). Then, the recorded elapsed time from the test was compared with the estimated time after the full-scale test.

RESULTS

The actual times are shown in Table 1. HELPNET received information via the AACN 7 s after the collision, and the "119" call (corresponding to "911" in the United States) from the HELPNET operator to the Tsukuba FD was made 1 min later. Then, the HEMS was requested via the hotline of the HEMS base 3 min later. The HEMS departed 7 min after the accident and arrived at the temporary helipad 18 min afterward (11 min flight time). Medical intervention was finally started 21 min after the collision.

Without AACN, the times were estimated to be 5 min before the 911 call would be received by the Tsukuba FD

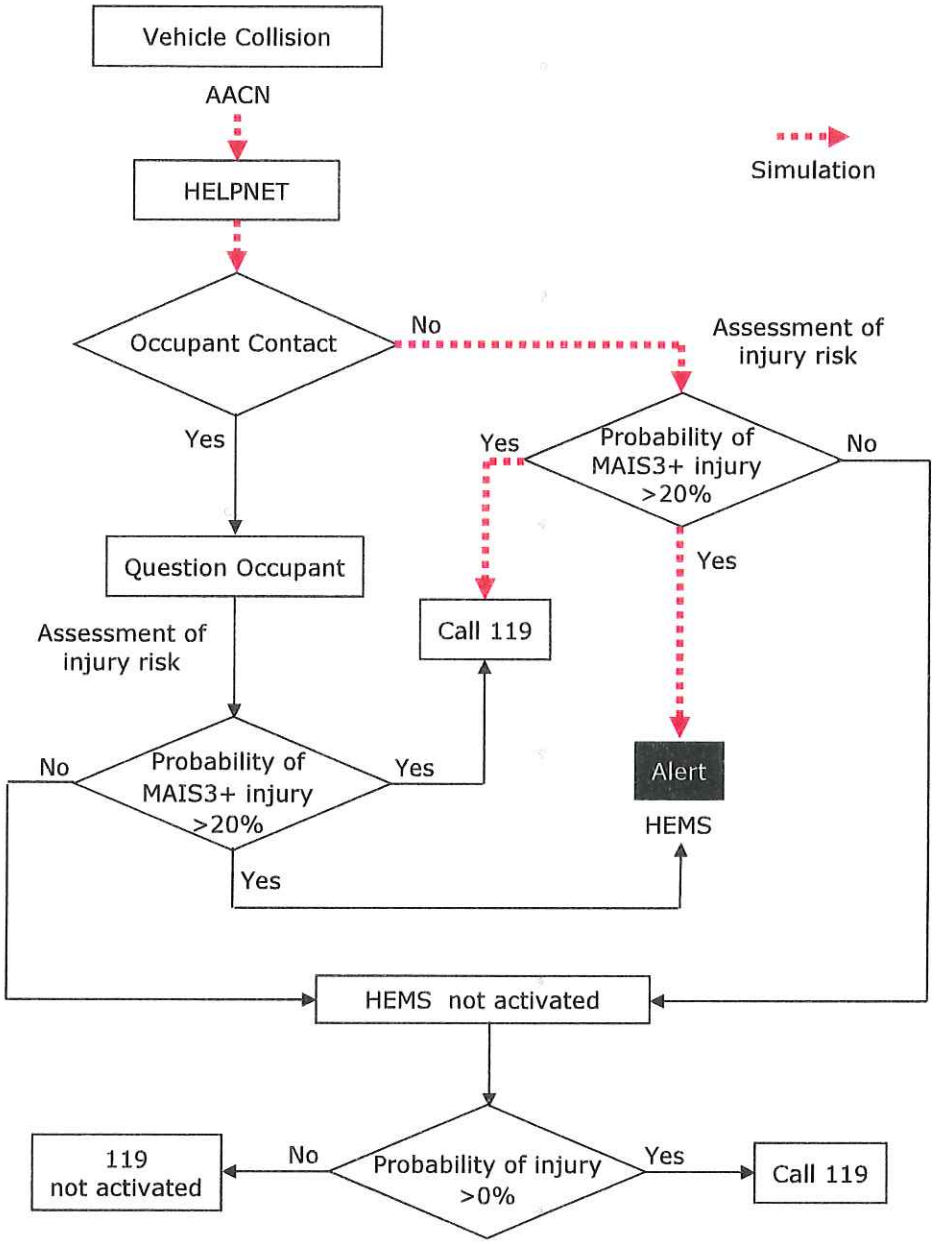

Figure 1. Helicopter emergency medical services activation protocol using the advanced automatic collision notification system. 119 corresponds to 911 in United States, AACN = advanced automatic collision notification, HEMS = helicopter emergency medical services, MAIS3+ = maximum abbreviated injury score 3 or more in 6 ranks.

and 14 min for EMTs at the scene to request the HEMS. In addition, the start of medical intervention was estimated to be 32 min after the collision, 11 min later than that with AACN.

DISCUSSION

HEM-Net and Toyota Motor Corporation planned this study. This was the first full-scale validation test linking ITS and HEMS to clarify the effectiveness and feasibility of HEMS alert by an AACN system installed in a car. This study showed that HEMS activation via AACN has the potential to reduce the time for the HEMS response.

It is recommended that the time from occurrence of the crash to EMS notification should be < 1 min, but the mean time from occurrence of the car crash to EMS notification is 5 min (range, 1–22 min) based on the 2008 traffic accident investigation report of Chiba Prefecture in middle-eastern Japan (14,15). In addition, the mean interval from EMS crash notification to alerting HEMS,

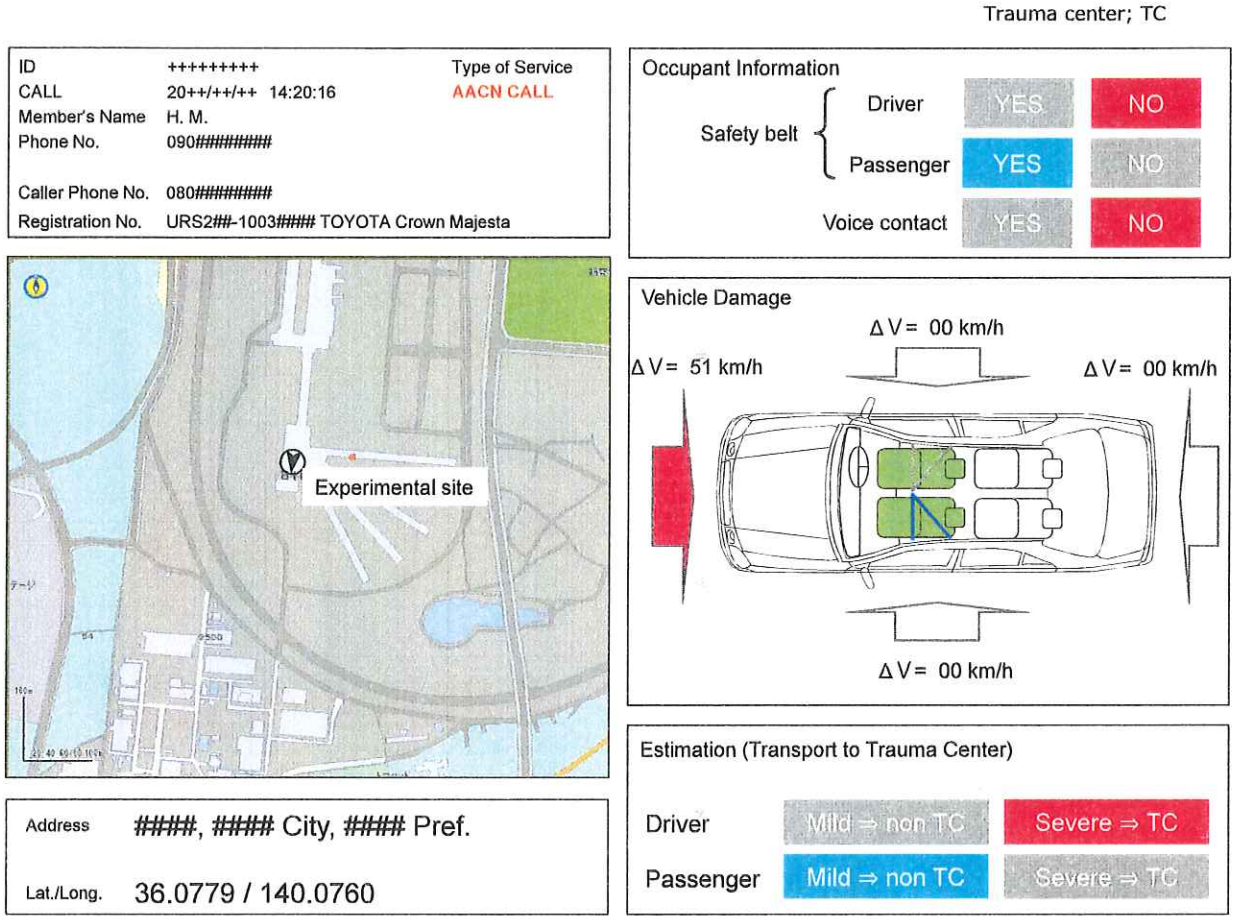

Figure 2. The screen of advanced automatic collision notification information. AACN = advanced automatic collision notification; TC = trauma center.

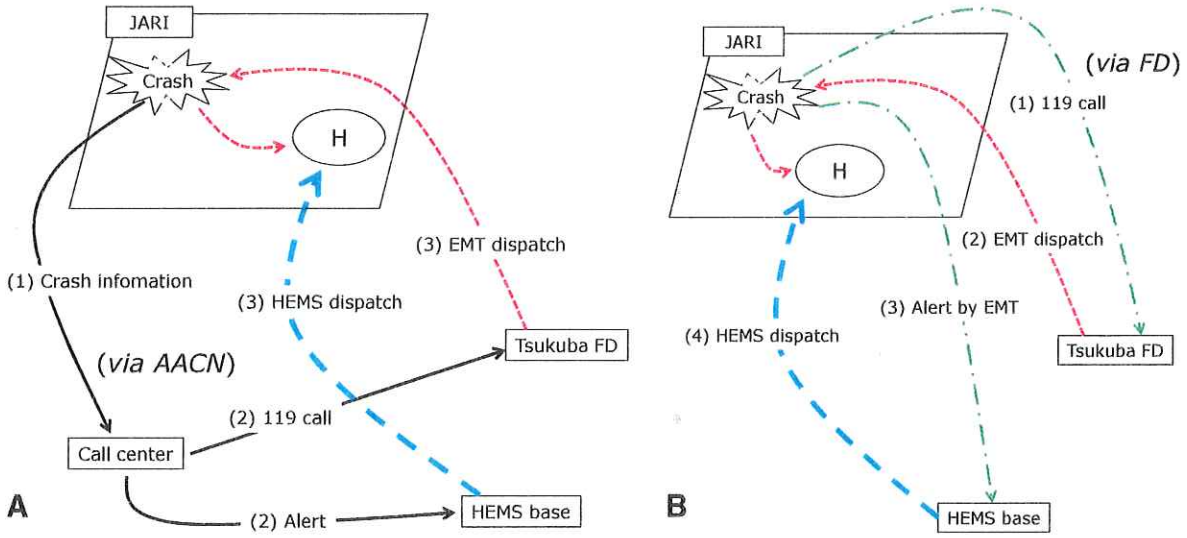

Figure 3. (A) Flow of helicopter emergency medical services (HEMS) alert via advanced automatic collision notification (AACN). (B) Flow of HEMS alert by emergency medical technician (EMT) at the scene. FD = fire department. 119 corresponds to 911 in United States. H = hospital.

Table 1. Actual and Estimated Elapsed Times

Event	Actual Time	Elapsed Time (min)
Actual Times for HEMS Alert Via AACN		
Experiment started	14:20:00	
Collision	14:20:16	0:00
HELPNET received AACN data	14:20:23	0:07
Voice contact by HELPNET	14:20:36	0:20
HELPNET contacted the FD	14:20:48	0:32
FD notified of the accident	14:21:00	1:00
HELPNET contacted the Hokusoh HEMS	14:22:36	2:20
FD dispatcher command sent to EMT HEMS alerted	14:23:00	3:00
EMT dispatched to the scene	14:24:00	4:00
HEMS departed	14:27:00	7:00
FD arrived at the scene and patient care started	14:30:00	10:00
EMT departed the scene	14:35:00	15:00
HEMS arrived at the TH	14:38:00	18:00
Treatment started	14:41:00	21:00
Patient transferred to the helicopter	14:50:00	30:00
HEMS departed the scene	14:53:00	33:00
HEMS landed at the hospital	15:04:00	44:00
Experiment ended		

Event	Estimated Time	Elapsed Time (min)
Estimated Times for HEMS Alert by EMT at the Scene		
Estimation start	14:20:00	
Collision	14:20:00	0:00
FD notified by 119 call	14:25:00	5:00
EMT dispatched to the scene	14:27:00	7:00
EMT requested HEMS HEMS alerted	14:34:00	14:00
HEMS departed	14:38:00	18:00
HEMS arrived at TH	14:49:00	29:00
EMT arrived at the TH Treatment started	14:52:00	32:00
Moved patient to the helicopter	15:01:00	41:00
HEMS took off	15:04:00	44:00
Estimated times for HEMS alert by EMT at the scene	15:15:00	55:00

AACN = advanced automatic collision notification; EMT = emergency medical technician; FD = fire department; HEMS = helicopter emergency medical services; TH = temporary helipad. 119 corresponds to 911 in United States.

helicopter departure, and arrival at the scene was 15 min, 19 min, and 31 min, respectively (15). In other words, the time taken by medical staff to reach the scene and start medical intervention is unacceptably long. This is a serious problem that negates the advantages of the HEMS system.

ACN in ITS technology was launched as the automotive telematics service known as OnStar (services that support and provide information using a communication system) by U.S. General Motors Company in their automobiles in 1996. Vehicles that run off the road or crash in rural areas can be difficult to see (14). In such situations, the ACN system automatically reveals the crash site for emergency services using GPS, even if the crashed vehicle is out of sight from the road. Some automakers have been developing an ACN system that provides integrated telematics through a voice link to the occupants to gather information. In the United States, it is estimated that broader implementation of the ACN will reduce the number of road fatalities per year by approximately 12% in rural areas and 1.5% to 6% nationwide (16,17).

AACN is the successor to ACN. Improvements were made in the provision of various data (e.g., impact direction, speed, delta-V, number of occupants, and rollover data) and airbag implementation, and information on whether the occupants were wearing seat belts is sent from the event data recorder (EDR) placed in a car. These data are calculated instantly by sophisticated algorithms in AACN after the crash, and results of injury prediction can be sent not only to the EMS system, but also directly to trauma centers (13). In the United States, the development of a system called URGENCY is underway and consists of an AACN integrated with an EDR to predict the severity of occupant injury using a logistic regression model (11,18). Augenstein et al. reported that URGENCY information on crash severity can help dispatchers decide on the necessary actions to take instantly and automatically, which will assist with the preparation of appropriate resources, such as extrication equipment for severe crashes. On-site deaths were reported to be 40% when the 911 call is received within 1 min after the accident, but unfortunately, 54% of crashes takes > 10 min before the 911 call is received (14). If the severe trauma victim can be stabilized and transported to a trauma center in a shorter period of time, outcomes are likely to improve (19).

Adopting "vehicle telemetry data consistent with high risk of injury" in Step 3 was a major topic in the 2006 revision of the Center for Disease Control and Prevention guidelines (12). It could be assumed that the development of infrastructure for data transmission and spread of EDR use in vehicles made it possible. Adding vehicle telemetry data to field triage criteria is becoming common in Europe and the United States (20). The algorithm of AACN developed by Wake Forest University and Toyota Motor Corporation provides a tool for increasing the effectiveness of crash notification and triage assessment of the occupants involved in motor vehicle crashes.

When the HEMS is alerted by the FD dispatch center based on a 911 call, the HEMS staff might have limited information of the accident. However, if the HEMS are dispatched by the algorithm based on more accurate data compared with information obtained from a 911 call, we can eliminate cancellations or overtriage in the

use of the HEMS. There is a strong advantage in alerting the HEMS via the AACN system.

LIMITATIONS

There are some limitations in this study. First, this experiment revealed that medical intervention with the use of AACN was initiated 11 min earlier than the mean estimated time without the use of AACN. However, it is difficult to compare the times recorded in a single experimental use of the AACN under controlled situations with the mean time under real-world conditions. Repeated examinations would be desirable, but another full-scale car crash test is unlikely because of the lack of funds. Second, two variables (i.e., time from the collision to EMT arrival at the scene and transport time from the scene to the temporary helipad) were assumed to be constant in calculating the actual elapsed time of the HEMS activation via AACN. Furthermore, the time course in cases where the HEMS was dispatched without AACN was calculated using data based on the regular emergency response. Third, the experiment (excluding the collision) was performed on the JARI premises according to the regulations of the road traffic law and the civil aeronautics law, which would not accurately reflect the real-world HEMS situation.

HEM-Net and Toyota Motor Corporation are preparing to carry out the public operation of the HEMS alert via AACN nationwide from late 2015. Honda Motor Corporation, Ltd., one of the giant automakers in Japan, also plans to equip the EDR with AACN in one of their vehicles. Further research is needed to evaluate whether combining AACN and HEMS can reduce mortality and morbidity of severe trauma patients.

Finally, this study was partially funded by Toyota Motor Corporation as a project titled "Study of Development for HEMS System Alerted by AACN" with their acknowledgement, but they had no involvement in the study design and measurement.

CONCLUSIONS

We have demonstrated that it is feasible to automatically alert and activate the HEMS via AACN. Directly alerting the HEMS via AACN is expected to play an increasingly important role in emergency medical care for patients with life-threatening trauma. Further research into combined AACN and HEMS is expected to reduce mortality and morbidity.

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