PILOT STUDY ON ADVANCED AUTOMATIC COLLISION NOTIFICATION AND HELICOPTER EMERGENCY MEDICAL SERVICE SYSTEM IN JAPAN

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ABSTRACT

This paper focuses on the pilot study on Advanced Automatic Collision Notification (AACN) and Helicopter Emergency Medical Service (HEMS) systems in Japan. The pilot study was carried out in Chiba prefecture by the AACN Committee in affiliation with Emergency Medical Network of Helicopter and Hospital (HEM-Net).

There were many opinions that Japanese accident data was preferable to develop a Japanese AACN algorithm. Then, the Occupant Injury Predict Algorithm newly developed by Nihon University was utilized for the study. About 2.8 million Japanese accident data (so called ITARDA Macro Data) were used to define logistic regression risk curves of fatal and severe injuries to car occupants. To validate this algorithm, the in-depth accident case study by Nihon University and Nihon Medical University at the Chiba Hokusoh Hospital was used. Moreover, to decide the threshold value, this in-depth accident study was also used.

Regarding the AACN prototype system, HELPNET infrastructures already developed for existing Japanese ACN service were used for sending vehicle data to the HELPNET center. In the simulated accident, Event Data Recorder (EDR) data was added on usual HELPNET data and transmitted from a car to a HELPNET server at the HELPNET center. The AACN server got vehicle data such as Delta V and seatbelt status as input to the algorithm.

The result was transmitted to a Tablet PC at the Fire Department Head Quarters and Chiba Hokusoh hospital simultaneously. An operator of HELPNET made an Emergency Call to both the Fire Department and Hokusoh hospital individually.

In case of severe injury, a Tablet PC indicated the situation and a doctor dispatched to the accident spot by a helicopter. After a helicopter with a doctor took off, verbal communications between the helicopter and Fire Department started to decide a rendezvous point nearby the crash spot. After landing, the doctor contacted the injured occupant who was carried by an ambulance there. The AACN prototype system for a limited area, only in Chiba prefecture, was developed.

AACN transmitting tests were carried out at some spots in Chiba prefecture within the jurisdiction of two headquarters individually. The prototype AACN system operated as intended. Within a minute from the airbag deployment signal, the algorithm result screen arrived simultaneously on AACN Tablet PCs at Chiba Hokusoh hospital, Chiba prefecture Fire Department H.Q. and also at the transmitting spot. The next step of AACN transmitting test should be that AACN activates HEMS of Chiba Hokusoh hospital. To expand cover area in Japan, collaborations of other HEMS base hospitals in other prefectures should be planed soon.

INTRODUCTION
In Japan, casualties of traffic accidents are recently decreasing. According to the National Police Agency, 573,824 traffic accidents occurred in Japan in 2014. Comparing with 2012, this was a decrease of 55,179. These crashes killed 4,113 peoples (decrease of 260) and injured 711,374 people (decrease of 70,120). Since 2004, the decreasing trend seems to continue, however, the situation is still serious [1].

Under continued conditions, it would be very difficult to achieve Japanese Government Target, which was that the traffic accident fatalities in Japan should be 2,500 or less by 2018 and realize the safest road traffic society in the world by 2020, decided in the Cabinet in 2013.

**Automatic collision notification (ACN)**

To decrease casualties of motor vehicle crashes, many technologies such as pre-crash and post-crash seem to be effective. Beside such technologies, collision notification technologies are also helpful to decrease dispatch of emergency medical service (EMS). In Japan, an automatic collision notification (ACN) service called HELPNET started in 2005. The scheme of HELPNET is provided in Figure 1.

![Figure 1. Existing ACN service in Japan](image)

In case of a collision with airbag deployment, the ACN system automatically contacts the HELPNET center and collision information such as airbag deployment data and Global Positioning System (GPS) data are sent to HELPNET server. An operator of HELPNET calls drivers of vehicles with a deployed airbag using a Digital Communication Module (DCM). If there is no answer from the driver, the operator calls the nearest Fire Department Head Quarter.

**Advanced automatic collision notification (AACN)**

Life saving potential of an advanced automatic collision notification (AACN) system is expected in Japan[2,3].
The scheme of AACN and HEMS system is provided in Figure 2. In December, 2011, the authors carried out a demonstration test of AACN and HEMS system at a test site of the Japan Automobile Research Institute (JARI). A crash test using a prototype vehicle with an AACN system was carried out. The vehicle with dummies struck a crash barrier at 50 kph. EDR’s data was transmitted to the server. Occupant Transportation Decision Algorithm (OTDA) of Wake Forest University [4] used these data to determine the kind of hospital to which the injured driver is to be transferred. From Chiba Hokusoh hospital, a helicopter with a doctor took off and landed at a rendezvous spot next to the barrier. The doctor contacted the dummy representing an injured driver after 21 minutes from the collision.

Three years have passed from this demonstration test. An AACN committee in affiliation with Emergency Medical Network of Helicopter and Hospital (HEM-Net) continued activities to realize AACN and HEMS systems in Japan. Dr. Mashiko was the chairman of the committee and all authors of this paper were involved in activities targeting a real service of AACN and HEMS systems in Chiba prefecture.

OBJECTIVES

The objectives of this study were to develop AACN and HEMS systems, using infrastructure already prepared for the existing ACN (HELPNET) service. At the beginning, after the development of the system, some real accident cases were considered to be used to examine real effectiveness of AACN and HEMS system. However, there were many restrictions of a real accident case usage without proper amendments of the terms of HELPNET service. Then, the study using real accidents was abandoned and the study of data transmitting simulation in Chiba prefecture for HELPNET, Chiba Fire Department. H.Q. and Hokusoh hospital was planned.

METHODS

To develop AACN and HEMS systems in Japan, the principal elements are described individually in the following.

Algorithm to estimate occupant injury

In this study, the TOYOTA-Nihon University algorithm was developed and utilized [5]. For the demonstration at JARI in Dec. 2011, OTDA developed by Wake Forest University was used. It was developed based on NASS-CDS data. Recently, at JSAE GIA Forum and JSAE comitee on the AACN, many attendees eager to develop Japanese algorithm made by Japanese accident data[2,3]. About 2.8 million of accidents from ITARDA Macro Data in Japan were used to define logistic regression risk curves of fatal and severe injured car occupants. Risk factors of the algorithm are summarized on Table 1. In order to validate this algorithm, combined data from the hospital based in-depth accident study by Nihon University and Nihon Medical University at the Chiba Hokusoh Hospital was used.

Table 1.

TOYOTA-Nihon University Algorithm used for the pilot study in Chiba prefecture.
Examples of major risk curves are provided in Figure 3. These curves depict injury probabilities for Frontal impact without seatbelt, Frontal impact with seatbelt and Near Side impact with seatbelt. For a delta V of 40 kph, the risk of fatal and severe injury was 53%, 16% and 25%, respectively.

![Figure 3. Risk curves of the algorithm used for the pilot study](image)

**Figure 3. Risk curves of the algorithm used for the pilot study**

**Threshold for dispatch decision**

The threshold for dispatch decision was analyzed and decided using the in-depth accident study by Nihon University and Nihon Medical University at the Chiba Hokusoh Hospital again. Doctors at Hokusoh hospital decided a decision threshold value after analyzing over triage rate and under triage rate for in-depth accident study cases. The decision threshold value seemed to be depended on a HEMS base hospital at which AACN and HEMS systems are used.

**Algorithm result screen design**

A sample algorithm result (in Japanese language) is provided in Figure 4. The screen consisted of four areas. At the upper left part, there was text information on Accident ID and time, name and color of the involved vehicle, GPS data and address of the accident spot. At the lower left part, there was a map showing the accident spot. At the upper right, there were crash conditions, such as Delta V and airbag deployment and risk of fatal and severe injury of front occupants. Finally, at the lower right, some comments were added.

![Figure 4. An algorithm result transferred to Tablet PC](image)
AACN scheme in Chiba prefecture

A prototype AACN scheme for the pilot study in Chiba prefecture is provided in Figure 5. The circled numbers in the figure represent the step by step process of the AACN scheme. There were two DCMs in the test vehicle. One was an original DCM initially equipped and the other was an additional DCM for the pilot study. Each step follows below.

Figure 5. AACN scheme for the pilot study in Chiba prefecture

**Step 1** The AACN scheme was triggered by an airbag deployment signal. EDR data of a test vehicle was transmitted to HELPNET server. GPS data and vehicle ID were also transmitted.

**Step 2** AACN server received vehicle data to input the algorithm from HELPNET server every 30 seconds. Other information, such as accident time, vehicle ID and GPS information were also received.

**Step 3** AACN server calculated a risk of front occupants using the algorithm and arranged an algorithm result screen.

**Step 4** An algorithm result screen was transmitted to Tablet PCs at Chiba prefecture Fire Department H.Q. and Chiba Hokusoh hospital simultaneously (also at the accident spot).

**Step 5** HELPNET operator called Chiba prefecture Fire Department H.Q. by HOT LINE. This step was usual HELPNET ACN operation. In addition, in case of AACN, HELPNET operator confirmed the arrival of an algorithm result screen on Tablet PC at the H.Q..

**Step 6** After a call to Chiba prefecture Fire Department H.Q., HELPNET operator called Chiba Hokusoh hospital by HOTLINE. In case of high risk of the front occupant, a doctor was send to the accident spot by a helicopter.
**Step 7** Verbal communication was made between Chiba Hokusoh hospital and Chiba prefecture Fire Department H.Q. to decide a rendezvous spot for a helicopter and an ambulance.

**RESULTS**

A total of 6 cases of transmission from 2 accident spots were carried out during the first pilot test period in March, 2015. No error transmission occurred and of the AACN system seemed to function as intended. Within a minute from the airbag deployment signal, the algorithm result screen arrived simultaneously on Tablet PCs at both Chiba Hokusoh hospital and Chiba prefecture Fire Department H.Q.

The effectiveness of AACN and HEMS systems are not established yet because a transmission test with HEMS activated by AACN was not finished at the time of writing this paper.

**DISCUSSIONS**

This study was organized by the AACN committee under Emergency Medical Network of Helicopter and Hospital (HEM-Net). It was natural that Chiba Hokusoh hospital, as a pioneer of HEMS base hospital in Japan, contributed a fundamental part of this study. In Japan, there are 47 helicopters for HEMS and 49 HEMS base hospitals, as of March, 2015. In order to cover all of Japan, the number of cooperative HEMS base hospitals should be increased step by step. The authors had selected 6 HEMS base hospitals from Hokkaido to Kyusyu in Japan. A similar pilot study should be planned for each hospital.

Regarding the AACN algorithm, the authors adopted a newly developed algorithm by Nihon University in this study. Based on ITARDA macro accident data, logistic regression risk curves were produced. Many other algorithm were based on in-depth accident data such as NASS-CDS [6-14]. Comparing with in-depth accident data, ITARDA macro accident data had limited information. For example, there is no information on CDC-code, Delta V, MAIS, ISS etc.. However, ITARDA macro data seemed to be suitable for algorithm risk factors used in this study according to evaluation result using in-depth accident study carried out between Nihon University and Nihon Medical University Chiba Hokusoh hospital.

Regarding the threshold for dispatch decision, the authors adopted a decision value calculated using in-depth accident study at the same hospital. The over triage rate and the under triage rate were analyzed. It became obvious that a decision threshold value depended on each HEMS base hospital. However, there was no other HEMS base hospital which conducted an individual accident study. This issue needs to be solved in future.

**CONCLUSIONS**

The AACN and HEMS pilot system in Chiba prefecture was developed in cooperation with Nihon Medical University Chiba Hokusoh hospital, which was a pioneer of HEMS base hospitals, and Chiba prefecture Fire Department Head Quarters.

At some spots in Chiba prefecture, transmitting tests were carried out and prototype system operated as intended. Within a minute from airbag deployment signal, the algorithm result screen arrived on Tablet PCs at both Chiba Hokusoh hospital and Chiba prefecture Fire Department Head Quarters simultaneously.

To expand this pilot study on AACN and HEMS system widely, the next step was scheduled among other HEMS base hospitals in Japan.

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