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Case Report

# A Smartphone Video Transmission System for Verification of Transfusion

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A B S T R A C T

A physician-staffed helicopter emergency medical service called a doctor helicopter (DH) in Eastern Shizuoka was equipped with a smartphone video transmission system in April 2018. We herein report on the introduction of this system for the verification of transfusion in the DH. A 51-year-old man visited a local hospital after cutting his left neck himself. He was diagnosed with jugular vein injury and underwent compressive hemostasis. As he entered profound hemorrhagic shock, he underwent tracheal intubation, massive fluid resuscitation, and administration of 3 vasopressor agents to maintain circulation. The Eastern Shizuoka DH was requested to transport this patient. After making contact with the patient, the staff of the DH started prehospital transfusion. Because this was the first case of transfusion in a prehospital setting for our hospital, we held a meeting in which we used a smartphone video transmission system to verify the condition surrounding the transfusion in the DH. By reviewing the video record, we confirmed that the transfusion was performed safely and correctly in the prehospital setting. This smartphone video transmission system was useful for verifying the activity of the staff in the DH.



The physician-staffed helicopter emergency medical service in the eastern part of Shizuoka Prefecture was started in 2004. In Japan, the helicopter emergency medical service is called the doctor helicopter (DH) and operates during the daytime. Two DHs (1 in the eastern portion and 1 in the western portion) cover all of Shizuoka Prefecture, with an arrival time at the nearest hospital of within 20 minutes. Our hospital (Juntendo University Shizuoka Hospital) serves as the base hospital for the eastern DH and is responsible for serving the eastern region of Shizuoka Prefecture, including the Izu Peninsula.[1] This region, which is approximately 4,090 km$^2$ in area with a population of approximately 2 million, is mountainous, with only a few hospitals.[2] In addition, few hospitals are equipped to perform urgent blood transfusion. The journey from the southern tip of Izu Peninsula to the critical care medical center of our hospital takes 2 hours by ambulance but only 15 minutes by helicopter. In 2017, there were over 1,100 air dispatches in Eastern Shizuoka, which was the third-highest frequency in Japan.

Smartphones are now readily available and are able to transmit a large quantity of data rapidly. The smartphone video transmission system provided by Nippon Telegraph and Telephone Corporation is able to send live images to multiple receivers at a time using a special application with conventional commutation costs (Figs. 1 and 2).[3] The DH in Eastern Shizuoka was equipped with this smartphone video transmission system in April 2018. The doctor and nurse onboard each have a smartphone, so 2 different videos from these staff members can be seen on the monitor in the DH control room and emergency room in our hospital. We herein report on the introduction of this system for the verification of transfusion in the DH.

## Case Presentation

A 51-year-old man visited a local hospital after cutting his left neck himself around 5 AM. He had a history of depression and alcoholism. His family history was unremarkable. He was diagnosed with jugular vein injury and underwent compressive hemostasis. Because he entered profound hemorrhagic shock, he underwent tracheal

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**Figure 1.** A smartphone video transmission system. The smartphone is used as a video camera and a voice transmitter (both as a microphone and speaker). The smartphone is placed in the right chest pocket.

intubation, massive fluid resuscitation, and administration of 3 vasopressor agents (dopamine, dobutamine, and noradrenalin) to maintain circulation because the local hospital did not have blood products and it would take some time before requested blood products would arrive.

The Eastern Shizuoka DH received the request to transport this patient at 8 AM. Because the Eastern Shizuoka DH does not start operating until 8:30 AM, we prepared 6 units of washed red blood cells in a cooler box according to the massive transfusion protocol of our hospital. Because Japan has labor regulations concerning helicopter piloting, such as keeping the helicopter piloting duration under 8 hours at a time, the start time of 8:30 AM was selected by the DH management company. At our hospital, 30 minutes is the maximum time blood products are allowed to be kept outside of a regular refrigerator. The massive transfusion protocol of our hospital prescribes 6 units of blood type O washed red blood cells and/or an unregulated number of units of blood type AB fresh frozen plasma. Two physicians and 1 nurse boarded the DH, and the DH took off. At 8:41 AM, the staff of the DH made contact with the patient, who had been transported to the rendezvous zone in an ambulance. The patient remained in a coma with nonreactive fixed pupils and in a shock state without pulsation at the radial artery but with pulsation at the femoral artery under no sedation. His heart rate was 136 beats/min, and his saturation was 74% under 100% oxygen. The staff of the DH initially took a blood sample and then started transfusion by manual pumping in the ambulance. Our approach to drawing blood samples before transfusion is based on a strict Japanese rule. The results of the analysis of the blood sample are shown in Table 1. The 3 vasopressors were reduced to 1. Because 1 of the 2 venous routes was occluded, we had to secure another venous route in order to start transfusion, which took some time because he was already edematous because of massive fluid resuscitation at the referring hospital and his profound shock state. The patient was moved to the DH, and the DH left the rendezvous zone at 9:08 AM while still performing transfusion (Fig. 3). These processes were monitored by a smartphone video transmission system and reviewed in real time by the medical staff in the emergency room and the staff in the DH control room of our hospital to make them aware of the patient's condition before his arrival.

On arrival at 9:23 AM at our hospital, the patient's vital signs were as follows: Glasgow Coma Scale of E1VTM1, blood pressure of 126/54 mm Hg, regular pulse rate at 96 beats/min, and respiratory rate of 30 breaths/min assisted by a ventilator. His axillary temperature could not be measured by a thermometer, suggesting it was below 35.0°C. We had no time to exchange the bladder catheter in order to monitor the core temperature. He entered cardiac arrest (pulseless electrical activity) at 9:30 AM but obtained return of circulation by additional transfusion. He received an additional 4 units of washed red blood cells, 6 units of fresh

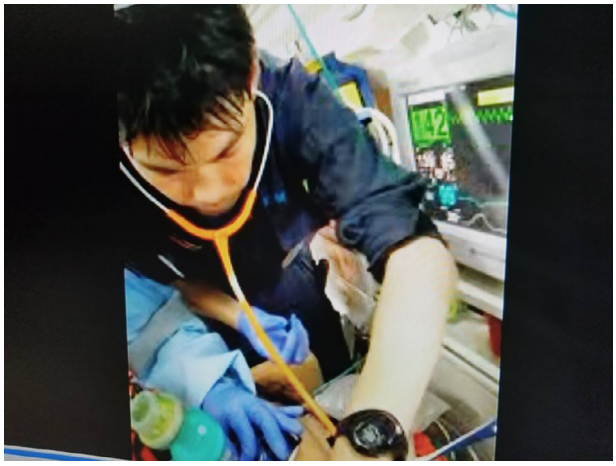

**Figure 2.** The smartphone video transmission system. The scene is shared live on a screen in the helicopter control room and the emergency room in our hospital.

**Table 1**
Results of the Analysis of the Prehospital Blood Sample

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| Cell blood count and biochemical analysis: white blood cell count = 3,100/$\mu$L, hemoglobin = 3.1 g/dL, platelets = 5.5 $\times$ $10^4$/$\mu$L, total protein = 1.4 g/dL, albumin = 0.9 g/dL, aspartate aminotransferase = 25 IU/L, alanine aminotransferase = 17 IU/L, blood urea nitrogen = 13.5 mg/dL, creatinine = 1.49 mg/dL, glucose = 162 mg/dL, sodium = 161 mEq/L, potassium = 4.2 mEq/L, chloride = 15 mEq/L, activated partial thromboplastin time = > 150 (27.1) seconds, thromboplastin time = > 150 (12.1) seconds, fibrinogen = < 20 mg/dL, fibrinogen degradation products = 536 $\mu$g/mL |

frozen plasma, and 8 units of cryoprecipitate. We did not use rewarming devices when we performed transfusion because these devices become obstacles during manual transfusion pumping. Instead, we used an air warming blanket although this failed to obtain normothermia during the patient's time in the emergency room. Whole-body computed tomographic imaging revealed a skull fracture of unknown cause, traumatic subarachnoid hemorrhaging, brain swelling, jugular vein injury, tracheal injury resulting in massive blood aspiration in the lungs, and mediastinal hematoma. He suffered pulseless electrical activity again at 10:03 AM but obtained return of circulation by infusion of adrenaline at 10:09. He was finally transferred to the intensive care unit at 12:30 PM; his condition had been explained to his wife. Unfortunately, he developed complications including coagulopathy and hypoxic hypoperfusion encephalopathy and ultimately died the same day.

Because this was the first case of transfusion in a prehospital setting for our hospital because of a request from the referring local hospital for a patient suffering from severe shock caused by a neck injury, we held a meeting in which we used a smartphone video transmission system to verify the condition surrounding the transfusion in the DH. By reviewing the video record, the staff of the DH and the Department of Blood Transfusion Management confirmed that the transfusion had been performed safely and correctly in the prehospital setting. At the meeting, it was recommended that transfusion requests be met with increased numbers of medical staff members to perform the additional work of managing the transfusion. In addition, our hospital only has frozen plasma and cryoprecipitate, which both require time for resolution; as such, it was recommended that transfusion of these agents be performed after air medical transportation to our hospital for patients requiring such a massive transfusion.

## Discussion

This is the first report to describe the usefulness of a smartphone video transmission system for the verification of a transfusion procedure in a DH. Newly developed strategies for severe trauma management include the early identification of injuries that are life-threatening and require surgical hemostasis, management of moderate hypotension, rational intravascular volume replacement, prevention of hypothermia, correction of acidosis, optimization of oxygen carriers, and identification of factors required by the patient (fresh frozen plasma, platelets, tranexamic acid, fibrinogen, cryoprecipitates, and prothrombin complex).[4,5] Because massive fluid resuscitation causes dilutional coagulopathy, clot disruption from increased blood flow, decreased blood viscosity, and interstitial edema, there is an increased risk of multiorgan failure and fatality.[4,5] This tendency is also noted in the prehospital setting.[6] Accordingly, early blood product transfusion is performed even in prehospital settings, including during air medical transportation.[7-11] However, there has been only 1 medical report concerning prehospital transfusion in Japan.[12] Therefore, this is the second report concerning prehospital transfusion in a DH in Japan and the first case of such transfusion in the Eastern Shizuoka DH. We verified the performance of this transfusion after the fact. This activity, held after the flight had occurred, was meant to improve the quality of subsequent similar events.

Three controversial points concerning the management of this patient should be mentioned. The first is the usefulness of prehospital transfusion. The use of blood products is possible, but previous reports are conflicting concerning its usefulness, which can be jeopardized by state, regional, and local legislations as well as, in some places, religious issues. The second is the evacuation method. We tentatively chose a "stay and play" method at the scene when we evacuated the patient because we had previously encountered another patient who entered cardiac arrest caused by hemorrhagic shock without transfusion because of our selecting a "load and go" method (rendezvous with ambulance transfer to the helicopter and transfusion en route back to the hub hospital).[13] Further studies will be needed to determine which method is more effective for patients with hemorrhagic shock (a stay

**Figure 3.** Transfusion in a physician-staffed helicopter. The patient received transfusion during air evacuation.

**Table 2**
Benefits and Drawbacks of a Smartphone Video Transmission System

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| Benefits |
| • Live video and audio at scene can be shared among all departments concerned. |
| • Communication between the hospital staff and those at the scene is made possible through the system (hands-free setup). |
| • Hospital staff can see what is happening at the scene through the system. |
| • The burden on the staff working at the scene is lightened. |
| • Advance preparation can be performed smoothly at the hospital. |
| • By reviewing the recorded video, information from the scene can be shared later. |
| • By reviewing the recorded video, the activity of the staff of the DH can be verified later. |
| • By reviewing the recorded video, good feedback can be provided to young staff members of the DH. |
| • By reviewing the recorded video, a new protocol can be created after discussing the activity at the scene. |
| • A plan-do-check-act cycle can be established using this system. |
| Drawbacks |
| • The initial cost is substantial. |
| • The smartphones become warm when the system is active, which can make them uncomfortable to hold. |
| • When the smartphone is placed in the chest pocket, the staff at the scene cannot check the screen easily and therefore cannot see what images are being transmitted to the hospital. |

DH = doctor helicopter.

and play/treat then transfer or a scoop and run/load and go approach). The third is the rewarming method. We routinely execute efforts to prevent hypothermia, but we do not routinely perform rewarming for patients with hypothermic hemorrhagic shock. We believe that acidosis and hypothermia have a protective effect on malperfusion of tissue because of hypotension.[14,15] The lethal triad (hypothermia, acidosis, and coagulopathy) of hemorrhagic shock is a sign of an unfavorable outcome.[16] However, no clinical reports have described the effectiveness of aggressive rewarming during resuscitation for patients in a hypothermic hemorrhagic shock state. At the very least, we should have measured the core body temperature in the present patient in order to monitor his temperature.

The benefits and drawbacks of using a smartphone video transmission system to monitor the activity in the DH are shown in Table 2. In the present case, this system was useful for checking the activity of the staff in the DH later by reviewing the recorded video. In addition, compared with a written medical record, making a recording using a smartphone video transmission system was quite easy for the staff of the DH and could be accomplished while they were busy working. A senior physician from the dispatch center being able to advise the onboard physician might be extremely useful. The lack of or limited communication is a constant issue plaguing emergency medical services. Based on the records of this case, our institute established a new protocol for massive transfusion in the DH. In addition, in order to comply with the basic rules of our hospital concerning massive protocol transfusion, the new protocol included an increase in the number of staff of the DH, going from 1 nurse and 1 doctor to 2 nurses and 2 doctors in order to separate management of the patient and management of transfusion and a clear description of the role of the doctors and nurses during transfusion. However, this new protocol has not been exercised since its establishment. From facilitating patient monitoring and diagnostics to improving the efficiency of medical education and communication, smartphones play a vital role in the practice of medicine today, as shown in this report.[17] In Japan, free public wireless local area networks as well as a variety of live video transmission systems using microwaves or real-time wireless transmission technology for high-capacity high-definition video from high-speed moving bodies, such as drones, have been developed.[18] These systems may become alternatives to smartphone systems for sharing such information in the future.

One limitation associated with this case report was its use of a narrative case method. An adequate evaluation of the usefulness of this smartphone video transmission system will require determining whether or not the implementation of this system helps improve the skill of the staff in the DH or the final outcome of the patients. Therefore, future prospective studies involving a greater number of patients are needed to further examine this system.

## Conclusion

This smartphone video transmission system was useful for verifying the activity of the staff in the DH. Future prospective studies will be needed to further examine this system.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.amj.2018.11.012.

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