Mini Review

Preliminary study of prehospital use of smart glasses

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Background: A smart glasses system is a computerized communicator with a transparent screen and video camera that can be worn as a pair of glasses. There have been no reports on the use of smart glasses in the prehospital setting.

Purpose: To conduct a preliminary investigation on whether smart glasses were smoothly used bidirectionally between the prehospital setting and the receiving hospital.

Methods: From March 1, 2022, to March 31, 2022, one smart glasses unit was installed in an ambulance at one branch of the fire department near our hospital. The physician on the computer, who received video and voice transmission from the smart glasses when the ambulance was dispatched, evaluated the transmission status with regard to video reception, voice reception, and voice transmission. In addition, the activity time was compared between cases in which the smart glasses system was used (patient) and not used (control).

Results: During the investigating period, 12 cases were analyzed as patients. The rate of good video reception was 75%, the rate of good voice reception was 50%, and the rate of good voice transmission was 25%. There was no significant change in the activity time between the patient and control groups.

Conclusion: We performed a preliminary investigation on the usability of smart glasses in the prehospital setting. Using smart glasses, patient information was shared by video and voice before arrival at the hospital, and did not affect the activity time. However, the instability of the communication status should be recognized.

Key words: prehospital, smart glasses, usability, emergency department, trial operation

INTRODUCTION

A SMART GLASSES system is a computerized communicator with a transparent screen and video camera that can be worn as a pair of glasses (Fig. 1).¹ Smart glasses can combine artificial intelligence, augmented reality, and object recognition to provide real-time visual and audio references via a mobile Wi-Fi (wireless fidelity) system, as well as provide decision-making support for users who wear them.² Smart glasses can concretely enable (i) hands-free access to information (medical records, blood test results, or X-rays); (ii) real-time communication, allowing to see what the user sees for remote collaboration and professional support; (iii) hands-free support, providing point-of-view audiovisual examination of the patient's symptoms and physical issues; and (iv) a vast reduction in the need for time-consuming reports, eventually resulting in critical time savings.² These capabilities are essential for delivering the benefits of advanced sensor technology, artificial intelligence and remote training, patient care, and providing support to first responders and medical personnel. Previous reports have suggested the usefulness of smart glasses in surgical operations, rehabilitation, and medical education.³⁻⁹ However, there have been no reports on the use of smart glasses in the prehospital setting involving collaboration among fire department, receiving hospital, and private company staff. Earlier and more precise recognition of the patient’s status at the receiving hospital using smart glasses in comparison to a cellular phone may result in earlier preparation to accept patients and improve patient outcomes. Accordingly, we decided to use smart glasses at the scene. The main purpose of this study was to conduct a preliminary investigation on...
whether smart glasses were smoothly used bidirectionally between the prehospital setting and the receiving hospital.

**METHODS**

**THE PROTOCOL** of this retrospective study was approved by the Juntendo University review board (E22-0032), and examinations were conducted according to the standards of good clinical practice and the Helsinki Declaration.

Shizuoka Hospital, affiliated with Juntendo University, is a hospital with 577 beds and a critical care medical center in Izu Peninsula in eastern Shizuoka Prefecture (located near Tokyo). The hospital serves a population of approximately 1,230,000. It is located in an area controlled by the fire department of Sunto Izu. A physician-staffed helicopter (helicopter emergency medical service [HEMS]) is based at Juntendo Shizuoka Hospital, and our department staff mainly treat severely ill or traumatized patients at the prehospital area. Initially, we tried to use smart glasses (VUZIX M400; AVR Japan Corporation, Tokyo, Japan) at the prehospital area in HEMS. However, transmission of video or voice could not work smoothly because Izu Peninsula is a mountainous area with poor mobile Wi-Fi connectivity. Therefore, we decided to use smart glass connectivity between our hospital and the nearby branch of the fire department of Sunto Izu in a country town.

Emergency medical services (EMSs) are provided by the fire defense headquarters of local governments in Japan. The EMS system is single tiered, with ambulances staffed by three crew members who are trained in rescue, stabilization, transport, and advanced care of traumatic and medical emergencies. There are three levels of care provided by ambulance personnel, including a basic-level ambulance crew (First Aid Class One), a second level (Standard First Aid Class), and the highest level (emergency life-saving technicians [ELSTs]). ELSTs are trained in all aspects of basic life support and some advanced life support procedures relevant to prehospital emergency care, such as tracheal intubation, securing a route, and the administration of adrenaline to patients with cardiac arrest after receiving orders from physicians.

1. The use of smart glasses in the present study

ELSTs received training on how to use the smart glasses and were dispatched in an ambulance to the patient at the prehospital scene from 09:00 to 17:00. After wearing the smart glasses, the ELST contacts a medical clerk at our hospital to establish communication via a personal computer that can receive video and voice from the smart glasses of the ELST. The medical clerk calls an emergency physician on duty to respond to the messages from the ELST. When the ELST treats the patient, the ELST switches on the smart glasses and sends video and voice transmissions showing the management of the patient at the scene and during transportation, and monitors images in the ambulance that show vital signs or electrocardiography. After recognition of the patient’s status by the physician on the computer based on the video and voice transmissions, the physician starts preparing to accommodate the patient in our hospital. In some situations, the physician on the computer sends suggestions via an equipped microphone to the ELST on how to treat the patient using bidirectional verbal communication. When the patient arrives at our hospital, appropriate treatment can be smoothly provided (Fig. 2).

2. A preliminary investigation was performed on whether smart glasses could be smoothly used bidirectionally between the prehospital and the receiving hospital in a country town from March 1, 2022, to March 31, 2022. Smart glasses were set up in an ambulance at one branch of fire department of Sunto Izu, which is near our hospital. To evaluate whether the smart glasses could work...
smoothly between the prehospital and the receiving hospital bidirectionally, the physician on the computer, which receives video and voice transmissions from the smart glasses worn by the ELST, rated the smart glasses’ transmission status with regard to video reception, voice reception, and voice transmission on a 3-point scale of “poor,” “fair,” or “good” at each dispatch. The video and voice senders are ELSTs, and the receivers are physicians in the hospital. In addition, we retrospectively investigated the activity time (from contacting the patient to arrival at the hospital) between the cases in which the smart glasses were used (patient group) and cases in which smart glasses (control group) were not used. Furthermore, at the end of the preliminary investigation period, a questionnaire survey was administered among ELSTs who took part in the investigation to determine the benefits, drawbacks, and improvements in relation to the application of the smart glasses.

Data were analyzed using Student’s unpaired t-test and the chi-square test. P-values of <0.05 were considered statistically significant. Data are shown as the mean ± standard deviation.

RESULTS

DURING THE INVESTIGATION period, 58 cases were transported to our hospital. Among them, smart glasses were used in 19 cases. After excluding 7 cases with missing data because the emergency physician on duty was unable to respond, 12 cases were analyzed in this study. Transmission status of the smart glasses are shown in Table 1. The rates of good video reception, good voice reception, and good voice transmission were 75%, 50%, and 25%, respectively.

The comparison between the patient and control groups with regard to the disease (external/internal), activity time (duration from contacting the patient to arrival at the hospital), transportation time (duration from scene departure to arrival at the hospital), receiving hospital’s level (primary/secondary/tertiary), and 28-day survival rate are shown in Table 2. There was no significant change between the two groups.

The results of the questionnaires completed by ELSTs, which investigated benefits, drawbacks, and improvements, are shown in Table 3. The results of the questionnaire indicated voice instability and video instability as dominant

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concerns when smart glasses were used at the prehospital scene, even in the country town.

**DISCUSSION**

This was the first report to describe the results of the preliminary investigation on the usability of smart glasses in a prehospital setting. The use of the smart glasses

| Table 1. Background of patients and results of using smart glasses |
|---|---|---|---|---|---|---|
| No | Age | Sex | Complaint | Video reception†,‡ | Voice reception†,§ | Voice transmission†,¶ | Final diagnosis |
|---|---|---|---|---|---|---|---|
| 1 | 64 | Male | Moving difficulty | ☐ | ☐ | N/A | Dehydration |
| 2 | 70 | Male | Hemiparesis | ☐ | ☒ | N/A | Putaminal hemorrhage |
| 3 | 91 | Female | Dyspnea, chest pain | ☐ | ☐ | × | Heart failure |
| 4 | 1 | Male | Head contusion | △ | ☒ | N/A | Head contusion |
| 5 | 81 | Female | Abdominal pain | ☐ | ☐ | × | Ileus |
| 6 | 86 | Male | Back pain | ☐ | ☐ | × | N/A | Acute aortic dissection |
| 7 | 80 | Female | Hip pain | ☐ | × | N/A | Femoral neck fracture |
| 8 | 97 | Female | Hip pain | △ | ☒ | N/A | Femoral neck fracture |
| 9 | 75 | Female | Head contusion | ☐ | ☐ | ☐ | N/A | Head contusion |
| 10 | 16 | Male | Head contusion | ☐ | △ | N/A | Cerebral concussion |
| 11 | 48 | Female | Palpitation | × | × | N/A | Supraventricular tachycardia |
| 12 | 83 | Male | Head contusion | ☐ | ☒ | N/A | Skull fracture |

†, O; Good; △, Fair; ×, Poor; N/A, not applicable.
§, Video reception rate: ☐/△/× (%): 75/16.7/8.3.
¶, Voice reception rate: ☐/△/× (%): 50/8.3/41.7.
¶, Voice transmission rate: ☐/× (%): 25/75.

| Table 2. Comparison between the patient and control groups |
|---|---|---|---|
| Variables | Patients (n = 12) | Control (n = 41) | P-value |
|---|---|---|---|
| Age | 66 ± 28.6 | 65 ± 21.9 | 0.88 |
| Sex (male/female) | 6/6 | 22/19 | 0.83 |
| Disease (external/internal) | 6/6 | 17/24 | 0.31 |
| Duration of activity (scene – arrival) (min) | 30 ± 8.6 | 36 ± 12.8 | 0.08 |
| Transportation time (departure – arrival) (min) | 12 ± 4.2 | 13 ± 7.4 | 0.73 |
| Receiving hospital’s level (primary/secondary/tertiary) | 4/5/3 | 9/23/9 | 0.74 |
| 28-day survival rate (alive/dead) | 12/0 | 40/1 | 0.89 |

| Table 3. Questionnaire by emergency life-saving technicians |
|---|---|---|---|
| Content | Ratio (%) |
| Benefit | Faster startup of smart glasses | 40 |
| Feeling of security with supervision by physicians | 20 |
| Share wound site and condition information between prehospital and hospital | 20 |
| Share electrocardiography information between prehospital and hospital | 13 |
| Stability of putting smart glasses on | 7 |
| Drawback | Voice instability | 63 |
| Image instability | 21 |
| Delayed response by physicians at hospital | 11 |
| Smart glasses coming into sight interferes with activity | 5 |
| Improvement | Communication stability | 58 |
| Quick response by physicians at hospital | 21 |
| Skill training on use of smart glasses | 11 |
| Set up smart glasses as fixed-point video | 5 |
| Reconsidering indication at the scene near the hospital | 5 |

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did not influence the activity time of the ELSTs. However, the stable use of the smart glasses at the prehospital setting was the most important weakness in the preliminary investigation.

Before starting the preliminary study, we predicted that the use of the smart glasses would prolong the activity time of the ELSTs because handling the smart glasses is complicated. However, the activity time in the patients group did not change in comparison with the control. This might be because the ELSTs underwent training on how to use the smart glasses before commencement of the preliminary study. Accordingly, before use, training on how to use the smart glasses was important to perform smooth activity.

Our study revealed video and voice instability when the smart glasses were used in the prehospital setting. To transmit video and voice, the study used mobile Wi-Fi. The mobile Wi-Fi system transmits internet to compatible devices around it. The Wi-Fi system uses 2.4–5 GHz radiofrequency to deliver wireless internet access around our homes, schools, offices, and in public places. However, this has its limitations. Although Wi-Fi can cover an entire user, its bandwidth is typically limited to 50–100 Mbps using the IEEE802.11n standard. This is insufficient for moving large data files such as video. To transmit the data completely, we chose a locally located fire department in a country town; however, even in this setting, data were not transmitted completely. Therefore, new technological innovations are required to facilitate communication between the prehospital and the hospital setting, even in mountainous areas.

Another problem was the delayed response to the transmission data from the ELSTs. In addition, in the cases involving dispatch to a nearby the hospital, the ambulance had arrived at the hospital before the emergency physician checked the data from the smart glasses. This is because the emergency physician on duty might have to treat the other patients when the data were transmitted. To avoid a delayed response, another free physician is required in front of the device that receives data from the ELSTs, to facilitate a rapid response to the data. If the distance from the scene to the hospital is short, it might not be necessary to send the data from the smart glasses. We will perform another study to investigate whether the use of the smart glasses improved the outcomes of the patients, by increasing the number of smart glasses and ELSTs upon resolving these problems in the future.

CONCLUSION

WE PERFORMED A preliminary investigation on the usability of smart glasses in the prehospital setting, and found that the use of smart glasses was associated with benefits and drawbacks. Using smart glasses, patient information was shared by video and voice before arrival at the hospital, and did not affect the activity time. However, the instability of the communication status should be recognized. We will perform another study to investigate whether the use of the smart glasses is associated with improved patient outcomes after overcoming the drawbacks.

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DISCLOSURE

APPROVAL OF THE research protocol with approval No. and committee Name: Juntendo University review board (E22-0032).

Informed Consent: After the patient arrived at the hospital, the doctor gave Informed Consent to the patient or family.

Registry and the Registration No. of the study/Trial: N/A.

Animal Studies: N/A.

Conflict of Interest: None declared.

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